NIVERSITY OF TEXAS BULLETIN

No. 3534: September 8, 1935

GEOLOGY OF PALO PINTO COUNTY, TEXAS

By

F. B. PLUMMER

and

JOSEPH HORNBERGER, JR.

Bureau of Economic Geology
E. H. Sellards, Director

PUBLISHED BY
THE UNIVERSITY OF TEXAS
AUSTIN

Publications of The University of Texas

month,
r show
yearly
of the
ublica-
ic and
o time
lowing
them;
should
is, care
eau of
Bureau
erests,
ing all
lressed
Austin.

n the
s,

THE UNIVERSITY OF TEXAS PRESS

THE UNIVERSITY OF TEXAS BULLETIN

No. 3534: September 8, 1935

GEOLOGY OF PALO PINTO COUNTY, TEXAS

By

F. B. PLUMMER

and

JOSEPH HORNBERGER, JR.

Bureau of Economic Geology

E. H. Sellards, Director

PUBLISHED BY THE UNIVERSITY FOUR TIMES A MONTH AND ENTERED AS SECOND-CLASS MATTER AT THE POSTOFFICE AT AUSTIN, TEXAS, UNDER THE ACT OF AUGUST 24, 1912

The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of Democracy, and while guided and controlled by virtue, the noblest attribute of man. It is the only dictator that freemen acknowledge, and the only security which freemen desire.

Mirabeau B. Lamar

CONTENTS

ILLUSTRATIONS

TABLES

ERRATA

T.O.C.

Page 42, line 1, for (B–11) read (B–21).

Page 46, line 29, for (A–20) read (A–21).
line 37, for (S–3) read (R–3).

Page 140, line 5, for 4,630,271,000,000 read 4,630,271,000.
line 6, for 31,933,000,000 read 31,933,000.
line 8, for 36,704,850,000,000 read 36,704,850,000.
line 9, for trillion read billion.
line 11, for 14 read 10.

Page 221, line 11, for 100-acre feet read 1,000-acre feet.

PREFACE

The task of assembling data on the geology and natural resources of Palo Pinto County has required several years of work and is the result of the help and coöperation of a large number of individuals. The senior author first became interested in Palo Pinto County in 1918, when he was stationed at Mineral Wells as geologist for Roxana Petroleum Company, now the Shell Corporation. During a two years residence, many observations were recorded and acquaintanceships made which helped much in a detailed study of the county, undertaken by the Bureau of Economic Geology twelve years later. The work of compiling the data has comprised three enterprises. First, the geologic map was made by the Coöperative Mapping Committee of the American Association of Petroleum Geologists working in coöperation with the Bureau of Economic Geology. Second, the assemblage of additional new data by Bureau geologists, who spent a season in the county, mapping surface geology and studying the structure of the oil and gas fields. Third, the task of collecting and compiling data on the natural resources of the county has followed the completion of the map. In this the Bureau has been greatly aided, and the final result made possible by the help of a large number of residents of the county and of geologists throughout the state. To all these the Bureau extends grateful acknowledgement and regrets that space does not permit the recording of all the long list of names of those who have contributed. Especial thanks are due the following persons:

M. A. Howell of Palo Pinto for an excellent base map and well-log data. J. W. Armstrong and the Prairie Oil Company for oil-well and geologic data. H. R. Montgomery of Mineral Wells and Jacksboro for oil-well and geologic data. C. F. Hedrick and the Texas and Pacific Coal and Oil Company for much geologic information and data on coal and oil. P. G. Russell and the Lone Star Gas Company for geologic data and information on natural gas. Judge Ritchie of Mineral Wells for assistance and information on coal, oil, and gas. A. Eaton of Mineral Wells for data on clay resources and information on mineral water, brick and tile.

W. N. Woodhall of the Crazy Water Company for data on mineral water. W. N. Nichols of Wichita Falls for information on the geology of the mineral-water sands. N. F. Shephard and Miss Veda Weatherly of Mineral Wells for data on the manufacture of mineral crystals. G. P. Maury of Mineral Wells and Fort Worth for information on the crushed-stone industry. Tom Richards of Mineral Wells and J. C. Son of Palo Pinto for valuable data on the history of the county. John Prichett of Austin and A. Streiff of San Antonio for valuable information and data on the Brazos River dam sites and on the water-conservation program. Ralph King studied and identified many fossils. George Harris of Waco has contributed information on fossils and fossil localities. Virgil Barnes and E. C. Sargent of Austin made analysis of mineral waters from various wells. Finally, Mrs. Helen J. Plummer has contributed no small part in editorial work, in drafting and compiling numerous maps, and in able assistance in the field. The authors have given very generously of their time in the preparation of this extended report on the geology and economic resources of the county.

E. H. SELLARDS, *Director*
Bureau of Economic Geology.

A

B

Views at Inspiration Point, eight miles south of Mineral Wells on Brazos River. A. View taken at the park grounds looking southward down the river; the massive ledges of the Brazos River sandstone are at the extreme left. B. Close view of the massive ledges of the Brazos River sandstone.

GEOLOGY OF PALO PINTO COUNTY, TEXAS

By

F. B. Plummer and Joseph Hornberger, Jr.

INTRODUCTION

Location.—Palo Pinto County is located within the Brazos River drainage system in north-central Texas about 50 miles west of Fort Worth, 60 miles south of Red River, and 200 miles north of Austin, between latitudes 98° E. and 98° 30′ E. and longitudes 32° 30′ N. and 33° N. (fig. 1). The county is situated on the eastern edge of

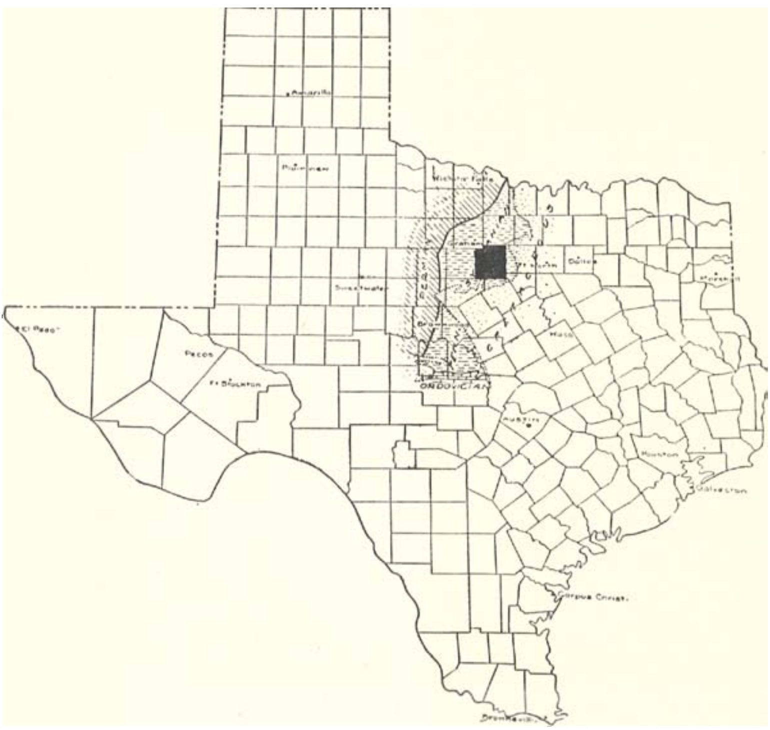


FIG. 1. Sketch map of Texas showing the location of Palo Pinto County.

the physiographic division known as the Osage Plains. Brazos River flows in a deeply intrenched, meandering course from northwest to southeast across the county. The area is reached easily by the Texas and Pacific Railway from Texarkana to El Paso, which crosses the south end of the county, by State Highway No. 1 (National Highway 80), which runs east and west across the state through the center of the county, and by a north-and-south State Highway No. 66. It is thus advantageously located with respect to drainage lines, transportation lines, economic resources, and trade centers, advantages that have contributed greatly to its steady development and present prosperity.

Historical resumé.—The name Palo Pinto is derived from the Spanish words *palo pinto*, meaning painted tree. It was first given by early Spanish explorers to Palo Pinto Creek, a large branch of Brazos River in the southwestern part of the county. Early settlers later named the county after this creek. The name is thought to refer to the red wood of the cedar (*Juniperus*). The tree grows abundantly in the valleys and on the steep slopes of the central part of the county and furnishes picturesque coloring to the landscape. The first reference to the name in literature, which we have been able to find, appears on Chamber's "Atlas of North America," published in London in 1831.

In the diary of Big-Foot Wallace, as recorded by Duval,[1] Wallace writes on October 23, 1837: "We struck a branch of Palo Pinto Creek, on which we intended to begin our work of locating and surveying land."

The first attempt to colonize the land that is now Palo Pinto County seems to have been by W. S. Peters,[2] the grandfather of President H. Y. Benedict of The University of Texas. Peters in 1841 received a grant of land 100 miles wide with the provision that he settle 600 families on it within three years. Peters was unable to locate his full quota of families, and the colony was of short duration. On July 1, 1848, the contract with Peters expired, and all land not held by colonists was claimed by the government. The original contractors, Peters, Mercer *et al.*, claimed important interests and organized a company known as the Texan Emigration and Land Company to protect their rights. The Legislature of 1852

[1]Duval, J. C., The adventures of Big-Foot Wallace: J. W. Burke and Co., Macon, p. 30, 1885 (3d ed.).

[2]Paddock, B. B., Northern and Western Texas: Lewis Publishing Co., New York, vol. 1, p. 80, 1904.

granted to the company 1700 sections of 320 acres each.[3] Some of this acreage is located in the northeastern part of what is now Palo Pinto County.

Among the first settlers who came to the new country were Bob Dalton and Col. Slaughter, who settled on the north side of Brazos River, W. D. Nicklas and E. P. Costello, who settled west of Pickwick, and Jim Metcalf, who established a home near the community now known as Metcalf. The settlers were engaged chiefly in cattle raising. The water holes along Palo Pinto, Ioni, Caddo, and Keechi creeks were utilized by the early pioneers, for all the early settlements were located near a water supply. The first white boy born in the county was Buck Harris, who had his first birthday 83 years ago. The first female child was Sarah Jane Slaughter (Mrs. D. C. Harris), who was 82 years old in 1934.

The first settlers came in contact with the Caddo, Comanche, and Kiowa Indians and found them in undisputed possession of the territory. The Comanches were wild, ferocious, warlike hunters, who were always a menace. The Caddos, Whacos, and Kiowas were more peacably inclined, and they engaged in trading, exchanged courtesies, and some even allied themselves with the early settlers against the Comanches. The Caddos had camps or small settlements along the Brazos near the mouth of Turkey Creek, on Sunday and Palo Pinto creeks in the southern part of the county, and at Indian Village near the mouth of Caddo Creek in the western part. In the early 50's an unfortunate circumstance[4] broke up all friendly relations with the Caddos and caused much hatred and bloodshed. A man named Lavender, living on Buck Creek in Hood County, reported that he had been shot at by Caddo Indians camped on Sunday Creek. John Middleton, living near Lipan, organized and led a party against the Caddos and forced them to withdraw to a new site in the vicinity of Golconda, now Palo Pinto. Meanwhile, a parley was arranged with the Caddos, who stoutly denied the charge. It was agreed, finally, that they should be allowed to remain in peace at their new location. Meanwhile, a Stephenville settler, by the name of Garland, organized another party and followed the Indians

---

[3]Hartsfield, L.W., A history of Stephens County: Thesis, The University of Texas, pp. 13, 15, 1929.

[4]Ewell, T. T., A history of Hood County, Texas: pp. 16, 17, Granbury News, Granbury, Texas.

to Golconda. Garland, not knowing about the stipulations of the parley, and becoming excited by finding remnants of female wearing apparel along the way, concluded that the Indians had committed further depredations. Accordingly, in the night he attacked the camp of the Caddos without warning and killed all except two squaws and a few children. The revengeful spirit of the Caddo was fully aroused by this unfortunate affair. A campaign of depredations, surprise attacks and murder was at once started, and such consternation was spread throughout the frontier that many settlers decided to withdraw from the Brazos valley and the lands of these infuriated Indians.

Fort Griffin was established on Clear Fork of Brazos River in 1852 to protect the white settlers and a road was laid out connecting it with Fort Worth. The highway ran through the central part of Palo Pinto County, crossing Caddo Creek near the west county line. The forts and military roads encouraged settlement, and in 1856 enough settlers were on hand to petition successfully for the establishment of a county. Palo Pinto County was created by an act of the Legislature, August 27, 1856, and organized April 27, 1857. Golconda was laid out as the county seat at the present site of the town of Palo Pinto. The name was changed to Palo Pinto in 1858. The county was divided into six precincts in 1857, and another road was laid out, by order of the court, from Weatherford (Parker County) to Palo Pinto to Fort Belknap and to Graham in Young County. The courthouse at Palo Pinto was built in 1858. A third highway was laid out from Palo Pinto to Breckenridge in 1859.

The period from 1860 to 1866 was a difficult one. The government withdrew its soldiers from the Texas forts to serve in the Union armies. Citizens of Texas organized patrols for their own defense. Indians ran wild over north Texas territory, stealing and murdering. In 1862 at least 150 families lived in Palo Pinto County. Small isolated communities built stockades and gathered together for mutual protection. The stockades became centers of population, trading posts, and later towns. An early stockade community is described by Hartsfield.[5] An inclosure was made around about five acres by digging a trench and setting in it short oak and elm tree

[5]Hartsfield, L. W., A history of Stephens County: Thesis, The University of Texas, pp. 30–31, 1929.

trunks on end, and by packing earth firmly around them. Rude, one-room log huts and a school-house were constructed inside the inclosure. On Sundays the school-house served as a church. During the period from 1863 to 1873 the families of most ranchmen lived in such communities, while the heads of the families were on the range looking after the cattle or chasing Indian marauders. In 1866 and 1867 the situation was especially acute. All organized resistance to the Indians had broken down, and each little community had to shift for itself. All colonization ceased, and many families withdrew from Palo Pinto County to safer areas. It was during this epoch that Bob Dalton, father of B. S. Dalton now living on the Dalton ranch, was murdered[6] by Comanche Indians. Dalton was returning from Dodge City, Kansas, where he had driven and sold a large herd of cattle. He had received $12,500 for the herd and had the money in the tray of a leather trunk. The Indians overtook the Dalton party near the boundary of the county 20 miles from his home, killed Mr. Dalton, ransacked his outfit, broke open the leather trunk, but missed the money concealed in the tray.

In 1871 the twelfth legislature provided for the raising of twenty-two companies of soldiers for the protection of the frontier. These companies were stationed in the "Indian country," the Indians were moved to reservations, and conditions were gradually improved.

In 1877 Mineral Wells was settled by Judge J. A. Lynch.[7] The discovery of mineral water in his well led to the establishment of a tent colony which grew into a prosperous town.

The Texas and Pacific Railway was constructed across the southern part of the county in 1880, and the towns of Brazos, Santo, Mingus, and Strawn were laid out. From 1860 to 1880 the population[8] increased from 1524 to 5885. The first hotel in the county was opened up by S. S. Taylor at Palo Pinto about 1874. The first newspaper, the *Western Star*, was published in 1876 by J. C. Son, and the first bank was established by Cunningham Brothers in 1883. The first coal mine was opened up at Rock Creek, east of Mineral Wells, in the 80's. The Mineral Wells and Northwestern Railroad

[6]Taylor J. J., Report of an address by Carroll McConnell at Old Settler's Reunion at Palo Pinto: Dallas News, p. 9-I, Aug 25, 1933.

[7]Yeager, B. A., Some early history of the founding of Mineral Wells: *The Daily Index*, Mineral Wells, Texas p. 10 Jan. 30, 1929.

[8]U. S. Census reports for 1860 and 1880.

was built from Mineral Wells to Jacksboro in 1890. Oil was discovered near Strawn in 1909. A splendid paved highway was completed across the county in 1918. In 1921 Crazy Hotel, the leading resort hotel in north Texas, burned to the ground. It was soon replaced, however, by two of the finest hotels in the State, the new Crazy Hotel completed in 1928, and the Baker Hotel finished in 1930. The present population is 17,600.

The principal industries are cattle, sheep, and goat raising, farming, oil and gas production, coal mining, brick and tile manufacturing, cutting and marketing cedar posts, distribution of mineral water and mineral-water crystals, and in entertaining and housing large numbers of resort visitors who journey to the county each year to gain health from the medicinal waters and to enjoy the beautiful scenery afforded by the rock cliffs, winding streams, and "painted" trees.

STRATIGRAPHY[9]

Surface Section

MAJOR SUBDIVISIONS

The pre-Quaternary rocks exposed at the surface in Palo Pinto County belong to the Pennsylvanian system of the Paleozoic era. The strata are divided into formations on a basis of their lithologic character and arranged in natural stratigraphic succession, as follows:

---

[9]*Literature.*—Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey, Second Ann. Rept., pp. 521–531, 1891. Kennedy, William, Report of Palo Pinto County: MS. at Bureau of Economic Geology, pp. 1–110, 1916. Matteson, W. G., A review of the development in the new central Texas oil fields during 1918: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 173–175, 1919. Plummer, F. B., Preliminary paper on the stratigraphy of the Pennsylvanian formations of north-central Texas: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 140–150, 1919. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 1–237, 1921. Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas: Jour. Geol., vol. 30, pp. 18–12, 1922. Goldman, Marcus I., Lithologic subsurface correlation in the "Bend Series" of north-central Texas: U. S. Geol. Survey Prof. Paper 129, pp. 1–22, 1921. Dobbin, C. E., Geology of the Wiles area, Ranger District, Texas: U. S. Geol. Survey Bull. 736, pp. 55–69, 1922. Cheney, M. G., Stratigraphic and structural studies in north-central Texas: Univ. Texas Bull. 2913, pp. 1–28, 1929, Scott, Gayle, and Armstrong, J. M., The geology of Wise County, Texas: Bull. 3224, pp. 1–77, 1933. Scott, Gayle, and Armstrong, J. M., The geology of Parker County, Texas: MS. submitted to Bureau of Economic Geology, Univ. Texas, 1933. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, vol. 1, pp. 55–144, 1933.

Cisco group—
  Graham formation
Canyon group—
  Caddo Creek formation
  Brad formation
  Graford formation
  Palo Pinto formation
Strawn group—
  Mineral Wells formation
  Garner formation
  Millsap Lake formation

The formations have been further subdivided into members, shown in the columnar section, Plate II, and are briefly described in the following paragraphs.

MILLSAP LAKE FORMATION[10]

Stratigraphy.—The Millsap Lake[11] formation outcrops in the extreme southeastern corner of Palo Pinto County southeast of a line drawn from Thurber on the southwest to Lake Mineral Wells on the northeast (Pl. II). It lies unconformably upon the Bend group of strata and is overlain unconformably by the Thurber coal or equivalent strata.

The formation in Parker County has been divided by Scott and Armstrong[12] into three members, and to the limestones of the middle member (Lazy Bend) they have assigned the names given in the following list. The limestones of their upper member (Grindstone Creek) are named for the first time in this report.

3. *Grindstone Creek member.* All the strata from the top of the Brannon Bridge limestone upward to the base of the Thurber coal. Scott and Armstrong have designated as their type locality the area west of Grindstone Creek in southwestern Parker County.

---

[10]*Literature.*—Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., p. 381. 1890. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 19–74, 1922. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, pp. 107–108, 1933.

[11]*Definition.*—The formation was named by Scott and Armstrong (Geology of Parker County, MS.) to replace the old name Millsap by Cummins no longer recognized by the Committee on Geological Nomenclature, U. S. Geological Survey, since the old name is in good usage to designate a Mississippian formation in Colorado. Millsap Lake includes all the strata from the top of the Smithwick shale upward to the base of the Thurber coal. Where the coal is not present, the upper boundary is drawn at the top of the Goen limestone.

[12]Scott, Gayle and Armstrong, J. M., Geology of Parker County: MS., submitted to Bureau of Economic Geology, 1933.

b. Goen limestone. This name is here given to the limestone that caps the knolls around Goen Cemetery and is especially well seen on the north side of the Millsap-Brazos road 0.5 of a mile by road northeast of Goen Cemetery entrance. (Locality 181–T–6.) This limestone is designated as Si on the geologic map, Pl. II.

a. Santo limestone. This bed is typically exposed along the creek 0.4 of a mile by road south of the railroad crossing in Santo and is designated as Sj on the geologic map, Pl. II.

2. *Lazy Bend member*. This series of shales, sandstones, and limestones between the base of the Kickapoo Falls limestone upward to the top of the Brannon Bridge limestone are identified by Scott and Armstrong, who have the sequence exposed along Brazos River and its tributaries in the vicinity of Lazy Bend of Brazos River, but only the uppermost strata occur in Palo Pinto County. The following limestones have been named by Scott and Armstrong.

d. Brannon Bridge limestones. Three prominent limestones separated by 10-foot breaks of shale and some sand outcrop in the vicinity of Brannon Bridge on the Brazos about six miles south-southwest of Millsap in Parker County. The upper two (Sl and Sm on Pl. II) have been mapped across the southeastern corner of Palo Pinto County.

c. Meek Bend limestone. This 20-foot bed is typically exposed in Parker County near Meek Bend of the Brazos.

b. Dennis Bridge limestone. This 10-foot bed lies at the base of the section conspicuously exposed on the Brazos at the south end of the bridge at Dennis, Parker County.

a. Kickapoo Falls limestone. This bed was named by Plummer and Moore for the prominent exposures at Kickapoo Falls on Kickapoo Creek in the northern edge of Hood County.

1. *Dickerson member*. This division is made to include all Pennsylvanian strata exposed in Brazos River Valley below the base of the Kickapoo Falls limestone.

The total thickness of the Millsap Lake formation exposed at the surface in Palo Pinto County is about 600 feet. This includes the Grindstone Creek member and the upper part of the Lazy Bend member.

The succession of strata found in the Millsap Lake formation in Palo Pinto County is described in the following sections:

Section of the upper part of the Millsap Lake formation 3 miles west of Brazos measured southeastward from the top of the south-facing bluff north of the prominent bend in the Brazos-Santo road.

	Thickness *Feet*
6. Sandstone, dark gray, calcareous, coarse grained, ripple marked in places	1
5. Shale, gray, sandy in places, grading into soft, cross-bedded sand	24
4. *Goen limestone.* Limestone, yellow, soft, exceedingly fossiliferous, in places almost a coquina of shell fragments; contains minute bryozoa, corals, gastropods, sponges, crinoids, Spirifers, and a few small fusulinids identified as *Fusulina haworthi* (Beede)	1
3. Shale, sandy, light gray, calcareous, soft	50
2. *Santo limestone.* Limestone, blue, weathering to lemon-yellow, containing a few crinoid fragments; other fossils rare	1¾
1. Clay, light gray, covered	75?

Section measured one-quarter of a mile south of Southwestern Bell Telephone Santo Repeater Station, and 3.6 miles south-southeast of Santo.

	Thickness *Feet*
2. Sandstone, brownish gray, coarse grained, cross bedded	2
1. Clay, light gray, compact, free of sand or grit	30+

Section of the Millsap Lake formation measured 1.8 miles northwest of Live Oak School.

	Thickness *Feet*
5. Shale, gray, sandy, thin bedded	50
4. *Brannon Bridge limestone.* Limestone, blue, hard, having yellow and ochre-colored blotches of iron oxide and containing calcite veins, fragments of crinoids, and algae	1
3. Marl, gray, sandy, grading into pink and green variegated marl	25
2. Limestone, dark blue, hard, rough surfaced, thinly laminated, having very uneven bedding lines and weathering into small chips of hard, brittle limestone	8–10
1. Marl, gray, soft, sandy	22
Total section measured	106–108

Noteworthy features.—The most noteworthy features of the Millsap Lake formation in Palo Pinto County are: (1) a zone containing large spheroidal nodules made up of masses of the coral *Chae-*

tetes milleporaceus(?) Milne-Edwards and Haime; (2) soft, yellow, and richly fossiliferous marls containing a large variety of beautifully sculptured and turreted gastropods; (3) thick beds of thinly laminated, carbonaceous, siliceous, black shale used for making brick at Bennetts (Parker County); (4) evenly bedded, calcareous, platy, friable sandstone layers that furnish an excellent field stone for constructing walls and buildings.

The coral *Chaetetes milleporaceus* is well exposed on the north side of the Millsap-Brazos road five and one-quarter miles southwest of Millsap and 0.3 of a mile by road northeast of Goen cemetery. A section measured at this locality is as follows:

Measured section of the upper part of the Millsap Lake formation on the Millsap-Brazos road 0.5 of a mile by road northeast of Goen cemetery.

	Thickness *Feet*
7. Sandstone, light gray, weathering buff or brown, fine grained, thinly and evenly bedded	1
6. Marl, yellow, soft, poorly exposed	2
5. *Goen limestone.* Yellow, soft, impure limestone made up in some places of millions of minute, robust fusulinids, *Fusulina* cf. *F. euryteines* Thompson and showing on its under surface fucoid-like forms	4
4. Marl, greenish yellow, soft, poorly exposed, contains large nodules of *Chaetetes*	12
3. Limestone, grayish brown, made up largely of fossils and fossil fragments, rough surfaced	1
2. Sandstone, dark gray, weathering brownish, soft, friable, forming a gentle slope	5
1. Shale, gray, base unexposed	?
Total thickness of exposed section	25+

The corals occur at the top of bed No. 4 in the above section. The colonies are in the form of nodules 3 to 15 inches in diameter. Some of the nodules are spheroidal, others cup shaped, and all show plainly the cellular structure typical of the genus. The nodules are very numerous and in places form an almost continuous layer, from which they weather out in the form of concretions.

Paleontology and correlation.—The shales of the Millsap Lake formation are locally richly fossiliferous. Three especially noteworthy fossil zones are:

3. Shales between the Goen limestone and the Santo limestone, well exposed west of Brazos River about 300 feet west of the Millsap-Brazos road, 0.1 of a mile south of Goen Cemetery and about 5½ miles west of Millsap, in the extreme eastern part of Palo Pinto County.
2. Shales below the Sunday Creek coal, best exposed 2.8 miles southeast of Santo, on Santo-Patillo road.
1. Shales below the Kickapoo Falls limestone, best exposed south of Weatherford on the Stephenville road, in Hood County near the south line of Parker County.

The fossils that have been identified from these zones are presented in the following lists.

Fauna[13] *collected from the Dickerson shale member below Kickapoo Falls limestone 1.5 miles east of Lipan, Hood County; zone 1* (110-T-3).

Foraminifera—
- Wedekindella euthusepta (Henbest)
- Fusulina cf. F. haworthi (Beede)
- Fusulina, n. sp. A
- Fusulina, n. sp. B

Porifera—
- Fissispongia spinosa R. H. King n. sp. (MS.)
- Wewokella solida Girty

Anthozoa—
- Campophyllum sp.
- Lophophyllum profundum (Milne-Edwards and Haime)

Crinoidea—
- Hydreionocrinus sp.
- Delocrinus hemisphaericus (Shumard)

Echinoidea—
- Echinocrinus aculeata (Shumard)
- Echinocrinus cf. E. cratis (White)

Annelida—
- Spirorbis sp.

Bryozoa—
- Fistulipora nodulifera Meek
- Tabulipora sp.
- Polypora spinulifera Ulrich
- Septopora sp.
- Fenestella sp.
- Rhombopora lepidodenroides Meek
- Rhombopora tabulata Ulrich
- Prismopora triangulata White

Brachiopoda—
- Derbya crassa (Meek and Hayden)
- Schuchertella pratteni (McChesney)
- Chonetina flemingi var. crassiradiata Dunbar and Condra
- Echinoconchus knighti Dunbar and Condra
- Dictyoclostus cf. D. hermosanus (Girty)
- Marginifera muricatina Dunbar and Condra
- Linoproductus cf. L. prattenianus (Norwood and Pratten)
- Isogramma millepunctata (Meek and Worthen)
- Neospirifer dunbari R. H. King
- Neospirifer cf. N. cameratus (Morton)
- Ambocoelia planoconvexa (Shumard)
- Punctospirifer kentuckyensis (Shumard)
- Hustedia mormoni (Marcou)
- Composita subtilita (Hall)
- Composita sp.

Pelecypoda—
- Nucula anodontoides Meek
- Nuculopsis ventricosa (Hall)
- Anthraconeilo taffiana Girty
- Leda bellistriata Stevens
- Yolda glabra Beede and Rogers
- Conocardium, n. sp.
- Myalina swallovi McChesney
- Myalina sp.
- Astartella concentrica (McChesney)
- Astartella varica McChesney

Scaphopoda—
- Dentalium sp.
- Plagioglypta meekiana (Geinitz)

[13]Identifications by R. H. King, George D. Harris, and the authors.

Gastropoda—
- Worthenia speciosa (Meek and Worthen)
- Phanerotrema grayvillense (Norwood and Pratten)
- Murchisonia sp.
- Bellerophon crassus Meek and Worthen
- Bellerophon sp.
- Euphemites sp.
- Pharkidonotus percarinatus (Conrad)
- Euomphalus catilloides (Conrad)
- Euomphalus, n. spp. (2)
- Pseudozygopleura scitula (Meek and Worthen)
- Pseudozygopleura, n. spp. (7)
- Macrochilina regularis (Cox)
- Macrochilina brevis (White)
- Macrochilina paludinaeformis (Hall)
- Naticopsis sp.
- Trachydomia cf. T. wheeleri Swallow
- Trachydomia, n. sp.

Cephalopoda—
- Orthoceras sp.
- Pseudorthoceras knoxense? McChesney
- Strawnoceras brazoense Plummer and Scott, n. gen., n. sp. (MS).

Fauna[14] *collected half a mile east of the Santo-Patillo road 3.2 miles by road south-southeast of Santo; zone 2* (181–T–88).

Foraminifera—
- Fusulina cf. F. euryteines Thompson
- Fusulina, n. sp.

Porifera—
- Wewokella solida Girty
- Fissispongia tortacloaca (R. H. King)

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime)
- Lophophyllum sp.
- Campophyllum torquium (Owen)
- Chaetetes sp.

Crinoidea—
- Pentacrinus sp.
- Ulocrinus sp.
- Delocrinus hemisphaericus? (Shumard)
- Delocrinus sp.
- Hydreionocrinus sp.

Echinoidea—
- Echinocrinus aculeata (Shumard)
- Echinocrinus sp.

Bryozoa—
- Rhombopora lepidodendroides Meek
- Rhombopora tabulata Ulrich
- Polypora spinulifera Ulrich
- Fistulipora nodulifera Meek
- Fistulipora sp.
- Fenestella sp.
- Prismopora triangulata (White)
- Septopora sp.

Brachiopoda—
- Lingula carbonaria Shumard
- Orbiculoidea capuliformis? (McChesney)
- Derbya crassa (Meek and Hayden)
- Chonetina crassiradiata Dunbar and Condra
- Mesolobus cf. M. inflexus (Girty)
- Echinoconchus knighti Dunbar and Condra
- Dictyoclostus hermosanus? (Girty)
- Marginifera muricatina Dunbar and Condra
- Linoproductus cf. L. prattenianus (Norwood and Pratten)
- Isogramma sp.
- Spirifer rockymontanus Marcou
- Neospirifer dunbari R. H. King
- Neospirifer cameratus (Morton)
- Neospirifer cf. N. cameratus (Morton)
- Ambocoelia planoconvexa (Shumard)
- Punctospirifer kentuckyensis (Shumard)
- Hustedia mormoni (Marcou)
- Cleiothyridina orbicularis (McChesney)
- Composita subtilita (Hall)
- Composita ovata Mather
- Composita sp.

Pelecypoda—
- Solenomya radiata (Meek and Worthen)
- Edmondia sp.
- Nucula anodontoides Meek
- Nucula, n. sp.

---

[14]Identifications by R. H. King, George D. Harris, and the authors.

- Nuculopsis ventricosa (Hall)
- Anthraconeilo taffiana Girty
- Yoldia glabra Beede and Rogers
- Pinna sp.
- Pinna, n. sp.
- Myalina subquadrata Shumard
- Myalina swallovi McChesney
- Myalina, n. sp.
- Schizodus sp.
- Conocardium sp.
- Aviculopecten occidentalis (Shumard)
- Aviculopecten sp.
- Allerisma subcuneatum Meek and Hayden
- Allerisma terminale Hall
- Allerisma sp.
- Pleurophorus tropidophorus? Meek
- Astartella varica McChesney
- Astartella, n. sp.

Scaphopoda—
- Dentalium sp.
- Plagioglypta meekiana (Geinitz)

Gastropoda—
- Yvania knighti? J. M. Weller
- Yvania subconstricta (Meek and Worthen)
- Yvania inclinata J. M. Weller
- Phanerotrema graysvillense (Norwood and Pratten)
- Worthenia speciosa (Meek and Worthen)
- Orestes nodosus Girty
- Trepospira illinoisensis (Worthen)
- Murchisonia sp.
- Pleurotomaria carbonaria Norwood and Pratten
- Pleurotomaria granulostriata Meek and Worthen
- Euconospira sp.
- Bellerophon crassus Meek and Worthen
- Bellerophon sp.
- Pharkidonotus percarinatus (Conrad)
- Pharkidonotus tricarinatus (Shumard)
- Bucanopsis meekianus (Swallow)
- Bucanopsis texiliformis (Gurley)
- Bucanopsis sp.
- Patellostium montfortianum (Norwood and Pratten)
- Patellostium sp.
- Euphemites nodocarinatus (Hall)
- Euphemites sp.
- Euomphalus, n. spp. (2)
- Euomphalus catilloides (Conrad)
- Donaldina, n. spp. (2)
- Pseudozygopleura scitula (Meek and Worthen)
- Psuedozygopleura semicostata (Meek)
- Pseudozygopleura, n. spp. (11)
- Macrochilina regularis (Cox)
- Macrochilina brevis (White)
- Macrochilina paludinaeformis (Hall)
- Naticopsis cf. N. meeki Knight
- Naticopsis sp.
- Naticopsis, n. sp.
- Trachydomia cf. T. nodosum (Meek and Worthen)
- Trachydomia, n. sp.
- Meekospira peracuta (Meek and Worthen)

Cephalopoda—
- Orthoceras sp.
- Pseudorthoceras knoxense (McChesney)

Trilobita—
- Griffithides scitulus? (Meek and Worthen)

Fauna[15] *of the shale exposure 5½ miles southwest of Millsap, 0.1 of a mile south of Goen Cemetery on the Brazos road; zone 3 of Millsap Lake formation* (181-T-5).

Foraminifera—
- Ammodiscus incertus (d'Orbigny)
- Deckerella laheei Cushman and Waters
- Cornuspira cf. C. involvens (Reuss)
- Earlandia perparva H. J. Plummer
- Endothyra paucilocnlata Cushman and Waters
- Endothyranella powersi (Harlton)
- Glyphostomella triloculina (Cushman and Waters)
- Globivalvulina biserialis Cushman and Waters
- Wedekindella euthusepta (Henbest)
- Fusulina haworthi (Beede)
- Fusulina cf. F. euryteines Thompson

---

[15] Smaller foraminifera identified by Helen Jeanne Plummer; the rest of the species identified by R. H. King, George D. Harris and the authors.

Porifera—
- Fissispongia tortacloaca (R. H. King)
- Wewokella solida Girty

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime)
- Campophyllum torquium (Owen)
- Campophyllum sp.

Bryozoa—
- Fistulipora nodulifera Meek
- Tabulipora sp.
- Polypora spinulifera Ulrich
- Rhombopora lepidodendroides Meek
- Rhombopora tabulata Ulrich
- Prismopora triangulata (White)

Brachipoda—
- Crania modesta White and St. John
- Derbya crassa (Meek and Hayden)
- Mesolobus inflexus (Girty)
- Echinoconchus knighti Dunbar and Condra
- Dictyoclostus hermosanus? (Girty)
- Marginifera muricatina Dunbar and Condra
- Isogramma millepunctata (Meek and Worthen)
- Squamularia perplexa (McChesney)
- Spirifer opimus Hall
- Spirifer rockymontanus Marcou
- Neospirifer dunbari R. H. King
- Punctospirifer kentuckyensis (Shumard)
- Hustedia mormoni (Marcou)

Pelecypoda—
- Nucula anodontoides Meek
- Nuculopsis ventricosa (Hall)
- Yoldia glabra Beede and Rogers
- Myalina recurvirostris Meek and Worthen
- Astartella concentrica (McChesney)

Gastropoda—
- Yvania scitula (Meek and Worthen)
- Yvania subconstricta (Meek and Worthen)
- Worthenia speciosa (Meek and Worthen)
- Pleurotomaria beckwithiana McChesney
- Pleurotomaria carbonaria Norwood and Pratten
- Pleurotomaria granulostriata (Meek and Worthen)
- Phanerotrema grayvillense (Norwood and Pratten)
- Orestes nodosus Girty
- Orestes, n. sp.
- Murchisonia sp.
- Bellerophon crassus Meek and Worthen
- Pharkidonotus percarinatus (Conrad)
- Bucanopsis kansasensis (Shumard)
- Bucanopsis meekianus (Swallow)
- Bucanopsis ourayensis (Gurley)
- Bucanopsis, n. sp.
- Patellostium montfortianum (Norwood and Pratten)
- Euphemites blaneyanus (McChesney)
- Euphemites nodocarinatus (Hall)
- Euomphalus sp.
- Euomphalus catilloides (Conrad)
- Donaldina, n. sp.
- Streptacis, n. spp. (2)
- Pseudozygopleura moorei Knight
- Pseudozygopleura multicostata (Meek and Worthen)
- Pseudozygopleura, n. spp.
- Pseudozygopleura obtusicacuminis Knight
- Pseudozygopleura scitula (Meek and Worthen)
- Hemizyga spp.
- Paleostylus, n. spp.
- Soleniscus typicus Meek and Worthen
- Macrochilina brevis (White)
- Macrochilina paludinaeformis (Hall)
- Macrochilina regularis (Cox)
- Cylindritopsis vaningeni Knight
- Meekospira choctawensis Girty
- Actaeonina minuta (Stevens)
- Yunnania subsinuata (Meek and Worthen)
- Rhabdotocochlis, n. sp.
- Araeonema virgatum Knight
- Angyomphalus moniliferus (White)

Cephalopoda—
- Orthoceras sp.
- Pseudorthoceras knoxense (McChesney)

The following fossiliferous localities in Palo Pinto County, and in Hood County just south of Palo Pinto County, furnish good collections:

110–T–2. Limestone at falls on Kickapoo Creek, 8.5 miles by road southwest of the bridge at Dennis and approximately a mile south of the Parker-Hood county line. Type locality for Kickapoo Falls limestone.

110–T–3. Shale in small creek 4.5 miles east of Lipan and 1 mile southeast of Kickapoo Falls on south side of Lipan-Dennis road, Hood County. Dickerson member.

181–T–5. Small shale exposure on west side of Millsap-Brazos road about 5½ miles in direct line southwest of Millsap and 0.1 of a mile south of Goen Cemetery, and about 2 miles east-northeast of Inspiration Point. Shale below Goen limestone. (Coördinates T-14, geologic map of Palo Pinto County.)

181–T–6. Limestone on north side of Millsap-Brazos road 0.5 of a mile by road northeast of Goen Cemetery. Goen limestone. (Coördinates T-13, geologic map of Palo Pinto County.)

181–T–88. Shale exposure 0.5 of a mile east of the Santo-Patillo road on secondary road that turns east at a point 2.7 miles by road south-southeast of the railroad crossing in Santo. Shale below Sunday Creek coal. (Coördinates O–20, geologic map of Palo Pinto County.)

GARNER FORMATION[16]

Stratigraphy.—The Garner formation[17] outcrops in an escarpment capped by the Brazos River sandstone and conglomerate. This 200-foot escarpment extends in a tortuous course from South Palo Pinto Creek, two miles southeast of Strawn, northeastward to the W. T. Malone Survey, five miles southeast of Mineral Wells. The escarpment is deeply incised by Brazos River and dissected by branch streams, so that it forms the rugged and picturesque topography of the Inspiration Point area (frontispiece, Pl. I). The Garner formation rests unconformably upon the Millsap Lake beds, is overlain by the Mineral Wells shales, and comprises the following members:

3. Brazos River sandstone (25′–75′).
2. Mingus shale (145′–210′).
1. Thurber coal (2′).

---

[16]*Literature.*—Bay, Harry X, A study of certain Pennsylvanian conglomerates of Texas: Univ. Texas Bull. 3201, pp. 119–188, 1932. Scott, Gayle, and Armstrong, J. M., The geology of Parker County: unpublished MS.

[17]*Definition.*—The Garner formation has been named by Scott and Armstrong (see preceding footnote) for all the strata in the Brazos River section from the base of the Thurber coal to the top of the Brazos River sandstone.

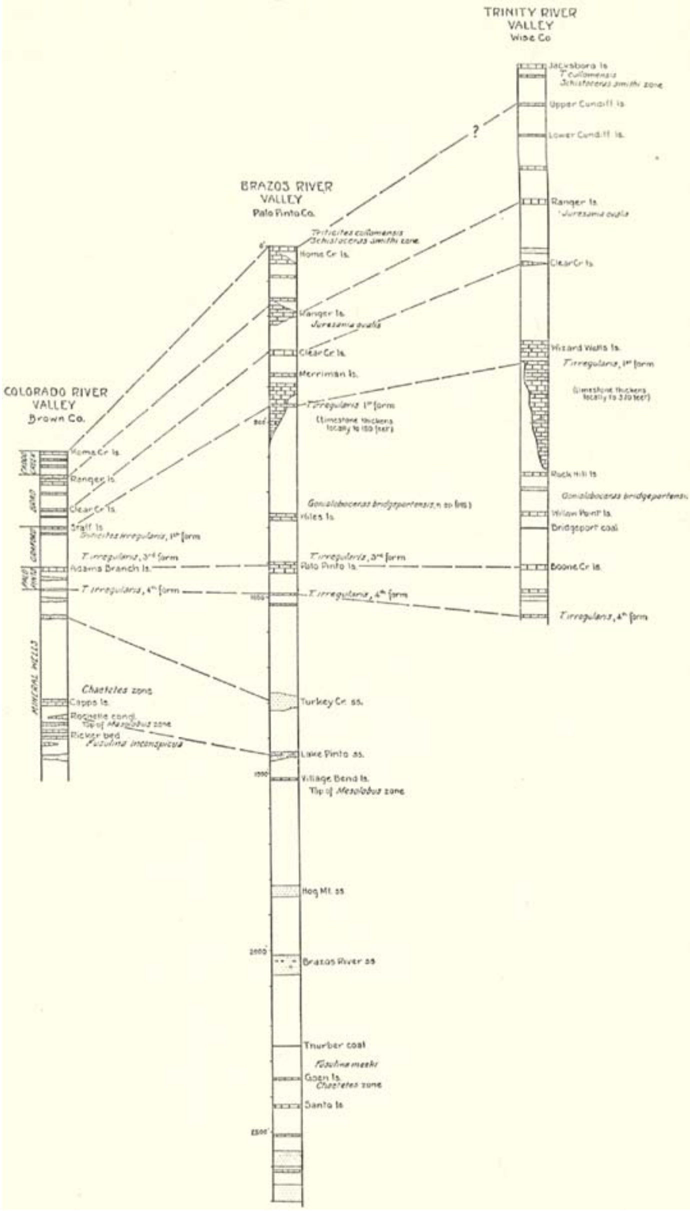


FIG. 2.—Columnar sections showing the correlations of Pennsylvanian strata in the Colorado, Brazos, and Trinity river valleys. Scale 1 inch = 550 feet.

The thickness of the Garner formation ranges from 195 feet in the southwest part of the county to 210 feet on the highway southeast of Minerals Wells.

Section of upper part of the Garner formation measured along Highway No. 1, 3 miles by road northwest of Millsap, just east of the Palo Pinto-Parker county line in the extreme western edge of Parker County (183–T–15).

	Thickness *Feet*
Brazos River sandstone—	
15. Sandstone, brown, soft, friable, cross-bedded, and ripple marked, forming slope	5
14. Conglomerate, reddish gray, made up of angular chert pebbles from ½ to ¾ of an inch in diameter, set in a matrix of finer pebbles and coarse quartz sand	3½
13. Sandstone, dark gray, containing pebbles of chert	2
12. Conglomerate, light gray, pebbles from ¼ to ½ inch in diameter; sand grains well rounded	5
11. Sandstone, dark gray, massive, coarse grained, containing pebbles of chert	2
10. Conglomerate, gray, containing dark, brick-red pebbles and also white pebbles largely of chert ranging in size from ⅛ of an inch to 1½ inches. All pebbles are subangular	5½
9. Sand, light gray, stained buff, fine grained, poorly bedded, calcareous	1¼
Mingus shale—	
8. Shale, gray, sandy, mostly covered by talus	10
7. Sandstone, gray, fine grained, calcareous, thinly bedded, having individual beds from ¼ to 1 inch in thickness; weathers to thin slabs having pitted surfaces	10
6. Shale, yellowish gray, sandy, containing near the top nodular concretions and a few fossils	2
5. Sandstone, gray, thin bedded, made up of slabs from 1 to 3 inches thick	4
4. Sandstone, yellowish gray, calcareous, thin bedded, individual beds from 1 to 3 inches in thickness, grading upward into thicker beds having a maximum thickness of 14 inches	19
3. Shale, gray, sandy, covered by talus	7
2. Shale, gray, sandy, containing streaks of carbonaceous matter and fragments of plant remains	18
1. Shale, bluish gray, very fine grained, unfossiliferous, weathers to fine chips and contains a few small, hard, buff-colored limonitic concretions	29+
Total thickness of measured section	123¼+

Section of the upper part of the Garner formation measured north of Brazos River along the Mineral Wells-Brazos road from Inspiration Point southeastward down the slope.

	Thickness *Feet*
Brazos River sandstone—	
4. Sandstone, reddish gray, medium grained, containing scattered pebbles of chert	9
3. Conglomerate, gray pebbles set in a matrix of sand, about half sand and half gravel	36
2. Sandstone, reddish gray, friable, cross-bedded, containing lentils of cross-bedded gravel; bedding lines dip at high angles	8
Mingus shale—	
1. Shale, bluish gray, soft, largely covered by talus	50+
Total thickness of measured section	103+

The Garner formation is a shallow-water, partly marine, partly fluviatile, and partly lacustrine deposit. The coal plants that produced the Thurber coal evidently grew along a low marshy sea coast. They were buried beneath marine sediments and nonmarine or brackish-water clays (Mingus shale member). The clays were covered later by a broad alluvial apron of gravel and sand (Brazos River sandstone member). The sand is thought to have been derived from an ancient mountain range situated in the vicinity of the Balcones fault zone, to have been transported westward from 80 to 100 miles, and to have spread out over a flat and gently inclined coastal plain by anastomosing streams (fig. 3). Westward beneath the surface the sand merges into marine sediments.

The formation is readily distinguished by the heavy conglomerate beds at the top, the coal layers at its base, and by the thick beds of slightly fossiliferous, siliceous shale.

Noteworthy features.—The Brazos River sandstone and conglomerate beds at the top of the section and the lentils of workable coal at the base are distinctive features of the Garner formation. The conglomerate beds have been described in detail by Bay.[18] The sandstone consists of a broad lentil or sheet of medium-grained and

[18]Bay, Harry X. A study of certain Pennsylvanian conglomerates of Texas: Univ. of Texas Bull. 3201, pp. 149-188, 1933.

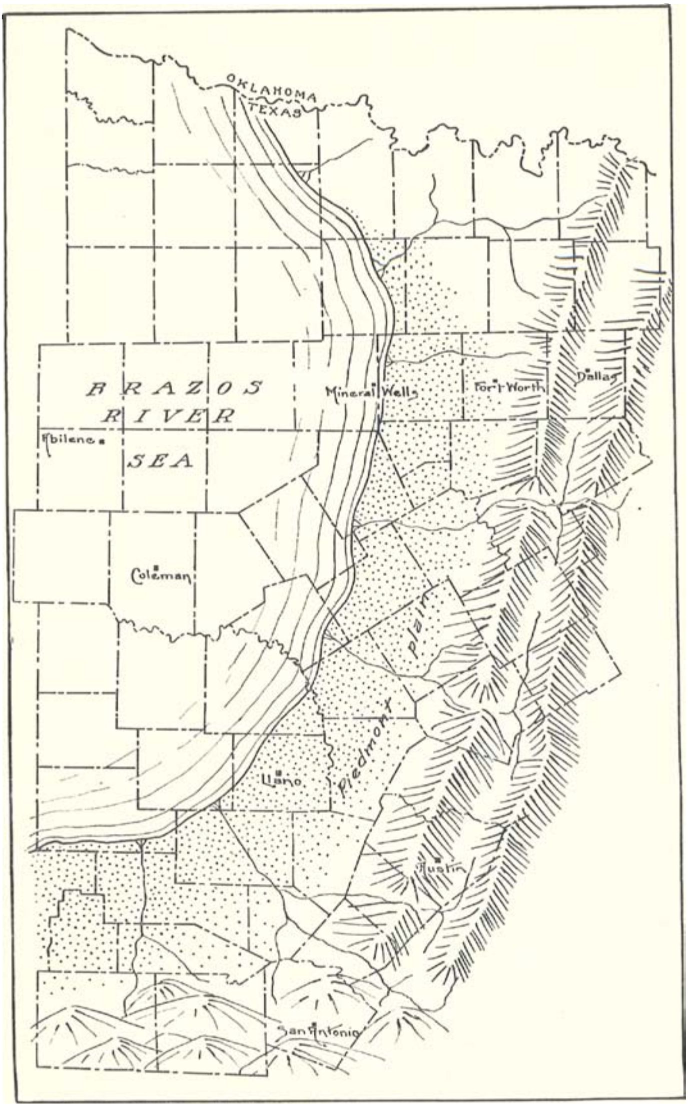


FIG. 3. Diagrammatic illustration of the conditions of deposition of the Brazos River sandstone. Streams transported sand and gravel from uplands to the east, spread this material broadly over a nearly flat coastal plain, and deposited their load, producing a broad, alluvial apron, which was thickest in the vicinity of Mineral Wells.

coarse, clastic material from 80 to 100 feet thick in its thickest portion in the vicinity of the high bluffs along Brazos River. The member along its outcrop east of Mineral Wells is made up of two thick layers of sand separated by a clay member. The upper layer consists of soft friable cross-bedded sand, carrying mineral water at the top, and coarse, hard, more or less consolidated conglomerate at the bottom. The lower layer is a thin, more evenly bedded, finer grained, calcareous sandstone containing fresh water. A screen analysis of the lower sand is as follows:

Screen analysis[19] *of the Brazos River sand collected along the Millsap-Palo Pinto road* (183–T–15).

Size in mm. On	Through	Weight in grams	Per cent
0.42	0.84	.10	.028
0.250	0.42	151.70	43.34
0.177	0.250	146.50	41.86
0.149	0.177	13.20	3.77
0.125	0.149	19.00	5.43
0.074	0.125	12.40	3.54
pan	0.074	3.70	1.057

The sandstone beds thin southwestward to 14 feet in the vicinity of Strawn and Thurber and northeastward to 25 feet in the southern part of Wise County, where they are penetrated by drill holes. The member thins northwestward as it passes beneath the overlying strata and changes from a fluviatile to a marine facies. In outcrop the upper layers consist of thick-bedded, coarse-grained, reddish-buff, ripple-marked, and cross-bedded sand. The middle portion is more massively bedded and consists of layers, lentils, and pockets of conglomerate interbedded with sandstone. The lower portion is a finer grained, thinly bedded, marine, calcareous sandstone containing in many places fragments of marine fossils.

The conglomerate consists largely of variegated, subangular, and angular chert pebbles, which range in color from gray to yellow to white, with small numbers in shades of red, green, and black. Some of the pebbles are beautifully banded with green or black and gray bands. The size ranges from 4 to 60 millimeters or even larger. The largest number lie between 4 and 16 millimeters in diameter. The matrix consists of rounded and subrounded quartz

[19]Analysis by T. H. Shelby, Jr.

and chert grains with the quartz predominating. In most localities the formation contains no recognizable fossils. Remnants of plants and balls of clay or cavities in which clay has been replaced partially or wholly by limonite are common. In one locality northwest of Brazos marine fossils have been found in the sand matrix. The strata at this locality show beach bedding and a thinning of the conglomerate member. It is evident, as pointed out by Bay,[20] that the Brazos River member is in part at least of fluviatile origin and that it grades westward into beach and marine deposits.

Paleontology.—The Garner formation is the least fossiliferous of any major geologic division in the county. Most of the strata are land deposits laid down near a coast. Certain thin layers carry marine fossils, as follows:

1. Calcareous sandstone at base of the Brazos River member on the Mineral Wells-Millsap highway about 3 miles by road northwest of Millsap and also along a farm road crossing the escarpment 1¾ miles west of Brazos.
2. Thin calcareous sandstone in the Mingus shale in the old Thurber Brick Company pit at Thurber and in an outcrop of clay above the coal in Dry Creek in western Parker County, due east of Mineral Wells.
3. Thin calcareous sandstone or impure limestone overlying the coal in the Strawn Coal Company mines northeast of Strawn and in the old mine shafts at Coalville.

Fauna[21] of the Garner formation.

Foraminifera—
- Ammobaculites sp.
- Ammodiscus incertus (d'Orbigny)
- Hyperammina sp.
- Hyperamminoides minuta (Cushman and Waters)
- Proteonina sp.
- Reophax arenata (Cushman and Waters)
- Spiroplectammina exrayensis (Cushman and Waters)

Brachiopoda—
- Ambocoelia planoconvexa (Shumard)
- Composita subtilita (Hall)
- Linoproductus sp.
- Neospirifer sp.
- Spirifer sp.

Pelecypoda—
- Allerisma subcuneatum Meek and Hayden

Gastropoda—
- Pleurotomaria carbonaria Norwood and Pratten

[20]Bay, Harry X, *op. cit.*, pp. 165–166.

[21]The foraminifera have been identified by Helen Jeanne Plummer, the remaining species by R. H. King and the authors.

The following fossil localities in the Garner formation in Erath and western Parker counties are noteworthy:

72–T–2. Thin sandy limestone lentil in the old clay pit of the Thurber Brick Co., southeast edge of Thurber, Erath County.

183–T–14. Westward-facing bluff of a small south-flowing branch of Dry Creek south of the Mineral Wells-Garner highway and about 1½ miles southeast of Lake Mineral Wells, about 1¾ miles east of the Palo Pinto-Parker county line.

183–T–15. Steep, southeastward-facing escarpment on Mineral Wells-Millsap highway, 3 miles by road northwest of Millsap in the west edge of Parker County. Poorly preserved fossils are present in a calcareous sandstone about halfway up the slope.

MINERAL WELLS FORMATION[22]

Stratigraphy.—The Mineral Wells formation[23] outcrops in a broad belt across the central part of the county. Its northwestern boundary, which is marked by the escarpment of the Palo Pinto limestone, is deeply indented by Brazos River and its branches, so that its outcrop in the vicinity of the streams makes a very dendritic pattern on the map (Pl. II). It rests unconformably upon the Brazos River sandstone and is overlain conformably by the Palo Pinto limestone. The formation is about 400 feet thick in the southwestern part of the county. It increases in thickness toward the northeast, so that northeast of Mineral Wells it reaches a thickness of 750 to 800 feet.

The Mineral Wells formation has been divided into the following members:

5. Keechi Creek shale. Gray, fossiliferous calcareous shale containing several thin layers of limestone and at least one lentil of sand. It is bounded at the top by the Palo Pinto limestone and at the base by the Turkey Creek sandstone.
4. Turkey Creek sandstone. Coarse-grained, cross-bedded, and massive, reddish-buff sandstone and conglomerate lying between the Keechi Creek and Salesville shales.

---

[22]*Literature.*—Bay, Harry X. A study of certain Pennsylvanian conglomerates of Texas: Univ. Texas Bull. 3201, pp. 166-173, 1932. Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey, Second Ann. Rept., p. 522, 1891. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 74-86, 1921. Scott, Gayle, and Armstrong, J. M., The geology of Wise County, Texas. Univ. Texas Bull. 3224 pp. 14–19, 1932; The geology of Parker County, unpublished MS., 1933.

[23]*Definition.*—The formation was named by Plummer and Moore (see preceding footnote). It was later redefined and restricted by Scott and Armstrong (unpublished MS.) and by Sellards (Univ. Texas Bull. 3232, pp. 108–109, 1933) to include the strata from the top of the Brazos River sandstone upward to the base of the Palo Pinto limestone.

3. Salesville shale. Gray, calcareous, sandy shale containing several lentils of sandstone and near its base a thin stratum of impure sandy limestone. This member extends from the top of the Lake Pinto sandstone upward to the base of the Turkey Creek sandstone.
2. Lake Pinto sandstone. Coarse-grained and cross-bedded sandstone lying between the Salesville and East Mountain shales. The type locality comprises the exposures at the tops of the bluffs around Lake Pinto west of Mineral Wells.
1. East Mountain shale. Gray and black, calcareous and siliceous shale containing in its upper portion the Village Bend limestone and near its base the Hog Mountain sandstone lentil. The type locality for this member is the extensive exposure on the south end of East Mountain in Mineral Wells.
   - b. Village Bend limestone. A grayish-buff, impure, hard, fossiliferous limestone from 6 inches to 4 feet thick occurring near the top of the East Mountain shale member. The type locality is the exposure near the west end of Village Bend of Brazos River, 2¾ miles in direct line southeast of Palo Pinto.
   - a. Hog Mountain sandstone lentil. A reddish-buff, medium-grained, thick-bedded sandstone lying in the lower portion of the East Mountain shale and typically exposed on the top of Hog Mountain three miles southeast of Mineral Wells.

Section of the Mineral Wells formation measured along the Palo Pinto-Santo road from a point 2 miles south to a point 4 miles south of Palo Pinto.

	Thickness *Feet*
Palo Pinto limestone—	
25. Limestone, grayish white, in places buff, smooth surfaced	1½
24. Shale, yellowish gray, poorly exposed	10
23. Limestone, light gray, thin bedded, having wavy bedding lines and weathering to small chips and slabs	10–25
Keechi Creek shale—	
22. Shale or marl, yellowish gray, contains layer or lentil of yellowish-gray, soft, calcareous sandstone	60½
21. Sandstone, reddish brown, soft, friable, weathers to form a gentle slope	4
20. Shale, gray, sandy, mostly covered	25
Turkey Creek sandstone—	
19. Sandstone, reddish brown, coarse-grained, containing numerous chert pebbles	10½

	Thickness *Feet*
18. Sandstone, yellowish gray, soft, poorly bedded, coarse grained, containing especially in upper 5 feet, chert pebbles that constitute a conglomerate	16
Salesville shale—	
17. Shale, sandy, thin bedded, containing lentils of sand. The shale and sand are in about equal proportions	24
16. Shale, light gray, changing to reddish purple in places, sandy, containing thin beds of fine-grained, calcareous sandstone	24
15. Marl, greenish black, containing nodules and concretions of yellow limonite, grades upward into more sandy and lighter colored beds	56
Lake Pinto sandstone—	
14. Sandstone, light gray, fine grained, ripple marked, and interbedded with thin beds of sandy shale. The sandstone beds are from ½ inch to 8 inches thick and are finely cross-bedded	7
13. Sandstone, yellowish gray, fine grained, calcareous, well laminated. The beds range in thickness from 2 to 12 inches	4½
12. Shale, yellowish gray, sandy	3
11. Sandstone, yellowish gray, fine grained, very calcareous	6
East Mountain shale—	
10. Shale, gray, soft, sandy, covered in most places by talus	48
9. Limestone, light gray, hard, thin and unevenly bedded, fossiliferous	3
8. Shale, grayish blue, soft, very thinly laminated, fossiliferous, contains *Chonetes*, *Ambocoelia*, *Marginifera*, *Composita*, etc.	9
7. Village Bend limestone—	
c. Limestone, yellowish gray, hard, massively bedded	1¾
b. Shale, yellowish gray, sandy, highly calcareous, grades in places to shaly limestone	6
a. Limestone, yellowish buff, sandy, hard, fossiliferous, breaks into 1-foot blocks	2
6. Clay, variegated, colors ranging from red to purple and yellow, soft, poorly laminated	28½
5. Sandstone, hard, fine grained, very calcareous in places, resembles an impure limestone	2
4. Shale, bluish green, soft, thinly laminated, fossiliferous, contains *Bellerophon*, *Orthoceras*, crinoids, etc., and numerous limonite concretions	15
3. Limestone, impure, fossiliferous, contains bryozoans, crinoids, etc.	¼

	Thickness *Feet*
2. Shale, light buff gray, sandy, grading upward into fine-grained, thin-bedded, soft, very calcareous, and fossiliferous sand	5
1. Limestone, light gray, hard, breaks with uneven fracture and contains numerous fossils	8
Total thickness measured	390–405

Section of the Mineral Wells formation at the northwest end of Village Bend of Brazos River, southeast of Palo Pinto.

	Thickness *Feet*
Lake Pinto sandstone—	
10. Sandstone, grayish yellow, thin bedded, very friable	5
9. Sandstone, grayish yellow, hard, calcareous, well cemented, projecting ledge at top of cliff	3
8. Sandstone, light grayish yellow, soft, uniformly bedded, contains few fossils	8
East Mountain shale—	
7. *Village Bend limestone*. Limestone, white on surface, blue where fresh, exceedingly hard at top, a limestone breccia of coral fragments *(Campophyllum, Zaphrentis, Syringopora), Tetrataxis, Glyphostomella*, etc. This is a typical coral reef and at the base is a dense, hard limestone	6
6. Marl, white, soft, contains beautiful very large *Campophyllum* corals, huge crinoid stems, *Composita*, etc. This bed weathers into small cobbles. In places it is hard and merges into the overlying bed	4
5. Shale, black, fine, soft, fossils very scarce and thin shelled, one fish tooth found	15
4. Sandstone, reddish buff, medium grained, mottled, with stains of iron oxide, not well bedded	2½
3. Shale, yellow, gray, very sandy, soft	5
2. Sandstone, light yellowish gray, fine grained, thin bedded, finely cross bedded (wind), at base has partings of sandy shale. Surface shows mud cracks, fucoid markings	2½
1. Shale, soft, very sandy, covered by talus from upper members	50+
Total thickness measured	101+

Noteworthy features.—Noteworthy features of the Mineral Wells formation are the coarse-grained, cross-bedded sandstone lentils and the peculiar coral-bearing Village Bend limestone. The Turkey

Creek sandstone is a coarse-grained, widespread sandstone and conglomerate resembling closely the Brazos River sandstone. It consists of lentils of conglomerate interbedded with massive, thin, red, reddish-brown, and buff beds of coarse to medium-grained sandstone. According to Bay[24] the material in the conglomerate lentil is largely siliceous and comprises chert, siliceous clay, quartzite, and quartz pebbles set in a matrix composed largely of quartz and some angular chert fragments. White pebbles predominate and make up about 79 per cent of the whole number. Gray pebbles include about 15 per cent of the whole, and yellow, red, black, and green comprise the rest. The shape of the pebbles, as described by Bay,[25] are as follows: 85 per cent are angular and subangular and range in size from 0.1 mm. or less to 32 mm. About 60 per cent of the pebbles of an average sample range between 1 and 8 mm.; 12 per cent are coarser, and 28 per cent are finer. The porosity of the rock, according to Bay, ranges between 5 and 17.2 per cent with an average of 14.6 per cent.

A screen analysis of the sand from this member is as follows:

Screen analysis[26] of Turkey Creek sandstone collected along the Palo Pinto-Mineral Wells road 3 miles east of Palo Pinto.

Screen size in mm. On	Through	Weight in grams	Per cent
0.42	0.84	1.6	.32
0.250	0.42	100.32	20.06
0.177	0.250	158.40	31.68
0.149	0.177	30.80	6.16
0.125	0.149	81.00	16.20
0.074	0.125	78.10	15.62

The Brazos River member constitutes a valuable water sand in the area northwest of the outcrop where it can be reached at a shallow depth.

The Lake Pinto sandstone is somewhat finer grained, more calcareous, and less persistent than the Brazos River sandstone, and it can be distinguished by its more even bedding in its upper portion. The upper ten feet consist of thin beds of fine yellowish-gray sand.

---

[24]Bay, Harry X, A study of certain Pennsylvanian conglomerates of Texas: Univ. Texas Bull. 3201, p. 167, 1932.

[25]*Idem*, p. 168.

[26]Analysis by T. H. Shelby, Jr.

In many places the layers of sandstone alternate regularly with thin beds of yellow siliceous clay, giving the upper portion of the outcrop a characteristic banded appearance. A screen analysis of the Lake Pinto sandstone is as follows:

Screen analysis[27] *of Lake Pinto sandstone collected on north side of Mineral Wells-Palo Pinto highway 2 miles west of Mineral Wells.*

Screen size in mm. On	Through	Weight in grams	Per cent
0.250	0.42	108.50	21.70
0.177	0.250	207.30	41.40
0.149	0.177	48.40	9.68
0.125	0.149	68.20	13.64
0.074	0.125	34.10	6.80
----	0.074	33.40	6.68

The Village Bend limestone is in many ways the most remarkable and interesting stratum in the county. At Mineral Wells it consists of a hard, dark-blue rock weathering to grayish buff or straw color. In the clay pit east of town it is less than 1 foot thick. At Lake Pinto it is from three to four feet thick and contains in places fragments or cobbles of yellowish, impure limestone, which resemble pieces of limonitic clay. At Village Bend it is six feet thick and is very hard, and its upper portion is made up of an agglomerate of broken corals and coral fragments. West of Lone Camp it is fully 14 feet thick, well bedded, and resembles closely the Palo Pinto limestone. Nearly everywhere its upper surface is covered by fossils. Many of the shells are so covered by incrustations of crystalline calcium carbonate that they are hardly recognizable. The limestone layer appears to have originated in shallow water and to have been deposited by lime-secreting organisms. Its surface supported a rich coral and brachiopod life and was in places wave washed, eroded, and broken by action of waves or other processes before the overlying shale was deposited.

The Hog Mountain sandstone resembles the Brazos River sandstone. It is, however, thinner, less persistent, and somewhat finer grained. It is impregnated in places by sulphates and carries mineral water high in sulphates.

---

[27] Analyses by T. H. Shelby, Jr.

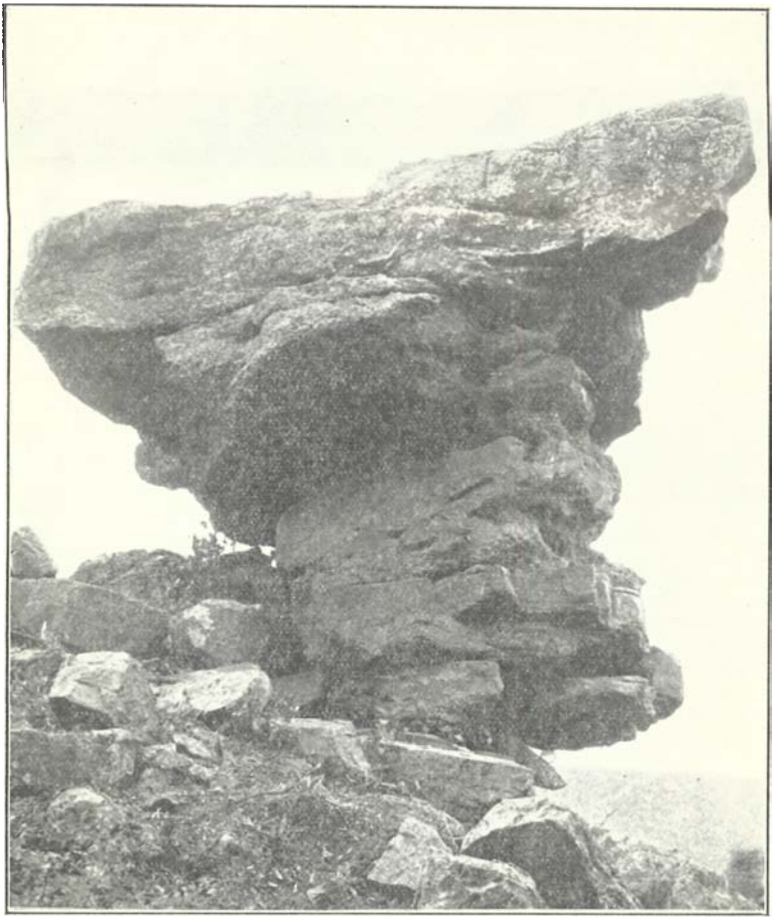


FIG. 4. Lake Pinto sandstone on East Mountain, Mineral Wells, showing conglomerate bed at top grading downward into coarse-grained sandstone. (Photo by J. L. Young Studio, Mineral Wells.)

Paleontology and correlation.—Five noteworthy fossil zones occur in the Mineral Wells formation as follows:

Zone 5. Keechi Creek shale from 60 to 90 feet below the base of the Palo Pinto limestone.

Zone 4. Salesville shale about 20 feet below the base of the Turkey Creek sandstone and just above a thin limestone member.

Zone 3. East Mountain shale about 20 feet below the Lake Pinto sandstone and just above the Village Bend limestone.

Zone 2. East Mountain shale about 30 feet below the Village Bend limestone.

Zone 1. East Mountain shale near its base and about 100 feet below the Village Bend limestone.

Lists of fossils collected from these zones are presented below.

Fauna[28] *of the East Mountain shale in the vicinity of Mineral Wells.*

Foraminifera—
- Ammobaculites stenomeca Cushman and Waters
- Ammodiscus incertus (d'Orbigny)
- Apterrinella grahamensis (Harlton)
- Cornuspira cf. C. involvens (Reuss)
- Endothyra pauciloculata (Cushman and Waters
- Endothyranella powersi (Harlton)
- Globivalvulina biserialis Cushman and Waters
- Glyphostomella triloculina (Cushman and Waters)
- Hemigordius liratus Cushman and Waters
- Hyperammina glabra Cushman and Waters
- Orthovertella protea Cushman and Waters
- Orthovertella sellardsi Plummer
- Rectocornuspira calcarina (Waters)
- Rectocornuspira holdenvillana? Warthin
- Reophax arenata (Cushman and Waters)
- Spiroplectammina clavata Cushman and Waters
- Tetrataxis corona Cushman and Waters
- Textularia fuscalignensis Cushman and Waters

Porifera—
- Fissispongia tortacloaca (R. H. King), *e*
- Wewokella solida Girty, *d*

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime), *b*
- Lophophyllum profundum var. radiosa Girty, *b*
- Michelinia eugeneae White, *a*

Crinoidea—
- Delocrinus hemisphaericus (Shumard), *b*
- Crinoid stems and plates, *a, b, c*

Annelida—
- Conularia cristula White

Brachiopoda—
- Lindstroemella patula (Girty), *e*
- Derbya crassa (Meek and Hayden), *b, c, d, e*
- Derbya bennetti? Hall and Clarke, *b*
- Derbya sp., *c*
- Chonetes fragilis R. H. King, n. sp. (MS.), *e*
- Mesolobus mesolobus (Norwood and Pratten), *e*
- Mesolobus mesolobus var. euampygus (Girty), *c, e*
- Juresania nebrascensis (Owen), *b, c, e*
- Dictyoclostus portlockianus (Norwood and Pratten), *e*
- Marginifera splendens (Norwood and Pratten), *c*
- Linoproductus inornatus R. H. King n. sp. (MS.), *e*
- Cancrinella boonensis (Swallow), *e*
- Squamularia perplexa (McChesney), *c, e*
- Neospirifer dunbari R. H. King, *c*
- Ambocoelia planoconvexa (Shumard), *b, c, d, e*
- Punctospirifer kentuckyensis (Shumard), *b, e*
- Hustedia acuticosta Newell, *e*
- Cleiothyridina orbicularis (McChesney), *b, c, e*
- Composita subtilita (Hall), *b, c, d, e*

Pelecypoda—
- Nucula anodontoides Meek, *c*
- Anthraconeilo taffiana Girty, *b*
- Nuculopsis ventricosa (Hall), *a, b, c*
- Leda arata (Hall), *b, c, e*
- Yoldia glabra Beede and Rogers, *b, e*
- Astartella concentrica (McChesney), *b*

---

[28]The foraminifera have been identified by Helen Jeanne Plummer, and the rest by R. H. King and the authors.

Astartella varica McChesney, *b*
Gastropoda—
  Phanerotrema grayvillense (Norwood and Pratten), *b, e*
  Orestes brazoensis (Shumard), *b, c, e*
  Orestes nodosus Girty, *a, b*
  Trepospira illinoisensis (Worthen), *b, c, e*
  Murchisonia sp., *b*
  Pleurotomaria beckwithiana McChesney, *b*
  Pleurotomaria carbonaria Norwood and Pratten, *b*
  Pharkidonotus percarinatus (Conrad), *b, c, e*
  Bucanopsis meekiana (Swallow), *b*
  Patellostium montfortianum (Norwood and Pratten), *b, e*
  Euphemites blaneyanus (McChesney), *b*
  Euphemites sp., *b*
  Euomphalus catilloides (Conrad), *b, d, e*
  Donaldina stevensana (Meek and Worthen), *b*
  Psuedozygopleura sp., *b*
  Pseudozygopleura cf. P. nana (Girty), *a, b*
  Macrochilina paludinaeformis (Hall), *b*
  Meekospira choctawensis Girty, *b, e*
Cephalopoda—
  Metacoceras sp., *b*
  Pseudorthoceras knoxense (McChesney), *b*

Localities represented above—

a, 181–T–91, Calcareous shale above Village Bend limestone at 5th Ave. and NE. 1st St., Mineral Wells.
b, 181–T–84, South end of SW. 7th Ave., Mineral Wells.
c, 181–T–83, North end of Lake Pinto just east of small bridge over creek.
d, 181–T–19, West end of dam, Lake Pinto, west of Mineral Wells.
e, 181–T–9, Old shale excavation in east edge of Mineral Wells.

Ostracoda[29] *of the East Mountain shale in the vicinity of Mineral Wells.*

Paraparchites thomasi Coryell and Sample
Paraparchites palopintoensis Coryell and Sample
Paraparchites brazoensis Coryell and Sample
Paraparchites latidorsatus Warthin
Paraparchites oblongus Coryell and Sample
Hollinella digitata Kellett
Hollinella bulbosa Coryell and Sample
Hollinella harltoni Kellett
Hollites papillosus Coryell and Sample
Cornigella minuta Warthin
Cornigella longispina Coryell and Sample
Jonesina acuneata Warthin
Jonesina ampla Warthin
Jonesina texana Harlton
Kirkbyina laevis Warthin
Moorites minutus (Warthin)
Moorites hewetti Coryell and Billings
Moorites parallela Coryell and Sample
Moorea elongata Coryell and Sample
Amphissites centronotus (Ulrich and Bassler)
Amphissites girtyi Knight
Amphissites pinguis (Ulrich and Bassler)
Amphissites dattonensis Harlton
Amphissites irregularis Coryell and Sample
Bairdia hispida Harlton
Bairdia seminalis Knight
Bairdia pennata Coryell and Sample
Bairdia auricula Knight
Bairdia rogatzi Coryell and Sample
Bairdia oklahomaensis Harlton
Bairdia ciscoensis Harlton
Bythocypris centralis Coryell and Billings
Bythocypris parallela Knight
Bythocypris texensis Coryell and Sample

[29]Coryell, H. N., and Sample, C. H., A study of the ostracoda fauna of the East Mountain shale, Mineral Wells formation, Mineral Wells, Texas: Am. Midland Nat., vol. 13, pp. 245–280, pls. 21–26, 1932.

Bythocypris palopintoensis Coryell and Sample
Bythocypris pediformis Knight
Bythocypris semicirculus Coryell and Sample
Healdia simplex Roundy
Healdia oklahomaensis Harlton
Healdia glennensis Harlton
Healdia cuneata Coryell and Billings
Healdia alba Coryell and Billings
Healdia formosa Harlton
Healdia longa Knight
Cytherella tongia Coryell and Sample
Cytherella gloria Coryell and Sample
Cytherella wewokena Warthin
Cytherella watkinsi Coryell and Sample
Cytherella proxima Coryell and Sample
Cavellina lintris Coryell and Sample
Cavellina pulchella Coryell
Cavellina reversa Coryell
Cavellina jejuna Coryell and Sample
Sulcella sulcata Coryell and Sample
Sulcella warthini Coryell and Sample

Fauna[30] *of the Village Bend limestone, East Mountain shale.*

Foraminifera—
- Apterrinella grahamensis (Harlton)
- Calcitornella heathi Cushman and Waters
- Calcitornella elongata Cushman and Waters
- Endothyra pauciloculata Cushman and Waters
- Endothyranella stormi (Cushman and Waters)
- Hemigordius harltoni Cushman and Waters
- Orthovertella sellardsi Plummer
- Spiroplectammina clavata Cushman and Waters
- Tetrataxis corona Cushman and Waters

Anthozoa—
- Campophyllum sp.
- Lophophyllum profundum (Milne-Edwards and Haime)

Crinoidea—
- Ulocrinus sp.
- Delocrinus sp.

Echinoidea—
- Echinocrinus sp.

Bryozoa—
- Rhombopora lepidodendroides Meek
- Rhombopora sp.
- Septopora sp.

Brachiopoda—
- Rhipidomella carbonaria (Swallow)
- Derbya sp.
- Marginifera splendens (Norwood and Pratten)
- Rhynchopora magnicosta Mather
- Dielasma subspatulatum? Mather
- Squamularia perplexa (McChesney)
- Neospirifer latus Dunbar and Condra
- Neospirifer dunbari R. H. King
- Cleiothyridina orbicularis (McChesney)
- Composita subtilita (Hall)

Pelecypoda—
- Astartella varica McChesney

Gastropoda—
- Phanerotrema grayvillense (Norwood and Pratten)
- Orestes nodosus Girty
- Murchisonia sp.
- Patellostium montfortianum (Norwood and Pratten)
- Naticopsis sp.
- Platyceras sp.

Fauna[31] *of the Salesville shale* (181-T-72).

Foraminifera—
- Ammodiscus incertus (d'Orbigny)
- Glomospira simplex Harlton
- Hemigordius calcareus Cushman and Waters
- Hyperammina glabra Cushman and Waters
- Proteonina cervicifera Cushman and Waters
- Reophax sp.

---

[30]Identifications by R. H. King and the authors, except the foraminifera, which have been identified by Helen Jeanne Plummer.

[31]Identifications by R. H. King and authors, except the foraminifera, which have been identified by Helen Jeanne Plummer.

Porifera—
- Fissispongia tortacloaca (R. H. King)
- Wewokella solida Girty

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime)
- Lophophyllum sp.
- Zaphrentis sp.

Annelida—
- Conularia crustula White

Bryozoa—
- Rhombopora lepidodendroides Meek
- Cystodictya sp.

Brachiopoda—
- Lindstroemella patula (Girty)
- Chonetina wyandottensis Newell
- Chonetina primitiva R. H. King, n. sp. (MS.)
- Juresania nebrascensis (Owen)
- Echinoconchus semipunctatus (Shepard)
- Marginifera lasallensis (Worthen)
- Linoproductus inornatus R. H. King, n. sp. (MS.)
- Cancrinella boonensis (Swallow)
- Isogramma millepunctata (Meek and Worthen)
- Leiorhynchus rockymontanum (Marcou)
- Ambocoelia planoconvexa (Shumard)
- Punctospirifer kentuckyensis (Shumard)
- Cleiothyridina orbicularis (Mc-Chesney)
- Composita subtilita (Hall)

Pelecypoda—
- Anthraconeilo taffiana Girty
- Nuculopsis ventricosa (Hall)
- Conocardium obliquum Meek and Worthen
- Astartella varica McChesney
- Astartella concentrica (Mc-Chesney)

Gastropoda—
- Phanerotrema grayvillense (Norwood and Pratten)
- Worthenia speciosa (Meek and Worthen)
- Worthenia tabulata (Conrad)
- Trepospira illinoisensis (Worthen)
- Pharkidonotus percarinatus (Conrad)
- Patellostium montfortianum (Norwood and Pratten)
- Pseudozygopleura sp.

Fauna[32] *of the Keechi Creek shale.*

Foraminifera—
- Ammobaculites stenomeca Cushman and Waters
- Ammodiscus incertus (d'Orbigny)
- Calcitornella heathi Cushman and Waters
- Cornuspira cf. C. involvens (Reuss)
- Deckerella clavata Cushman and Waters
- Endothyra pauciloculata Cushman and Waters
- Endothyranella stormi (Cushman and Waters)
- Glomospira duplex Cushman and Waters
- Glyphostomella triloculina (Cushman and Waters)
- Hemigordius harltoni Cushman and Waters
- Hemigordius calcareus Cushman and Waters
- Hyperammina glabra Cushman and Waters
- Orobias ciscoensis (Harlton)
- Orthovertella protea Cushman and Waters
- Rectocornuspira holdenvillana Warthin
- Spiroplectammina clavata Cushman and Waters
- Tetrataxis corona Cushman and Waters
- Trepeilopsis grandis (Cushman and Waters)
- Triticites irregularis (Schellwien and Staff), *a*

Porifera—
- Fissispongia tortocloaca (R. H. King), *c*
- Coelocladia spinosa Girty, *c*
- Wewokella solida Girty, *b, c*

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime), *b, c*
- Lophophyllum profundum var. radicosa Girty, *c*

[32]Identifications by R. H. King, George D. Harris, and authors; smaller foraminifera identified by Helen Jeanne Plummer.

Crinoidea—
- Ulocrinus sp., *c*

Echinoidea—
- Echinocrinus sp., *b, c*

Bryozoa—
- Septopora sp., *b*
- Rhombopora lepidodendroides Meek, *a, c*
- Fenestella sp., *b, c*

Brachiopoda—
- Orbiculoidea capuliformis? (McChesney), *b*
- Meekella striatocostata (Cox), *a, b, c*
- Chonetina wyandottensis Newell, *b, c*
- Juresania nebrascensis (Owen), *b, c*
- Marginifera lasallensis (Worthen), *b, c*
- Marginifera splendens (Norwood and Pratten), *b, c*
- Linoproductus inornatus R. H. King, n. sp. (MS.) *a, b, c*
- Isogramma millepunctata (Meek and Worthen), *b, c*
- Dielasma bovidens (Morton), *a*
- Squamularia perplexa (McChesney), *a, b, c*
- Neospirifer dunbari R. H. King, *a*
- Ambocoelia planoconvexa (Shumard), *b*
- Punctospirifer kentuckyensis (Shumard), *c*
- Hustedia acuticosta Newell, *c*
- Cleiothyridina orbicularis (McChesney), *a*
- Composita subtilita (Hall), *a, b, c*

Pelecypoda—
- Nuculopsis ventricosa (Hall), *b, c*
- Yoldia sp., *b*
- Schizodus sp., *b, c*
- Astartella varica McChesney, *b, c*

Gastropoda—
- Phanerotrema grayvillense (Norwood and Pratten), *b, c*
- Worthenia tabulata (Conrad), *b, c*
- Worthenia speciosa (Meek and Worthen), *c*
- Orestes brazoensis (Shumard), *b, c*
- Trepospira illinoisensis (Worthen), *b, c*
- Pleurotomaria carbonaria Norwood and Pratten
- Pharkidonotus percarinatus (Conrad), *c*
- Euphemites blaneyanus (McChesney), *b, c*
- Patellostium montfortianum (Norwood and Pratten), *c*
- Euomphalus catilloides (Conrad), *b, c*
- Pseudozygopleura scitula (Meek and Worthen), *c*
- Macrochilina paludinaeformis (Hall), *b, c*
- Naticopsis sp., *c*
- Trachydomia sp., *c*
- Platyceras sp., *b*

Trilobita—
- Griffithides scitulus (Meek and Worthen), *c*

Localities represented above—

a, 67–T–27, Limestone 4.8 miles SW. of Strawn, in Eastland County.
b, 181–T–64, Limestone in Keechi Creek shale near road 2.5 miles by road NW. of Salesville.
c, 181–T–43, Calcareous shale about one-quarter of a mile NNW. of Union Hill School.

Good fossil localities in the Mineral Wells formation are common, and the following[33] are some of the best:

181–T–2 (O–11). Excellent shale exposure south of a small tank at base of east end of Barbers Mountain, 5½ miles in direct line southwest of Mineral Wells, and one mile west of Oakes Crossing on Brazos River. Southeast corner of section 16, Block A, Texas & Pacific Railroad Survey. Lower part of East Mountain shale about 50 feet above Brazos River sandstone.

[33]The designation in parentheses refers to coördinates on the geologic map of Palo Pinto County.

181–T–3 (B–11). Shale exposure in southwestern part of Thomas Court Survey, 2 miles west of Strawn and south of the road. Keechi Creek shale below Palo Pinto limestone.

181–T–4 (S–9). Clay pit of present brick yard (Reliance Brick Co.) about three-quarters of a mile east of the center of Mineral Wells and north of the cemetery. East Mountain shale capped by Lake Pinto sandstone; the most fossiliferous zone lies below the Village Bend limestone.

181–T–9 (S–9). Old abandoned shale excavation 0.6 of a mile due east of the intersection of Hubbard and Oak streets in Mineral Wells, and on the north side of East Hubbard Street. Steep East Mountain shale slope containing Village Bend limestone. The best collecting is below the limestone.

181–T–10 (R–7). Steep slope east side of Mineral Wells-Union Hill School road, 1.1 miles from point where this road forks westward from the Jacksboro highway north of Mineral Wells. Near center of section 36, Block A (E. of B.), Texas & Pacific Railroad Survey. Salesville shale capped by Turkey Creek sandstone.

181–T–12 (T–3). Thin limestone member containing abundant minute fusulinids on east side of old Mineral Wells-Jacksboro highway, 0.9 of a mile north of Hughes. Keechi Creek shale; few large fossils.

181–T–16 (O–7). High point east of bend in Brazos River about half a mile below the mouth of Keechi Creek. Limestone in Keechi Creek shale above talus slope about 40 feet below Palo Pinto limestone.

181–T–17 (R–9). Shale slope at south end of prominent, small outlier capped by Lake Pinto sandstone in southwestern part of Mineral Wells, near base of slope and just above a small pond and dam, and west of the road to Inspiration Point.

181–T–18 (T–8). Shale outcrop east end of prominent large outlier, one-half mile northwest of Camp Wolters and 1.2 miles northeast of the large brick yard in Mineral Wells. Upper part of East Mountain shale member of Mineral Wells formation.

181–T–19 (R–9). Shale slope west end of dam at south end of Lake Pinto, above spillway, one mile west of Mineral Wells. East Mountain shale member and Village Bend limestone rich in fossils.

181–T–34 (O–9). Shale slope on west side of secondary road to Turkey Creek dam site, and 1.1 miles by road northwest of Brazos Valley School, about three-quarters of a mile northeast of Brazos River, and about 4 miles west of Mineral Wells. Salesville shale member.

181–T–38 (J–15). Shale slope above Village Bend limestone on north side of secondary road, 3½ miles west of Lone Camp in southwest corner of section 54, Texas & Pacific Railroad Survey. East Mountain shale.

181–T–43 (Q–5). Shale outcrops near base of high escarpment about a quarter of a mile north-northwest of Union Hill School, about 5½ miles north-northwest of Mineral Wells. Keechi Creek shale member.

181–T–45 (L–12). Bluff on north side of Village Bend of Brazos River, 2¾ miles in direct line southeast of Palo Pinto. Near west line of section 37, Block 1, Texas and Pacific Railroad Survey. East Mountain shale member.

181–T–51 (N–11). Road cut 0.9 of a mile by road southeast of a filling station located on Highway No. 1 at a point 4.1 miles west of the Brazos River bridge. The cut is on the east side of the road at a sharp bend, in the west side of section 18, Block A, Texas & Pacific Railroad Survey. East Mountain shale.

181 T–52 (C–21). Shale exposure about half a mile in direct line southwest of the town of Strawn at west end of an east-west road three blocks south of the railroad and on the west side of a north-south intersecting road. Keechi Creek shale.

181–T–64 (R–4). Shale slope and road ditch on north side of Salesville-Graford road 2.5 miles by road northwest of the post office in Salesville. Keechi Creek shale with soft yellowish marl bed.

181–T–69 (P–9). Roadside bank and creek exposure at sharp bend on Highway No. 1, about 4 miles west of Mineral Wells and 0.5 of a mile by road northeast of the Brazos River bridge. East Mountain shale.

181–T–72 (Q–5). Prominent shale exposure near foot of escarpment along fence line, ½ of a mile due north of Union Hill School, near east end of A. B. & M. Survey, about 5½ miles north-northwest of Mineral Wells, and ¼ of a mile northeast of Station 181–T–43. Keechi Creek shale of Mineral Wells formation.

181–T–74 (L–13). Shale exposure at side of road, about 3 miles by road southeast of Palo Pinto on the Santo road. East Mountain shale below Village Bend limestone.

181–T–83 (R–9). Shale exposure in shallow excavation on west side of a trail near the north end of Lake Pinto and northwest of a small bridge over the creek that feeds the lake. East Mountain shale.

181–T–84 (R–9). Knoll near base of high slope about 200 feet south of the south end of Southwest Seventh Ave., Mineral Wells. The marl just above a hard limestone ledge is rich in fossils of the East Mountain shale member.

181–T–91 (S–9). Conspicuous knoll in Mineral Wells at corner of Northeast Fifth Ave. and Northeast First Street. Here the 12-inch Village Bend limestone is overlain by a bed of yellowish and fossiliferous marl of the East Mountain shale member.

PALO PINTO FORMATION[34]

Stratigraphy.—The Palo Pinto formation[35] caps a prominent escarpment that extends from the southwestern corner of the county, southwest of Strawn, to the northeastern corner, east of Oran (Pl. II). It has been deeply dissected by Brazos River and its tributaries, so that its outcrop in places makes a dendritic map pattern corresponding to the normal drainage pattern of streams that have eroded deep canyon-like valleys back into their escarpments. The limestone lies apparently conformably upon the Mineral Wells formation and is overlain conformably by the Graford formation.

The Palo Pinto beds consist of thick, irregularly bedded limestone, a few thin marls or very calcareous clay beds, and a little chert. The formation is about 50 feet thick in the south end of the county but thickens northward to nearly 100 feet east of Oran, from whence it thins northeastward. The succession of strata is best presented in described sections.

Section of the Palo Pinto formation about three-quarters of mile south of Spring Gap School and about 3 miles south-southwest of Metcalf, northeast corner of sec. 66, Blk. 2, T. & P. R. R. Survey.

	Thickness Ft.	in.
3. Limestone, gray, fossiliferous, weathering to irregular slabs. Caps the first terrace back of the main escarpment	1	2
2. Marl, yellow, shaly, nonfossiliferous	12	
1. Limestone, gray, thinly bedded, containing in places chert nodules 3 to 10 inches in diameter. The chert is most plentiful in a zone 6 feet from the top of the ledge and contains numerous small fusulinids and a few other fossils	24	
Total thickness measured	37	2

---

[34]*Literature.*—Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 92–95, 1922. Sellards, E. H., Pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, p. 110. 1933. Wegemann, C. H., A reconnaissance in Palo Pinto County, Texas, with special reference to oil and gas: U. S. Geol. Survey, Bull. 621, pp. 51–55, 1915. Scott, Gayle, and Armstrong, J. M., The geology of Wise County, Texas: Univ. Texas Bull. 3221, pp. 20–29, 1932.

[35]*Definition.*—The formation was named by Plummer and Moore (see above footnote) and made to include only the massive limestone ledges overlying the Strawn group and underlying the thick marl bed in the base of the Graford formation at the type locality along Highway No. 1 west of Palo Pinto. The formation includes a thin limestone above, 10 to 15 feet of marl, and a massive limestone below.

Section of the Palo Pinto formation, 5 miles southwest of Palo Pinto, near the southeast corner of sec. 50, Blk. 1, T. & P. R. R. Survey.

	Thickness *Feet*
3. Limestone, light gray, rough surfaced, weathers to small slabs	1
2. Marl, yellowish gray, poorly exposed	10
1. Limestone, light gray, thin and unevenly bedded, sparsely fossiliferous, broken by numerous joints and wavy bedding lines	25
Total thickness measured	36

Section of the Palo Pinto formation along a small branch on the north side of Brazos River, 3 miles below the Palo Pinto-Graford bridge.

	Thickness *Feet*
5. Limestone, light gray rough surfaced, massively bedded	6½
4. Shale, covered by talus	12½
3. Limestone, gray, rough surfaced, fossiliferous, thick bedded	18½
2. Shale or marl	1
1. Limestone, gray. unevenly bedded, hard, fossiliferous, contains a tiny *Triticites*, many echinoid spines, productids, etc.	5½
Total thickness measured	44

The Palo Pinto limestone formation is distinguished from other limestones of the Canyon group by the following criteria:

1. Thin beds separated by uneven and, in places, distinctly wavy planes.
2. Nodules of chert containing very small fusulinids belonging to the genus *Triticites*.
3. Stylolitic structure.

Paleontology and correlation.—The Palo Pinto limestone contains a rich fauna in which brachiopods predominate, although bryozoans, pelecypods, and gastropods are present in most places in large quantities. The brachiopod assemblage includes such characteristic forms as *Marginifera wabashensis* (Norwood and Pratten). *Dielasma bovidens* (Morton), especially large and robust forms of *Composita subtilita* (Hall), *Meekella striatocostata* (Cox), *Neospirifer alatus* Dunbar and Condra, and large numbers of *Squamularia perplexa* (McChesney). The following group is representative of the Palo Pinto limestone fauna.

Fauna of the Palo Pinto limestone.

Foraminifera[36]—
- Deckerella clavata Cushman and Waters
- Tetrataxis corona Cushman and Waters
- Glyphostomella triloculina (Cushman and Waters)

Brachiopoda—
- Crania modesta White and St. John
- Meekella striatocostata (Cox)
- Chonetina verneuiliana (Norwood and Pratten)
- Juresania nebrascensis (Owen)
- Echinoconchus semipunctatus (Shepard)
- Dictyoclostus crassicostatus Dunbar and Condra
- Marginifera splendens (Norwod and Pratten)
- Marginifera wabashensis? (Norwood and Pratten)
- Linoproductus prattenianus (Norwood and Pratten)
- Rhynchopora magnicosta Mather
- Dielasma bovidens (Morton)
- Squamularia perplexa (McChesney)
- Neospirifer alatus Dunbar and Condra
- Neospirifer dunbari R. H. King
- Punctospirifer kentuckyensis (Shumard)
- Hustedia mormoni (Marcou)
- Cleiothyridina orbicularis (McChesney)
- Composita argentea (Shepard)
- Composita ovata Mather
- Composita subtilita (Hall)
- Composita magna Newell

Pelecypoda—
- Aviculopecten carboniferus (Stevens)
- Aviculopecten mccoyi Meek and Hayden
- Allerisma terminale Hall

Gastropoda (mainly casts)—
- Euconospira missouriensis (Swallow)
- Bellerophon sp.
- Naticopsis sp.
- Platyceras sp.

The following fossil localities[37] in the Palo Pinto limestone are noteworthy:

181–T–1 (A–20). Outcrop of limestone on north side of road to old Strawn oil field, 3 miles west of Strawn.

181–T–22 (A–21). Outcrop of limestone one-quarter mile south of the road to the old Strawn oil field and near the railroad, 3 miles west of Strawn.

181–T–37 (F–16). Outcrop of limestone in a small branch on west side of road, 1½ miles west and 1¼ miles south of Spring Gap School.

181–T–41 (S–3). Quarry of Mineral Wells Crushed Stone Co., 3 miles due north of Salesville on the Salesville-Oran road in the east half of the Moreau Forest Survey, and one-quarter mile south of the railroad. (The highly fossilfierous layer in the bottom of the old quarry is now submerged by water.)

181–T–48 (D–18). Old limestone quarry on west side of Strawn-Metcalf highway, 4 miles north of Strawn and 8.2 miles by road

---

[36]Abandoned rock quarry northwest of Salesville on Oran road. The quarry is now filled with water, and the fossiliferous shale break is inaccessible.

[37]The designation in parentheses after the locality number refers to coördinates on the geologic map of Palo Pinto County.

south of Metcalf road fork, and at the entrance to Crouch's Ranch (old Hinkson Ranch).

181–T–63 (R–4). Outcrop of limestone on the Salesville-Graford road about 3½ miles by road west-northwest of Salesville, near the middle of section 2524, T. E. & L. Co. Survey.

181–T–77 (M–11). Escarpment of Palo Pinto limestone on Highway No. 1, 2½ miles by road east of Palo Pinto. (Type locality for Palo Pinto limestone.)

GRAFORD FORMATION[38]

Stratigraphy.—The Graford formation[39] outcrops along a belt of rugged, in places deeply incised, territory bordered on the southeast by the outcrop of the Palo Pinto limestone and on the northwest by a steep escarpment capped by the Merriman limestone. The formation extends from the southwest corner of Palo Pinto County, west of Strawn, to the northeast portion of the county, north of Graford and Oran (Pl. II). The outcrop is about two miles wide in the southwest corner of the county and widens to six miles or more in the northeastern portion. Its thickness ranges from 400 to 600 feet.

The Graford formation consists of the massive Merriman limestone at the top overlying about 400 feet of shale and containing lentils of sand, a lentil of coal, and a few thin layers of limestone. The strata have been assembled into four members, as follows:

4. Merriman limestone. A gray, massive, jointed, resistant, fossiliferous limestone, from 20 to 75 feet thick. This is limestone mapped previously by Plummer and Moore as the Adams Branch limestone.

---

[38]*Literature.*—Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 95–107, 1921. Reeves, F., Geology of the Ranger oil field: U. S. Geol. Survey Bull. 736, pp. 111–170, 1922. Cheney, M. G., Stratigraphic and structural studies in north-central Texas. Univ. Texas Bull. 2913, p. 19, 1929. Scott, Gayle, and Armstrong, J. M., The geology of Wise County, Texas: Univ. Texas Bull. 3224, pp. 29–34, 1932. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, pp. 11–112, 1933.

[39]*Definition.*—The Graford formation was named by Plummer and Moore (see preceding footnote) and was made to include all the strata from the top of the Palo Pinto limestone upward in the section to the top of the limestone that caps the escarpment west of Graford. This escarpment-forming limestone at the time the formation was named was thought to be the equivalent of the typical Adams Branch limestone to the south. Subsequent work by Cheney, Armstrong and others (see preceding footnote) has shown that the true Adams Branch limestone in Palo Pinto County lies much lower in the section than the uppermost limestone of the Graford formation, and that this uppermost limestone is the equivalent of the Merriman limestone, named by Frank Reeves (U. S. Geol. Survey Bull. 736, p. 111, 1922).

3. Wolf Mountain shale. A bluish-gray, soft, fossiliferous shale containing numerous hard, small, brown, limonitic concretions and a few lentils or layers of sandstone. This shale is typically exposed below the capping Merriman limestone in the slopes of Wolf Mountain, 6 miles west-northwest of Palo Pinto.
2. Wiles limestone. A gray (blue when freshly broken), hard limestone, from 3 to 8 feet thick.
1. Posideon shale. Dark gray, soft, sandy to calcareous fossiliferous shale containing thin layers of limestone. Thickness about 50 feet. Typically exposed above the Palo Pinto limestone in the vicinity of Posideon.

The relative positions of these members in the section and their lithologic characters are shown in the following described sections:

Section of the upper part of the Graford formation on the west side of Wolf Mountain, 6 miles west-northwest of Palo Pinto.

	Thickness *Feet*
Merriman limestone—	
6. Limestone, light gray or nearly white, fossiliferous, containing numerous nodules of chert. Some of the chert nodules contain small fusulinids	4
5. Shale ?, yellowish gray, covered by slumped limestone	16
4. Limestone, gray, massive, much jointed, unevenly bedded, very rough surfaced, in places fossiliferous	28
Wolf Mountain shale—	
3. Shale, gray, sandy, soft, covered by talus	35
2. Limestone, yellowish buff, contains *Triticites irregularis* (Schellwien and Staff) in great abundance and a few other fossils	2
1. Shale, dark bluish gray, soft, silty, containing numerous limonitic concretions, and in the upper part thin layers of light-gray, fine-grained sandstone carrying casts of worm tubes and leaf fragments	50+
Total thickness measured	135+

Section of the Graford formation, northeast end of Long Mountain just north of Brazos River, and 3 miles above the Palo Pinto-Graford bridge.

	Thickness *Feet*
Merriman limestone—	
15. Limestone, gray, massive, much jointed	56
Wolf Mountain shale—	
14. Shale?, covered by blocks of slumped limestone	42

	Thickness *Feet*
13. Shale, blue-gray, fossiliferous, containing numerous ferruginous concretions and many small fossils (upper fossil zone)	42
12. Shale, bluish gray, covered by talus and detritus	125
11. Shale, light gray, thinly laminated, almost paper thinness, fossiliferous	22
10. Shale, dark gray, in places black, containing numerous limonitic concretions and some gray nodules, very fossiliferous, carries numerous *Chonetina verneuiliana, Worthenia tabulata* (large form), *Trepospira depressa, Phanerotrema grayvillense, Anthraconeilo taffiana, Gastrioceras* n. sp., *Metacoceras cornutum, Metacoceras cornutum* var. *carinata, Griffithides scitulus,* etc.	41
9. Limestone, yellowish gray, sandy, very fossiliferous, contains numerous corals	1
8. Shale, very fossiliferous	11½
7. Limestone, buff, full of bryozoans, *Myalina*, etc.	½
6. Shale, yellowish gray, thinly laminated, soft, containing small, hard, limonitic concretions and many fossils	10
5. Shale, unexposed	3
Wiles limestone—	
4. Limestone, gray, streaked with vermilion and having very rough surface	3
Posideon shale—	
3. Shale	8½
2. Limestone, gray, hard	3½
1. Shale, gray, soft	30
Total thickness measured	399

Section of the Graford formation measured[40] *from the town of Palo Pinto northwestward to Brazos River* (fig. 5).

	Thickness *Feet*
Merriman limestone—	
22. Limestone (M), gray	27
Wolf Mountain shale—	
21. Shale (L), gray, containing lentils and thin layers of sandstone and a calcareous bed characterized by *Triticites irregularis* (Schellwien and Staff)	175
20. Limestone (K)	3
19. Shale	32
18. Limestone (J)	5
17. Shale	30

[40]Measured by O. E. Hans, H. E. Merry. Furnished by Merry Bros. and Perrini.

	Thickness *Feet*
16. Limestone (I), gray, iron stained, hard	2
15. Sandstone, thin bedded, fine grained	5
14. Shale	23
Wiles limestone—	
13. Limestone (H)	7
Posideon shale—	
12. Shale	14
11. Limestone (G)	1
10. Shale	4
9. Limestone (F), iron stained, with many chert nodules on surface	2
8. Shale	26
7. Limestone (E), gray	1
6. Shale	4
5. Limestone (D), yellowish gray, very persistent, forming an excellent marker	1
4. Shale	20
3. Limestone (C), gray, containing a layer of chert at its top	2
2. Shale (B), mostly unexposed, and contains one or two flaggy layers	18
Palo Pinto limestone—	
1. Limestone (A), gray, unevenly bedded, weathers to large, characteristic blocks containing large pits, and leaving chert nodules in relief. This bed forms a very prominent escarpment and thins eastward	20+
Total thickness measured	422+

Noteworthy features.—The Merriman limestone, the upper member in the Graford formation, is the thickest and one of the most persistent beds of limestone in north-central Texas. It is gray, weathers white, is thick and massively bedded, and forms high escarpments where cut by Brazos River and its tributaries. The limestone varies in thickness from 175 feet or more at Possum Kingdom Bend on the Brazos to 20 feet or less on Keechi Creek near the northern boundary of the county. In its thick massive facies south of McAdams Peak the rock is undoubtedly in the form of a reef[41] formed by local excessive accumulation of calcium carbonate in the ancient

[41]Plummer, F. B., Pennsylvanian sedimentation in Texas: Illinois State Geol. Survey, Bull. 60, p. 267, 1931.

seas. Similar reefs have been described by Scott and Armstrong[42] in Wise County. The attitude and variation in thickness of the Merriman limestone across the county is shown in the structure section on Plate II.

The *Triticites irregularis* bed, which occurs 60 feet below the top of the Merriman limestone, is the most persistent and most interesting feature of the formation. It is grayish buff, hard, 6 to 10 inches thick, and weathers to smooth elliptical chunks, which slump down the steep slopes and are in many places completely covered by

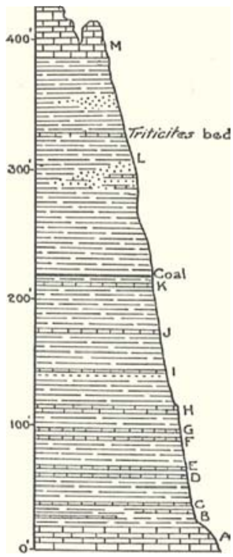


FIG. 5. Columnar section of the Graford formation measured northwestward from Palo Pinto to Brazos River (see accompanying described section).

debris from overlying shale and limestone. The bed is made up almost altogether of great numbers of the fusulinid *Triticites irregularis* (Schellwien and Staff). a small, slender, elongate form having truncated ends and irregularly shaped septa.

A bed of coal lies about 160 feet below the top of the formation in the central part of the county north of Palo Pinto. It is best exposed on the Dalton ranch, where it attains a thickness of nearly

[42]Scott, Gayle, and Armstrong, J. M., Geology of Wise County: Univ. of Texas Bull. 3224, pp. 31–33, 1932.

10 feet and can be traced for several miles. The seam is described more fully in the chapter on coal.

The Wiles limestone, which occurs 50 feet or more above the Palo Pinto limestone, is another persistent ledge of hard, blue-gray, massive, fossiliferous limestone, 5 to 10 feet in thickness. The ledge thickens westward beneath the surface and in some well sections attains a thickness of 50 to 100 feet, according to drillers, and may be mistaken for the Palo Pinto ledge below.

Paleontology and correlation.—The Graford formation contains a large, varied, and interesting assemblage of fossils. Two rich zones are especially noteworthy, and most of the fossils occur in these two zones. The lower zone comprises from 30 to 50 feet of section above the Wiles limestone; and the upper zone lies just above the bed containing *Triticites irregularis* (Schellwien and Staff), which is 60 feet below the top of the Merriman limestone.

The lower zone is especially characterized by large numbers of partly coiled, well-preserved, small trilobites belonging to the form *Griffithides scitulus* (Meek and Worthen). Associated with the trilobites are the ammonites *Gastrioceras anguloumbilicatum*, n. sp. (MS.), *Marathonites parkeri* (Heilprin), *Gonioloboceras bridgeportensis*, n. sp. (MS.), and a large assemblage of well-preserved invertebrate fossils exemplified by the following list. The same lower assemblage has been recognized at several localities southwest of Graford and near the town of Dalton in Palo Pinto County, and in the clay pit in the north edge of Bridgeport in Wise County.

Fauna[43] of the lower fossiliferous zone of the Graford formation.

Foraminifera—
- Ammobaculites inconspicua Cushman and Waters
- Ammodiscus incertus (d'Orbigny)
- Apterrinella grahamensis (Harlton)
- Calcitornella heathi Cushman and Waters
- Cornuspira cf. C. involvens (Reuss)
- Earlandia perparva Plummer
- Endothyra watersi Plummer
- Endothyra pauciloculata Cushman and Waters
- Glyphostomella triloculina (Cushman and Waters)
- Hyperammina bulbosa Cushman and Waters
- Nodosinella perelegans Plummer
- Orobias ciscoensis (Harlton)
- Orthovertella protea Cushman and Waters
- Tetrataxis corona Cushman and Waters

[43]The foraminifera have been identified by Helen Jeanne Plummer; the remaining fossils by R. H. King and the authors.

Brachiopoda—
- Orbiculoidea sp.
- Lindstroemella patula (Girty)
- Crania modesta White and St. John
- Derbya subcircularis Dunbar and Condra
- Derbya sp.
- Meekella striatocostata (Cox)
- Chonetes fragilis R. H. King, n. sp. (MS.)
- Chonetina cf. C. primitiva R. H. King, n. sp. (MS.)
- Chonetina verneuiliana (Norwood and Pratten)
- Juresania nebrascensis (Owen)
- Echinoconchus sp.
- Dictyoclostus crassicostatus Dunbar and Condra
- Marginifera lasallensis (Worthen)
- Marginifera splendens (Norwood and Pratten)
- Marginifera wabashensis (Norwood and Pratten)
- Linoproductus prattenianus (Norwood and Pratten)
- Linoproductus, n. spp. (2)
- Squamularia perplexa (McChesney)
- Neospirifer dunbari R. H. King
- Ambocoelia planoconvexa (Shumard)
- Punctospirifer kentuckyensis (Shumard)
- Hustedia mormoni (Marcou)
- Composita ovata Mather
- Composita subtilita (Hall)

Pelecypoda—
- Nucula anodontoides Meek
- Anthraconeilo taffiana Girty
- Leda bellistriata Stevens
- Leda arata (Hall)
- Yoldia glabra Beede and Rogers
- Pinna sp.
- Pteria longa (Geinitz)
- Limopteria sp.
- Myalina swallovi McChesney
- Conocardium obliquum Meek and Worthen
- Aviculopecten carboniferus (Stevens)
- Allerisma granosum (Shumard)
- Astartella concentrica (McChesney)

Gastropoda—
- Phanerotrema grayvillense (Norwood and Pratten)
- Worthenia tabulata (Conrad)
- Orestes brazoensis (Shumard)
- Trepospira illinoisensis (Worthen)
- Trepospira sphaerulata (Conrad)
- Pleurotomaria carbonaria Norwood and Pratten
- Euconospira sp.
- Bellerophon crassus Meek and Worthen
- Pharkidonotus percarinatus (Conrad)
- Pharkidonotus tricarinatus (Shumard)
- Patellostium montfortianum (Norwood and Pratten)
- Euphemites vittatus (McChesney)
- Euphemites blaneyanus (McChesney)
- Euomphalus sp.
- Euomphalus catilloides (Conrad)
- Euomphalus subquadratus (Meek and Worthen)
- Pseudozygopleura sp.
- Macrochilina regularis (Cox)
- Macrochilina medialis (Meek and Worthen)
- Meekospira choctawensis? Girty
- Auriptygma subtilistriatum Knight

Cephalopoda—
- Orthoceras sp.
- Pseudorthoceras knoxense (McChesney)

Trilobita—
- Griffithides? scitulus (Meek and Worthen)
- Phillipsia sp.

The upper zone, which lies just above the *Triticites* bed, is characterized by a wide variety of invertebrates, of which crinoids are particularly noteworthy. The following species have been collected from this zone:

Fauna[44] *from the upper part of the Wolf Mountain shale, below the Merriman limestone, east end of Long Mountain, Dalton Ranch.*

Foraminifera—
- Ammodiscus incertus (d'Orbigny)
- Apterrinella grahamensis (Harlton)
- Calcitornella heathi Cushman and Waters
- Cornuspira sp.
- Endothyra watersi Plummer
- Endothyranella stormi (Cushman and Waters)
- Globivalvulina biserialis Cushman and Waters
- Trochammina arenosa Cushman and Waters
- Triticites irregularis (Schellwien and Staff), 2nd form of M. White

Porifera—
- Girtyocoelia beedei Girty

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime)

Crinoidea—
- Delocrinus sp.
- Pentacrinus sp.

Bryozoa—
- Rhombopora lepidodendroides Meek
- Fistulipora sp.

Brachiopoda—
- Chonetina verneuiliana (Norwood and Pratten)
- Juresania nebrascensis (Owen)
- Echinoconchus semipunctatus (Shepard)
- Marginifera wabashensis (Norwood and Pratten)
- Linoproductus inornatus R. H. King, n. sp. (MS.)
- Isogramma millepunctata (Meek and Worthen)
- Neospirifer dunbari R. H. King
- Ambocoelia planoconvexa (Shumard)
- Composita subtilita (Hall)

Pelecypoda—
- Nucula sp.
- Leda bellistriata Stevens
- Astartella concentrica (McChesney)

Gastropoda—
- Orestes brazoensis (Shumard)
- Pleurotomaria beckwithiana (McChesney)
- Pseudozygopleura sp.

Cephalopoda—
- Metacoceras perelegans Girty

Fossiliferous outcrops[45] of the Graford formation from which good collections have been made are as follows:

181–T–11 (G–10). Shale slope on small outlier on west side of Wolf Mountain, 6 miles west-northwest of Palo Pinto. Wolf Mountain shale member about 170 feet below top of Merriman limestone.

181–T–14 (D–12). Thin limestone layer containing *Triticites irregularis* (Schellwien and Staff) on north side of Palo Pinto-Caddo road at Metcalf's Gap, 2 miles southeast of Brad. Wolf Mountain shale member 60 feet below Merriman limestone.

181–T–23 (L–3). Limestone at top of escarpment, 2¾ miles west, and 1¼ miles north of Graford. Merriman limestone.

181–T–27 (I–8). Fine shale exposure in valley at east end of McKenzie (or Long) Mountain, one-quarter of a mile west of Brazos River and 3 miles southwest of the Graford-Palo Pinto highway bridge over Brazos River. Wolf Mountain shale about 250 feet below top of Merriman limestone.

---

[44]The smaller foraminifera have been identified by Helen Jeanne Plummer: the remaining species by R. H. King, George D. Harris, and the authors.

[45]The designation in parentheses after the locality number refers to the coördinates on the geologic map of Palo Pinto County.

181-T-29 (J-9). Shale slope on side of Kyle Mountain, 4 miles north-northwest of Palo Pinto and three-quarters of a mile east of Brazos River. Upper part of Wolf Mountain shale.

181-T-61 (G-10). Shale escarpment on extreme west point of Wolf Mountain, section 16, Block 2, Texas and Pacific Railroad Survey. Wolf Mountain shale.

181-T-68 (H-11). Shale exposure southeast corner of Wolf Mountain, near center of section 23, Block 2, Texas and Pacific Railroad Survey. Wolf Mountain shale.

The correlation of the strata of the Graford formation with the strata in the Trinity Valley to the northeast and with those in the Colorado Valley to the south is shown in figure 2.

BRAD FORMATION[46]

Stratigraphy.—The Brad formation[47] outcrops in a belt about three miles wide in a southwest-northeast direction across the west half of the county (Pl. II). It includes the strata along the east-facing high escarpment capped by the Ranger limestone, and extends eastward to the outcrop of the Merriman limestone at the top of the Merriman escarpment.

The formation is deeply dissected by streams, and includes in its outcrop some of the most rugged and most picturesque topography in Palo Pinto County. The formation has an average thickness of 200 feet and is made up of the following members:

2. Ranger limestone (45').
1. Seaman Ranch beds (135').

Details of the stratigraphy of this formation are given in the following measured sections:

---

[46]*Literature.*—Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas: Jour. Geol., vol. 30, p. 35, 1922. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 107–116, 1922. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, p. 112, 1933.

[47]*Definition.*—The Brad formation was named by Plummer and Moore (see preceding footnote) and made to include the strata from the top of the limestone capping the escarpment west of Graford (here called Merriman limestone but previously referred to as Adams Branch limestone) upward to the top of the Ranger limestone. The type locality is the outcrop south of Brad.

Section of the Brad formation at its type locality south of Brad.

	Thickness *Feet*
Ranger limestone—	
9. Limestone, yellowish brown, hard, thin bedded	2
8. Shale, light gray, soft, mostly covered by talus	9
7. Limestone, gray, massive, many-jointed	15
6. Limestone, yellowish gray, massive, contains chert in places	20
Seaman Ranch beds—	
5. Shale, gray, soft, sandy	10
4. Sandstone, brown, calcareous	4
3. Shale, sandy in places, changing to cross-bedded sandstone	36
2. Limestone, brown, fossiliferous, thin bedded	2
1. Shale, gray, sandy, containing lentils of brown, calcareous sandstone	96
Total thickness measured	194

Section of Brad formation north side of Pickwick-Graford road, 1½ miles east of Pickwick, north of McAdams Peak.

	Thickness *Feet*
Ranger limestone—	
5. Limestone, gray, thin bedded, gritty in places, distinctly cross bedded, fossiliferous	6
4. Limestone, gray, massively bedded, hard, jointed, weathers in large square blocks	4
Seaman Ranch beds—	
3. Shale, gray, containing lentils or layers of brown, calcareous sandstone	60
2. Limestone, dark grayish brown, very fossiliferous, contains numerous corals, crinoid stems, many gastropods, especially the species *Euomphalus catilloides* (Conrad)	1
1. Shale, light gray, soft, very thin bedded, containing many thin layers and seams of limonite, base not exposed	60
Total thickness measured	131

Noteworthy features.—The most noteworthy features of the Brad formation are the chert and ferruginous nodules in the Ranger limestone. These nodules are more numerous in the southern outcrop of the bed than in the northern district. In fact, in the Colorado Valley the Ranger limestone received the name "cherty limestone" from

Drake because of its cherty beds. The chert nodules are white and irregular and are from six to twelve or more inches in diameter. Some nodules contain minute fusulinids and other minute fossils, but most of them are barren. The ferruginous nodules are cubical limonite pseudomorphs after pyrite, are three-eighths to one-half inch in diameter, and in some places in the limestone they are quite numerous and are associated with the chert.

Paleontology and correlation.—The shales of the Brad formation are more sandy and less fossiliferous than those of most other divisions in Palo Pinto County. Small collections of fossils have been obtained from the Ranger limestone and somewhat larger ones from a thin, brown limestone and adjacent shale that occurs in the middle of the Seaman Ranch beds.

Fauna[15] of the Brad formation.

Foraminifera—
- Glyphostomella triloculina (Cushman and Waters)
- Endothyra watersi Plummer
- Endothyra pauciloculata Cushman and Waters
- Hemigordius regularis Plummer
- Cornuspira cf. C. involvens (Reuss)
- Triticites sp.

Porifera—
- Fissispongia tortacloaca (R. H. King)
- Fissispongia jacksboroensis R. H. King, n. gen., n. sp. (MS.)

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime)
- Lophophyllum profundum var. radicosa Girty

Crinoidea—
- Hydreionocrinus patulus Girty
- Ulocrinus sp.
- Delocrinus sp.

Echinoidea—
- Echinocrinus sp.

Brachiopoda—
- Lindstroemella patula (Girty)
- Derbya jacksboroensis Dunbar and Condra
- Chonetes granulifer Owen
- Chonetina flemingi (Norwood and Pratten)
- Juresania ovalis Dunbar and Condra
- Juresania nebrascensis (Owen)
- Juresania rectangularis R. H. King, n. sp. (MS.)
- Echinoconchus sp.
- Dictyoclostus crassicostatus Dunbar and Condra
- Marginifera lasallensis (Worthen)
- Marginifera wabashensis (Norwood and Pratten)
- Linoproductus prattenianus (Norwood and Pratten)
- Linoproductus platyumbonus Dunbar and Condra
- Linoproductus inornatus R. H. King, n. sp. (MS.)
- Cancrinella boonensis (Swallow)
- Neospirifer dunbari var. alata Dunbar and Condra
- Neospirifer dunbari R. H. King
- Ambocoelia planoconvexa (Shumard)
- Punctospirifer kentuckyensis (Shumard)
- Hustedia acuticosta Newell
- Composita persulcata R. H. King, n. sp. (MS.)

Pelecypoda—
- Edmondia aspenwallensis? Girty
- Nucula anodontoides Meek
- Nucula sp.
- Leda arata (Hall)

---

[15]The smaller foraminifera have been identified by Helen Jeanne Plummer; the remaining forms by R. H. King and the authors.

Yoldia glabra Beede and Rogers
Pinna sp.
Myalina subquadrata? Shumard
Myalina swallovi McChesney
Myalina perattenuata Meek and Hayden
Schizodus sp.
Conocardium obliquum Meek and Worthen
Allerisma sp.
Astartella concentrica (McChesney)

Scaphopoda—
Dentalium, n. spp. (2)

Gastropoda—
Phanerotrema grayvillense (Norwood and Pratten)
Worthenia tabulata (Conrad)
Orestes brazoensis (Shumard)
Trepospira illinoisenses (Worthen)
Euconospira sp.
Bellerophon stevensianus McChesney
Pharkidonotus tricarinatus (Shumard)
Bucanopsis meekiana (Swallow)
Patellostium montfortianum (Norwood and Pratten)
Euphemites vittatus (McChesney)
Euomphalus catilloides (Conrad)
Macrochilina paludinaeformis (Hall)
Trachydomia whitei? Knight
Meekospira choctawensis Girty

Outcrops[49] that have furnished good collections of fossils from the Brad formation are as follows:

181–T–25 (G–5). Limestone bench on McAdams Peak, 2 miles southeast of Pickwick. Ranger limestone.

181–T–26 (G–5). Limestone along old Pickwick-Graford road, 2 miles east of Pickwick and one mile north of McAdams Peak. Ranger limestone.

181–T–33 (B–5). Limestone on Mrs. C. F. Crandill's ranch, one-half mile southeast of Fox Hollow schoolhouse, 3½ miles south and 2½ miles east of the northwest corner of Palo Pinto County. Ranger limestone.

181–T–44 (G–4). Shale exposure on east side of small outlier just west of Dalton Mountain and one-half mile north of the Graford-Pickwick road and about 2¾ miles east of Pickwick. Seaman Ranch shale 66 feet below the Ranger limestone.

181–T–46 (G–4). Shale exposure on south side of Dalton Mountain, north of the Pickwick-Graford road, 3 miles east of Pickwick. Seaman Ranch shale 160 feet below Ranger limestone.

181–T–47 (H–1). Shale exposure 0.1 of a mile east of the Christie well, 1½ miles northeast of the Graford-Graham road on east side of Frog Hollow valley on the Allen and Richie ranch, T. J. Bradford Survey. Seaman Ranch shale.

181–T–81 (F–5). Shale exposures along gullies on south side of Pickwick-Graford road, 1.4 miles by road east of Pickwick and about three-quarters of a mile northwest of McAdams Peak. Seaman Ranch shale.

The correlation of the Brad formation is shown in the columnar sections, figure 2.

---

[49]The designation in parentheses after the locality number refers to the coördinates on the geologic map of Palo Pinto County.

CADDO CREEK FORMATION[50]

Stratigraphy.—The Caddo Creek[51] formation outcrops in a narrow and much-dissected belt from one-quarter to one-half mile wide, trending southwest-northeast across the northwest corner of Palo Pinto County west of Brazos River, and in somewhat wider, though equally tortuous, strips around six outliers capped by the Home Creek limestone along the west side of the county west of Brad (Pl. II). The area of the outcrop is extremely rugged and constitutes in most places the face of the bold escarpment capped by the Home Creek limestone.

The average thickness of the formation in Palo Pinto County is 175 feet. It thickens somewhat northward and ranges from about 120 feet in southern Stephens County to 220 feet in Jack County. The formation has been divided into the following members:

2. Home Creek limestone (20').
1. Hog Creek shale (155').

Details of the individual beds in the Caddo Creek formation are presented in the following measured sections:

Section[52] of the Caddo Creek formation, 6 miles north of Brad.

	Thickness Feet
Home Creek limestone—	
8. Limestone, brownish yellow, blue on fresh surface, hard, breaks with a conchoidal fracture	2
7. Shale, blue gray, soft	5
6. Limestone, grayish white, nodular	6
5. Shale, covered with talus	5
4. Limestone, gray, massive, contains concretionary nodules of chert	24
3. Shale covered with talus	10
2. Limestone, grayish buff, ferruginous, massive	5

[50]*Literature.*—Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas. Jour. Geol., vol. 30, pp. 35-36, 1922. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 117-121, 1922. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, pp. 112–113, 1933.

[51]*Definition.*—The Caddo Creek formation was named by Plummer and Moore (see preceding footnote) and made to include all the strata in the Brazos River Valley from the top of the Ranger limestone upward to the top of the Home Creek limestone.

[52]Measured by S. W. Wells.

	Thickness *Feet*
Hog Creek shale—	
1. Shale, gray, in places black and carbonaceous, containing lentils of sandstone in the upper half	117
Total thickness measured	174

Section of the Caddo Creek formation on the M. Castleman Survey 2 miles north and one-half mile west of Pickwick, along an east-west road over a mountain west of Brazos River.

	Thickness *Feet*
Home Creek limestone—	
14. Limestone, grayish white, hard	1
13. Shale or marl, unexposed	10
12. Limestone, light grayish white, hard, rough surfaced, breaks into rough-surfaced chunks, contains a few fossils and a little chert in the upper layers	10
Hog Creek shale member—	
11. Clay or shale covered by talus	5
10. Shale, greenish gray, soft, containing streaks and spots of white gypsiferous material	5½
9. Limestone, nodular, porous; uneven surfaces carrying fragments of shells	¾
8. Shale, gray, sandy, calcareous, soft, contains a layer or lentil of gray conglomerate from 6 to 8 inches thick made up of subangular and rounded pebbles of the same gray sand and a few pebbles of limestone	2½
7. Shale, poorly exposed	31?
6. Sandstone, yellowish gray, soft, fine grained, thin bedded	4
5. Shale, greenish gray, poorly exposed	33
4. Limestone, gray, hard, rough surfaced, forms a bench	¾
3. Shale, bluish gray, nonfossiliferous, somewhat sandy, containing thin streaks and seams of limonite	54
2. Shale, dark grayish blue, weathers to light grayish yellow, soft, thinly laminated, containing great number of small limonitic concretions; few fossil fragments and one layer of concretionary limestone poorly exposed along a ditch near side of road	46
Ranger limestone—	
1. Limestone, gray, hard, irregularly bedded, weathers to form unevenly shaped chunks	10+
Thickness of section measured	213+

Noteworthy features.—The Caddo Creek formation has the narrowest belt of outcrop of any of the Canyon formations except the Palo Pinto. It constitutes in most places only an escarpment below the Home Creek limestone, and consequently it is obscured by talus and slope wash. The formation consists mostly of shale with sandy layers and one or two thin layers of limestone, which in some places produces benches beneath the Home Creek outcrop. In some places the shales carry so many small ferruginous nodules, that they have the appearance of gravel beds.

Paleontology and correlation.—The Caddo Creek formation is not particularly fossiliferous in Palo Pinto County. The Home Creek limestone contains a few fossils, mostly the common middle Pennsylvanian species that live in highly calcareous environments. The shales are ferruginous, carbonaceous, and of a type that carry few marine fossils. Outside Palo Pinto County, however, a few collections have been made from this formation, and doubtless some may be discovered in the future somewhere within the area of Palo Pinto County.

The correlation of the strata of this formation with those exposed in the Colorado River valley is shown in figure 2.

GRAHAM FORMATION[53]

Stratigraphy.—The Graham formation[54] outcrops in the extreme northwestern corner of Palo Pinto County, northwest of Brazos River. It caps some of the highest divides west of Brad (Pl. II).

The formation consists of thin limestones, thin sandstones, and a thick bed of soft, laminated shale that grades upward into sandy shale. The total thickness of the formation is about 400 feet, but only the lower 125 feet of the section are exposed in Palo Pinto County. This part of the section comprises the following members:

4. Bunger limestone (6′).
3. Gonzales Creek shale (116′).

[53] *Literature.*—Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas: Jour. Geol., vol. 30, pp. 27-28, 1922. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 125–152, 1921. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, pp. 113–114, 1933.

[54] *Definition.*—The Graham formation was named by Plummer and Moore and made to include all the strata from the top of the Home Creek limestone upward to the base of the Avis sandstone. The type locality is the bluff on Salt Creek west of Graham, Young County.

2. Eastland sandstone (10′–15′).[55]
1. Finis shale (50′).

Section of the lower portion of the Graham formation near the center of the Susan Latham Survey, measured along a small branch near a north-south road 5½ miles south of Bunger, Young County.

	Thickness *Feet*
Bunger limestone—	
11. Limestone, grayish yellow, unevenly bedded, hard; breaks into thin, uneven, rough-surfaced chips from 2 to 6 inches thick; contains traces of fossils and a network of curved veins of darker calcite, probably algal remains. The lower surface in places is covered by branching algal groups and large fucoid markings	6
Gonzales Creek shale—	
10. Shale, greenish, yellow, soft, covered by talus	20
9. Limestone, buff, rough surfaced, sandy, contains many crinoid remains, exposed only in a road ditch	1
8. Shale, covered by talus and soil	14
7. Sandstone, buff, calcareous, soft, medium and fine grained, smooth surfaced, thin bedded	2
6. Shale, light yellowish gray, sandy, grading downward into a non-arenaceous shale	12
5. Coal or very carbonaceous shale	½
4. Shale, gray, contains large numbers of nodules of limonitic material and a few hematitic nodules	4
3. Shale, dark gray, thinly laminated, contains many impressions of leaves and stems of coal plants	2
2. Shale, gray and blue, contains blotches of red, grades downward into sandy shale containing thin layers of sandstone	46
Eastland sandstone—	
1. Sandstone, dark grayish brown, thin bedded at top grading downward into thick, massive beds of medium- to coarse-grained sand	14
Total thickness of section measured	121½

[55]The Eastland sandstone is here defined as the first continuous sandstone bed above the Home Creek limestone. It is well exposed in the railroad cut about a mile northwest of Eastland, Eastland County, and the main escarpment lies north and northeast of Lake Eastland (Cy_2 on geologic map of Eastland County, Coöperative Mapping Committee, Bureau Economic Geology). It caps escarpments west of Finis in Jack County, and many elevations along Caddo Creek northeast of Caddo in Stephens County.

Section of Graham formation below that of the above section, south end of the sandstone escarpment on south side of Susan Latham Survey, 6½ miles south of Bunger, Young County.

	Thickness *Feet*
Eastland sandstone—	
5. Sandstone, dark grayish brown, massively bedded, same as No. 1 in above section	14±
Finis shale—	
4. Shale, bluish gray, calcareous, covered by sandy soil and forming long slope	52±
Home Creek limestone—	
3. Limestone, white, hard, smooth surfaced	1
2. Shale, unexposed; forms red soil	15
1. Limestone, white, hard, irregularly bedded, fossiliferous; forms escarpment	16
Total thickness of section measured	98±

Noteworthy features.—Characteristic features of the Graham formation are: (1) the well-known *Uddenites* zone of ammonites and numerous associated fossils that occur in the lower layers of the formation just above the Home Creek limestone; (2) the *Campophyllum*[56] zone consisting of great numbers of large corals that occur in places above the *Uddenites* zone and adjacent to the Eastland sandstone; (3) the Bunger limestone with its peculiar, uneven partings and its algal markings; and (4) the thin coal seam and associated carbonaceous shale containing leaf impressions similar to those in the Gonzales shale about 50 feet below the Bunger limestone. The coal bed is about six inches thick and consists of black, impure, poor-grade, earthy coal. It overlies a thick bed of dark-gray, thinly laminated, soft shale containing many impressions of leaves and stems of coal plants and numerous limonite nodules, some of which carry traces of plant remains. This carbonaceous zone in places is highly ferruginous. The iron oxidizes to produce a deep red soil that can be traced across the county from the Brazos to the Colorado River valley. The deep red color is a good criterion for distinguishing the Cisco from the Canyon.

[56]The *Campophyllum* bed has not yet been recognized in the short outcrop in Palo Pinto County but occurs to the northeast in Jack County and to the southwest in Stephens County.

Paleontology and correlation.—The fossils from the lower member of the Graham formation are about the best preserved and most interesting assemblages in the Pennsylvanian section. They are characterized by the well-known discoidal ammonite, *Uddenites*, and its associated cephalopods, *Marathonites*, *Agathiceras*, *Schistoceras*, *Gonioloboceras*, and *Gastrioceras*, thus constituting the richest ammonoid zone in the entire section.

Fauna[57] *of the Gonzales Creek shale west of Finis, Young County*

Anthozoa—
- Lophophyllum profundum (Milne-Edwards and Haime)
- Lophophyllum profundum radicosum Girty
- Zaphrentis gibsoni? White

Crinoidea—
- Delocrinus sp.

Brachiopoda—
- Trigonoglossa nebrascensis (Meek)
- Rhipodomella carbonaria var. subcircularis R. H. King, n. sp. (MS.)
- Chonetina? rostrata Dunbar and Condra
- Lissochonetes plattsmouthensis Dunbar and Condra
- Dictyoclostus crassicostatus Dunbar and Condra
- Marginifera wabashensis (Norwood and Pratten)
- Marginifera lasallensis (Worthen)
- Neospirifer texanus (Meek)
- Ambocoelia planoconvexa (Shumard)
- Composita subtilita (Hall)

Pelecypoda—
- Nuculopsis ventricosa (Hall)
- Leda bellistriata Stevens
- Yoldia glabra Beede and Rogers
- Pinna sp.
- Conocardium obliquum Meek and Worthen
- Allerisma subcuneatum Meek and Hayden
- Allerisma sp.
- Cypricardinia carbonaria Meek
- Astartella concentrica (McChesney)
- Astartella varica McChesney

Gastropoda—
- Phanerotrema grayvillense (Norwood and Pratten)
- Worthenia tabulata (Conrad)
- Trepospira illinoisensis (Worthen)
- Euphemites vittatus (McChesney)
- Euomphalus subrugosus (Meek and Worthen)
- Meekospira choctawensis Girty

Cephalopoda—
- Orthoceras, n. sp.
- Protocycloceras? rushense? (McChesney)

The correlation of the strata is shown in the columnar sections, figure 2. The ammonites and associated fossils are identical with the assemblages collected from beneath the *Campophyllum* limestone in the railroad cut 3.7 miles by road southeast of Jacksboro, Jack County, with those that occur not far above the Home Creek limestone east and northeast of Weedon School in Brown County, and with those found two miles east of Fife in McCulloch County, and they are very similar to the assemblage from the classic *Uddenites* zone at Wolfcamp in the Glass Mountains, Brewster County.

No good fossiliferous outcrops of Graham formation have been found in Palo Pinto County. Doubtless they occur, for excellent

[57]Identifications by R. H. King and the authors.

collections have been obtained just north of the county line in Jack County and west of the county line in Stephens County. These nearby localities are as follows:

118-T-8. Railroad cut on Rock Island Railroad under the viaduct on the Jacksboro-Mineral Wells highway, 3.7 miles by road southeast of the courthouse in Jacksboro, Jack County. Finis shale member.

214-T-27. Base of southwest-facing escarpment on right bank of Caddo Creek, about 0.2 of a mile upstream from the small bridge 1.5 miles by road northeast of Caddo, Stephens County. (Locality discovered by George D. Harris.) Shale just on top of Home Creek limestone.

Subsurface Section

CLASSIFICATION OF FORMATIONS

The deepest wells drilled in Palo Pinto County penetrate more than 5,000 feet of sedimentary strata beneath the Millsap Lake beds, the oldest strata that outcrop at the surface. These subsurface strata have been divided into three systems and five main divisions, as follows:

Pennsylvanian—
  Strawn group—
    Millsap Lake formation
  Bend group—
    Smithwick formation
    Marble Falls formation
Mississippian—
    Barnett formation
Ordovician—
  Ellenburger group

ELLENBURGER LIMESTONE[58]

Regional geology.—The Ellenburger[59] limestone has been encountered in the Palo Pinto County wells listed in Table 1.

---

[58]*Literature.*—Paige, Sidney, Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology: U. S. Geol. Survey Bull. 450, p. 21, 1911; Description of the Llano-Burnet quadrangles: U. S. Geol. Survey Atlas, Llano-Burnet folio (No. 183), 1912. Roundy, P. V., Girty, George H., and Goldman, M. I., Mississippian formations of San Saba County, Texas: U. S. Geol. Survey Prof. Paper 146, pp. 44-48, 1926. Udden, J. A., and Waite, V. V., Some microscopic characteristics of the Bend and Ellenburger limestones: Univ. Texas Bull. 2703, pp. 1-61, 1927. Dake, C. L., and Bridge, Josiah, Faunal correlation of the Ellenburger limestone of Texas: Geol. Soc. Am. Bull., vol. 43, pp. 725-741, 1932. Sellards, E. H., Stratigraphic and structural relations of pre-Carbonic formations in Big Lake field: Pan-Amer. Geol., vol. 57, p. 305, 1932; The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, vol. 1, pt. 1, pp. 70-71, 1933.

[59]*Definition.*—The name Ellenburger was given to the limestone outcropping in the Ellenburger hills of the Llano-Burnet region by Sidney Paige, and made to include the dolomitic limestone between the Wilberns formation and strata of Carboniferous age.

TABLE 1.—*Ellenburger limestone in wells in Palo Pinto County.*[60]

COMPANY	WELL	LOCATION	DEPTH *Feet*	THICKNESS PENETRATED *Feet*
Burton & McKee	Strawn Coal Co. No. 4	A. Ashworth Surv., 3½ mi. NE. of Strawn	3780-3797	17
Goodman, Lacey, & White	Guest No. 1	Burleson Co. Sch. lands Surv., sec. 73, 4 mi. N., 8½ mi. E. of NW. cor. of county	3835-3850	15
Gordon & Gholson	McDonald No. 2	T. & P. R. R. Co. Surv., Blk. 2, sec. 33, 1 mi. S. of Palo Pinto	4845-4887	42
Gordon & Gholson	Taylor No. 1	T. & P. R. R. Co. Surv., Blk. 1, sec. 21, 2 mi. W., 1 mi. S. of Palo Pinto	4792-4527	165
Magnolia Pet. Co.	Pennington No. 1	T. E. & L. Surv., Sec. 1789, 12 mi. W., 4½ mi. N. of Mineral Wells	4560-4650	90
Nelson Oil Syn.	Finch No. 1	Pates & Kent Surv., Blk. 44, 3 mi. S. of Gordon	3820-3821	1
Nelson Oil Syn.	Finch No. 2	N. Dickerson Surv., Subd. 45, Blk. 44, 3 mi. S. of Gordon	3820-4146	326
Owens, Burkett, & Wheeler	Sanger No. 1	J. J. Metcalf Surv., 10 mi. W., 3 mi. N. of Mineral Wells	4706-4890	84
Pender Prod. Co.	Rasmussen No. 2	T. & P. R. R. Co. Surv., Blk. 3, sec. 46, 2½ mi. SE. of Brad	4215-4245	30
Roxana Pet. Co.	Seaman No. 1	T. & P. R. R. Co. Surv., Blk. 3, sec. 6, 9½ mi. S., 1 mi. E. of NW. cor. of county	4519-4535	16
Shaw et al.	Chestnut No. 2	T. & P. R. R. Co. Surv., Blk. A, sec. 40, 9 mi. S., 1 mi. W. of Mineral Wells	4918-5123	205
Texas & Pacific Coal & Oil Co.	Lasseter No. 1	A. B. & M. Surv., sec. 5, 1⅓ mi. NE. of Gordon	4029-5630	1601
Texas & Pacific Coal & Oil Co.	Ringo No. 1	T. & P. R. R. Co. Surv., Blk. 2, sec. 85, 7½ mi. N., 12 mi. E. of SW. cor.	4250-4375	125
Texas & Pacific Coal & Oil Co.	Stuart No. 153	W. J. Betterton Surv., Blk. 1, 4 mi. W. of Strawn	3750-3776	26
The Texas Co.	McDonald No. 1	T. & P. R. R. Co. Surv., Blk. 1, sec. 31, 2 mi. W., 1 mi. S. of Palo Pinto	4635-4665	30
Zada Belle Oil Co.	Weldon No. 2	C. E. P. I. & M. Co. Surv., 2½ mi. S. of Pickwick	4640-4700	60

[60]Compiled by E. H. Sellards.

The Ellenburger limestone underlies the Carboniferous strata of Palo Pinto County. It is reached at depths varying from 4100 to 4500 in the western part of the county and below 5,000 feet in the eastern side. It is light gray or white, massively bedded, hard, crystalline, and dolomitic. The upper part is porous and contains sulphur water in most places. The total thickness of the formation in Palo Pinto County is unknown. The thickest section that has been drilled is 1601 feet in Lasseter No. 1. In other counties it is known to be more than 2000 feet thick.

Stratigraphic sections.—Details of the strata are given in the following descriptions of samples obtained from deep wells:

Description of samples of Ellenburger limestone from the L. E. Lasseter No. 1, drilled by Texas and Pacific Coal and Oil Company, section 5, 1½ miles northeast of Gordon.

	Depth *Feet*
Limestone, gray, crystalline, contains a little pyrite	4029–4035
Limestone, gray, hard, dolomitic	4035–4085
Limestone, gray, hard, dolomitic, containing some quartz crystals	4085–4151
Limestone, white to light gray, crystalline	4151–4200
Limestone, gray, crystalline	4200–5612
Total thickness represented	1583

Description of samples[61] *of Ellenburger limestone from the Finch No. 1, drilled by Nelson Oil Syndicate, Bates and Kent Survey, Block 44, 3 miles south of Gordon.*

	Depth *Feet*
Limestone, gray and light gray, dolomitic, containing pyrite and a few fragments of light-colored chert. In thin section the dolomite is finely crystalline, of uniform texture, and contains a few diamond-shaped crystals of dolomite from 0.1 to 0.5 mm. in size	3820–3827
Limestone, white, dolomitic, crystalline, numerous diamond-shaped crystals of dolomite	3827–3889
Limestone, white, dolomitic, fine grained, even textured, containing calcite and white or light-colored chert and a few large crystals of dolomite	3889–3992
Limestone, white, fine grained, containing much white chert, thin section shows finely granular texture	3959

[61]Described by J. A. Udden, D. D. Christner, and E. H. Sellards.

	Thickness *Feet*
Dolomite, light colored, fine textured, crystalline; dolomite contains fragments of light-colored chert	3991
Dolomite, gray, fine grained, containing light-colored chert, and finely granular and crystalline dolomite	4010
Dolomite, light gray, stained with iron and containing a few grains of quartz	4075–4088
Dolomite, light yellowish gray, largely crystalline, containing small quartz grains and fragments of light-colored chert	4088
Limestone, dolomitic, containing quartz grains and chert fragments. Some quartz grains have secondary crystalline faces	4130
Limestone, light gray, containing much chert and some minute quartz grains; one thin section shows larger crystals of dolomite imbedded in a fine-grained matrix	4133
Limestone, white, containing much crystalline calcite, fragments of dolomite, light-colored chert, and minute quartz grains, and a large number of zircon crystals varying in size from 0.01 to 0.1 mm. in size. Average size, about 0.02 mm.	4146

Noteworthy features.—The Ellenburger is distinguished in well samples from the overlying Pennsylvanian limestones by the following characteristics:

1. Color. The rock is generally light gray or grayish white, distinctly lighter in color than the limestones in the Bend group.
2. Reaction with acid. The rock does not in general effervesce so easily nor dissolve so readily in cold acid as do the light-colored Pennsylvanian limestones.
3. Microscopic character. Most thin sections of the rock viewed through the microscope consist of rhombic, angular crystals of dolomite a millimeter or more in size surrounded by a very finely crystalline, light-gray, ground mass of dolomite and calcite.
4. Chert. The chert nodules are more numerous and lighter in color than the chert in the Pennsylvanian.
5. Microscopic fossils. The rock contains less organic material, fewer, if any, foraminifera, and fewer, if any, spicules.

Paleontology and correlation.—The Ellenburger limestone, as it is represented by well cores and cuttings, rarely contains fossils. Small crinoid stems are found in some samples, and more rarely thin sections show traces of foraminifera. The formation in outcrop is somewhat more fossiliferous. The limestone north of Cherokee in San Saba County has been divided by Dake and Bridge[62] into five faunal zones, which have been named tentatively for equivalent zones in the Ordovician section of Missouri. The five zones have not been named in well sections, and all attempts to subdivide the formation from well samples in this county have proved unsuccessful.

BARNETT FORMATION[63]

Regional geology.—The Barnett formation[64] is penetrated by wells that drill into the Ellenburger limestone in Palo Pinto County. It lies unconformably upon the Ellenburger limestone,[65] or possibly in some places on white or pinkish-white Mississippian limestone, and it is overlain conformably by the Marble Falls limestone.

The formation consists of brownish-black shales interbedded with dark-brown or dense-black, hard, thin-bedded limestone layers. The shales and limestones contain numerous microfossils, much pyrite, and carbonaceous matter. The shales yield a snuff-colored mud slush while being drilled and contain many hard, thin streaks of flaggy limestones and concretions. They yield often an odor of oil and even small bubbles of oil and gas. The brownish-black strata are not distinguishable from the overlying Marble Falls limestone in most driller's logs, but they can be easily recognized by geologists in a series of well samples. The formation thickens somewhat toward the east from about 100 feet on the west side of the county to

---

[62]Dake, C. L., and Bridge, Josiah, Faunal correlation of the Ellenburger limestone of Texas: Bull. Geol. Soc. Am., vol. 13, pp. 725–748, 1932.

[63]*Literature.*—Girty, G. H., The Bend formation and its correlation: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 118–120, 1919. Girty, G. H., and Moore, R. C., Age of the Bend series: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 418–420, 1919. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 21-32, 1922. Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas: Jour. Geol., vol. 30, p. 26, 1922. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, vol. 1, pt. 1, pp. 92–94, 1933.

[64]*Definition.*—The Barnett formation was named by Plummer and Moore for the dark shales and few interbedded limestone layers between the top of the Ellenburger limestone and the base of the massive Marble Falls limestone. The type locality is an exposure near Barnett Springs in San Saba County.

[65]As far as is known, no Mississippian rocks of pre-Barnett age have been reported in Palo Pinto County. Lower Mississippian strata have been recognized, however, in well sections in Young County and may occur in places in Palo Pinto County.

TABLE 2.—*Thicknesses of the Barnett formation in wells in Palo Pinto County.*

COMPANY	WELL	LOCATION	DEPTH *Feet*	THICKNESS PENETRATED *Feet*
Burton & McKee	Strawn Coal Co. No. 1	Abner Ashworth Surv., 4600′ from E., 8600′ from N. line	3590–3780	190
Goodwin & White	Guest No. 1	Burleson Co. Sch. Lands Surv., SW. cor., NW. ½ sec. 73	3620–3835	215
Gordon & Gholson	Taylor No. 1	T. & P. R. R. Surv., SE. cor. NW. ¼ sec. 21, Blk. 1	4527–1720	193
Gordon et al.	G. W. McDonald No. 2	T. & P. R. R. Co. Surv., SE. cor. SE. ¼ sec. 33	4650–1845	195
Magnolia Pet. Co.	Pennington No. 1	Samuel F. Harding Surv., 1400′ S., 250′ E. of NE. cor. of survey	4570–4650	80
Nelson Oil Syn.	T. W. Finch No. 2	Dickerson Surv., Subd. 45	3685–3820	135
Owens & Burkett	Holt No. 1	J. J. Metcalf Surv., SE. cor.	4635–4706	71
Roxana Pet. Co.	Seaman No. 1	T. & P. R. R. Co. Surv., Blk. 3, NW. cor., sec. 6	4370–4519	149
T. G. Shaw	Chestnut No. 2	T. & P. R. R. Co. Surv., Blk. A, NE. cor. SW. ¼ sec. 40	4748–4918	170
The Texas Co.	Watson No. 1	T. & P. R. R. Co. Surv., Blk. 2, SW. cor. sec. 31	4410–1250	180
Texas & Pacific Coal & Oil Co.	Ringo No. 1	T. & P. R. R. Co. Surv., Blk. 2, NE. ¼ sec. 32	4010–4250	240
Texas & Pacific Coal & Oil Co.	Stuart No. 153	W. J. Betterton Surv., Blk. 1, 4000′ from E. line, 1200′ from N. line	3662–3750	88
Zola Belle Oil Co.	J. K. Weldon No. 1	A. J. Smith Surv., 1800′ S., 200′ W. of SE. cor.	4540–1640	100

160 to 250 feet on the east side. Table 2 shows the thickness of the formation in several wells.

Stratigraphic sections.—The following descriptions of samples from typical well logs illustrate the character of the Barnett strata in the county:

Descriptions of samples[66] *of Barnett shale from the Finch No. 2, drilled by Nelson Oil Syndicate, N. Dickerson Survey, Block 44, 3 miles south of Gordon.*

	Depth *Feet*
Shale, black, calcareous, contains a small number of minute pyrite crystals and much bituminous material. A thin section shows a large number of minute spicules and an impregnation of bituminous material; few foraminifera. When heated in a closed tube, much oil was distilled out on the side of the tube	3685–3820
Thickness	135

Descriptions of samples of Barnett shale from the Lasseter No. 1, drilled by the Texas and Pacific Coal and Oil Company, A. B. & M. Survey, section 5, 1½ miles northeast of Gordon.

	Depth *Feet*
Shale, densely black, fine grained, fossiliferous	3913–4005
Shale, black, soft, fossiliferous	4005–4029
Thickness	116

Descriptions of samples[67] *of Barnett shale from Seaman No. 1 drilled by Roxana Petroleum Company, Texas and Pacific Railroad Survey, Block 3, northwest corner of section 6.*

	Depth *Feet*	Thickness *Feet*
Shale, brownish black, sandy, slightly calcareous	4372–4420	48
Shale(?), no samples obtained	4420–4470	50
Shale, brownish black, sandy, slightly calcareous	4470–4510	40
Shale, black, sandy, containing glauconite	4510–4512	2
Shale, black, calcareous	4512–4517	5
Limestone, glauconitic	4517–4519	2
Total thickness		147

[66]Described by J. A. Udden, D. D. Christner, and E. H. Sellards.

[67]Goldman, Marcus I., Lithologic subsurface correlation in the "Bend Series" of north-central Texas; U S Geol. Survey, Prof. Paper 129, p. 1, 1921.

Noteworthy features.—The most characteristic features of the Barnett shale are its color, its petroliferous odor, and its fauna rich in species of *Goniatites.* The shales are soft, black or brownish black, easily distinguishable from the deep coal-black color of the Smithwick shale above. Freshly broken fragments give a strong odor of oil and, when distilled in a retort or closed tube, yield perceptible quantities of shale oil. The minute Mississippian goniatites that occur in the thin layers of limestone near the base of the formation furnish the most certain method of distinguishing the Barnett formation.

Paleontology.—The following fossils obtained from deep wells in the Strawn district and from the outcrop southeast of San Saba are characteristic of the formation:

Brachiopoda—
- Ambocoelia planoconvexa (Shumard)
- Leiorhynchus carboniferum (Girty)
- Lingula albapinensis (Walcott)
- Cleiothyridina sp.
- Composita sp.

Pelecypoda—
- Leda bellistriata Stevens
- Cancyella sp.

Gastropoda—
- Pleurotomaria cf. P. perhumerosa Meek

Cephalopoda—
- Goniatites cumminsi Hyatt
- Goniatites incisus (Hyatt)
- Goniatites choctawensis Shumard
- Gastrioceras entogonum (Gabb)

MARBLE FALLS FORMATION[68]

Regional geology.—The Marble Falls formation[69] is penetrated in all deep wells in Palo Pinto County. It contains the zone that car-

[68]*Literature.*—Hill, R. T., A portion of the geologic story of the Colorado River of Texas: Am. Geol., vol. 3, pp. 287–299, 1889. Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey, Second Ann. Rept., pp. 360–367, 1891. Udden, J. A., Baker, C. L., and Bose, E., Review of the geology of Texas: Univ. Texas Bull. 44, p. 42, 1916. Girty, G. H., The Bend formation and its correlation: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 71–81, 1919. Girty, G. H., and Moore, R. C., Age of the Bend series: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 418–420, 1919. Moore, R. C., The Bend series of central Texas: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 217–229, 1919. Goldman, M. I., Lithologic subsurface correlation of the "Bend Series" of north-central Texas: U. S. Geol. Survey Prof. Paper 129, pp. 1–22, 1921. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 32–55, 1921. Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas: Jour. Geol., vol. 30, pp. 26–30, 1922. Sellards, E. H., The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, vol. 1, pt. 1, p. 100, 1933.

[69]*Definition.*—The Marble Falls limestone formation was named by R. T. Hill in 1889. It now includes the lower Pennsylvanian strata from the top of the Barnett formation of

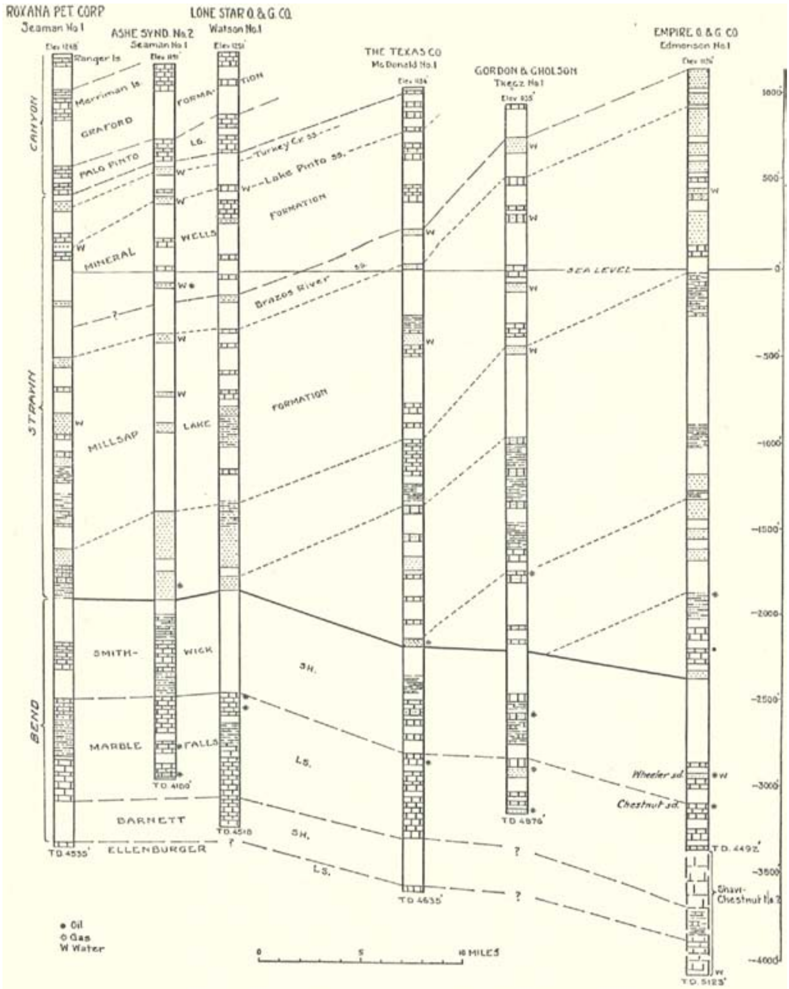


FIG. 6.—Northwest-southeast subsurface section across a portion of Palo Pinto County, showing the strata of the Strawn and Bend groups.

ries oil in deep wells in the Strawn Townsite pool, in the deep wells of the Dalton Ranch field, and in the Brazos pool. and also the zone that yields gas near Graford, on the Chestnut ranch south of Mineral Wells, and in the Brazos and Strawn Townsite gas pools.

Mississippian age upward to the base of the Smithwick shale formation. It is of Pottsville age and carries a Pottsville fauna easily distinguishable from the more specialized and more highly developed fauna of the Smithwick.

The formation consists of dark-gray and black, hard, fossiliferous limestones, interbedded with thinner layers of black, highly carbonaceous. splintery shale. The formation is about 400 feet thick in the western part of the county and increases in thickness toward the east to 1000 feet or more east of Mineral Wells, as shown in the cross section, figure 6. The average thickness in deep wells in the county is 600 feet.

The formation has not been subdivided into members. The upper 60 to 150 feet in most wells is more or less massive, dark-gray or black limestone. The middle 300 feet consists of alternating limestone and shale. The limestone layers range from a few feet to 50 feet thick. The formation contains a larger proportion of limestone in the sections penetrated in the western part of the county, and more shale in the wells in the eastern half (fig. 6). The lower 200 feet is made up of thick beds of gray, spotted, and black limestone, which is quite sandy in some sections. A brown, coarse-grained, siliceous sand, 10 to 15 feet thick, occurs near the base of the formation in wells near Palo Pinto.

Stratigraphic sections.—The following descriptions of samples from wells drilled through the Marble Falls formation in the county furnish lithologic details of the subsurface section of the formation.

Descriptions[70] *of samples of Marble Falls limestone from the Finch No. 2, drilled by Nelson Oil Syndicate, Bates and Kent Survey, Block 44, 3 miles south of Gordon.*

	Depth *Feet*
Limestone, black and dark gray, containing thin partings of black, fissile shale. Much bituminous material occurs in the shale and limestone. The limestone has a finely granular texture and contains organic fragments and many spicules. When heated in a closed tube the sample gives off very strong fumes of bitumen and some fumes of sulphur	3482–3685
Total section described	203

[70]Described by J. A. Udden, D. D. Christner, and E. H. Sellards.

Descriptions of samples of Marble Falls limestone from the L. E. Lasseter No. 1, drilled by Texas and Pacific Coal and Oil Company, A. B. & M. Survey, section 5, 1½ miles northeast of Gordon.

	Depth *Feet*
Limestone, dark gray to black, crystalline, fossiliferous, contains pyrite	3300–3310
Limestone, gray to dark gray, crystalline, hard	3310–3325
Limestone, gray, crystalline	3325–3330
Shale, black, fine grained; contains some fossil fragments and small amounts of hard, gray shale	3330–3340
Shale and limestone. Shale, black, mixed with some gray, hard shale; limestone, dark gray, crystalline, hard	3340–3345
Limestone, dark gray, crystalline	3345–3355
Shale, black, fine grained, hard; contains a minute pelecypod	3355–3395
Shale, black, hard, contains streaks of dark gray limestone, a little quartz, and pyrite	3395–3405
Shale, black. containing fragments of fossils	3405–3416
Limestone, dark gray to black, hard	3416–3445
Limestone, black and gray, hard, crystalline	3445–3467
Limestone, gray, fine grained, hard	3473–3477
Limestone, dark gray, crystalline, contains crinoid stems	3719–3723
Limestone, dark gray, interbedded with black shale	3723–3913
Total section described	613

Paleontology and correlation.—Only a few fossils have been obtained from well samples of Marble Falls limestone in Palo Pinto County. The few that have come to the surface, however, are identical with forms collected from the outcrop in San Saba County and prove definitely that the Marble Falls formation is present in the Palo Pinto County subsurface section and is fully developed.

Fossils obtained from samples of Marble Falls limestone are as follows:

Coelenterata—
- Lophophyllum sp.
- Campophyllum sp.
- Michelinia sp.
- Chaetetes milleporaceus Milne-Edwards and Haime

Bryozoa—
- Fenestella sp.
- Cystodictya sp.

Brachiopoda—
  Chonetes sp.
  Avonia arkansana (Girty)
  Squamularia sp.
  Spirifer rockymontanus Marcou
Pelecypoda—
  Aviculopecten sp.
Gastropoda—
  Bellerophon sp.
  Euphemites sp.
Cephalopoda—
  Orthoceras sp.
  Gastrioceras sp.
Trilobita—
  Griffithides scitulus var. major Meek and Worthen

SMITHWICK FORMATION[71]

Regional geology.—The Smithwick shale[72] underlies the Strawn strata throughout the county. It is penetrated at depths varying from 3075 to 3375 feet in the western part of the county and from 4000 to 4500 feet in the eastern part. It is overlain unconformably by a thick and persistent sand layer characterized by black and white chert grains, referred to by some oil geologists as "pepper and salt" sand and by others as the "Hurry up" sand. It is underlain conformably by the Marble Falls formation carrying a typical Marble Falls fauna.

The Smithwick formation in the western part of the county consists of three divisions, as follows:

3. Upper shale bed made up mostly of black, fissile, brittle shale or slate, but containing some gray shale, a little sandy shale, and a few layers of thin, hard, gray or black limestone. The average thickness of the upper division is 300 feet.

---

[71]*Literature.*—Paige, Sidney, Description of the Llano and Burnet quadrangles: U. S. Geol. Survey Atlas, folio 183, pp. 1–16, 1912; Mineral resources of the Llano-Burnet region, Texas: U. S. Geol. Survey Bull. 450, pp. 57–59, 1911. (See also references cited for Marble Falls formation.)

[72]*Definition.*—The Smithwick shale was named by Sidney Paige and made to include the strata between the top of the Marble Falls formation and the base of the Strawn group. The type locality was not definitely described by Paige. It has been regarded, however, as the exposures in the vicinity of Smithwick. Recently doubt has been raised concerning the age of the shales at Smithwick. No invertebrate fossils have been found, and plant remains indicate a strong possibility that these so-called Smithwick exposures are Strawn in age and not Bend. For this reason, Sellards has wisely suggested that the type locality be changed from Smithwick to the excellent and typical exposures of this shale formation along the bank of Colorado River one-half mile to one mile west of Bend, San Saba County, where it has been studied by so many geologists and where it carries a rich fauna.

2. Middle limestone divisions made up of lenticular layers of black limestone intercalated with black shale. In the wells on the Dalton ranch in the central part of Palo Pinto County, the limestones are described as gray, but elsewhere they are black. These limestones are locally referred to as the "Caddo lime" because they yield some oil in the Caddo field and in wells drilled on the Hart ranch in the extreme western part of the county. The limestone lentils change laterally to shales and lose their identity in the eastern part of the county (fig. 6). The average thickness of this middle division is 225 feet.
1. Lower shale division made up of shales, gray limestone lentils, and a sandy limestone at the top. This division is referred by some geologists to the Marble Falls, and it is quite possible that their interpretation is correct. Since the limestones are lenticular, however, and in places appear to change laterally to typical black, splintery Smithwick shale, and since in the eastern part of the county shales predominate in this part of the section, the division is referred tentatively to the Smithwick. The average thickness of this division is 185 feet.

Stratigraphic sections.—The following sections from typical wells in this county furnish further details of the strata of the Smithwick formation:

Section of the Smithwick formation in the Seaman No. 1, drilled by Roxana Petroleum Company, T. & P. R. R. Survey, Block 3, section 6, 4½ miles in a direct line north-northwest of Brad.

	Depth *Feet*	Thickness *Feet*
Upper shale division—		
Slate, blue, soft	2760–2875	115
Limestone, hard	2875–2885	10
Shale, dark gray, sandy	2885–2900	15
Shale, dark blue, brittle	2900–2925	25
Shale, dark blue, sandy	2925–2975	50
Middle or limestone division—		
Limestone, dark, sandy, hard	2975–3073	98
Lower shale division—		
Shale, dark, soft, fissile	3073–3150	77
Shale, dark blue	3150–3375	225
Limestone, hard, white	3375–3380	5
Slate, dark blue, soft	3380–3430	50
Total thickness		670

Descriptions of samples of Smithwick shale from the Dye No. 1, drilled by Roxana Petroleum Company, T. E. & L. Survey, section 379, 1½ miles east of Graford.

	Depth Feet	Thickness Feet
Shale, black	3380–3410	30
Shale, dark gray	3410–3430	20
Shale, black	3430–3570	140
Shale, blue gray	3570–3580	10
Shale, bluish black	3580–3590	10
Shale, dark gray	3590–3610	20
Shale, black	3610–3630	20
Shale, gray	3630–3650	20
Sand, brown	3650–3654	4
Shale, gray	3654–3886	232
Total thickness		506

Paleontology and correlation.—The black, splintery, fissile shale of the Smithwick formation contains few fossils. The softer, more calcareous layers adjacent to the thin limestone members in some sections are fairly fossiliferous in both microscopic and in large forms. In some places beautiful pyritized specimens are recovered from the drill cuttings. The following forms have been collected from samples of Smithwick shale obtained in an oil well in the Desdemona oil field:

Ambocoelia planoconvexa (Shumard)
Trepospira illinoisensis (Worthen)
Bellerophon smithwickensis Moore, n. sp. (MS.)
Leda bellistriata Stevens
Orthoceras sp.
Pronorites arkansasensis Smith
Prolecanites sandburgeri Schindewolf
Phanerotrema, n. sp., Moore, MS.
Pleurotomaria?, n. sp., Moore, MS.
Meniscophyllum, n.sp., Moore, MS.

STRAWN GROUP[73]

Regional geology.—The Strawn group[74] outcrops at the surface in the southeastern and southern parts of the county and in the

[73]*Literature.*—Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey, Second Ann. Rept., p. 522, 1891. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 59 87, 1921. Scott, Gayle, and Armstrong, J. M., The geology of Wise County, Texas: Univ. Texas Bull. 3224, pp. 14–19, 1932. Bay, Harry X, A study of certain Pennsylvanian conglomerates of Texas: Univ. Texas Bull. 3201, pp. 166–173, 1933. Scott, Gayle, and Armstrong, J. M., The geology of Parker County, Texas: MS. submitted for publication, 1933.

[74]*Definition.*—The Strawn group was named by Cummins in 1890 and made to include all the strata between the top of the Smithwick shale and base of the Palo Pinto limestone.

western half is penetrated in all wells that drill beneath the Palo Pinto limestone. The outcropping Strawn strata have already been described.

The strata encountered in wells below the horizon of the Thurber coal consists largely of blue, sandy, soft, unfossiliferous shale containing thick layers of coarse siliceous sandstone, thinner layers of fine calcareous sandstone or limestone, and a few beds of black carbonaceous shale. It is lighter colored, softer, and more sandy than the Smithwick, and it contains fewer and darker colored limestones than the Canyon. The upper strata of the Mineral Wells formation in some of the well sections in the western part of the county contain lentils and layers of hard, blue limestone, samples from which are mistaken for the Palo Pinto limestone by some geologists.

Stratigraphic sections.—The following sections of the Strawn strata, as described from typical well sections, show the aspects of the subsurface strata:

Section of the Strawn group of strata in the Dye No. 1, drilled by Roxana Petroleum Company, T. E. & L. Survey, section 879, 1½ miles east of Graford.

	Depth *Feet*	Thickness *Feet*
Garner formation—		
Brazos River sandstone—		
Sand, white	1020–1152	132
Conglomerate	1152–1155	3
Mingus shale—		
Shale, blue	1156–1166	10
Shale, white	1166–1177	11
Shale, blue	1177–1233	56
Limestone, bluish gray	1233–1238	5
Thurber coal—		
Coal, black	1238–1238½	½
Millsap Lake formation—		
Shale, blue	1238–1425	187
Sand	1425–1438	13
Limestone, grayish blue	1438–1447	9
Shale, blue	1447–1525	78
Sand, gray	1525–1528	3
Shale, blue	1528–1742	14
Limestone, dark blue, hard	1742–1747	5
Shale, blue	1747–1784	37
Limestone, blue, sandy	1784–1802	18

	Depth Feet	Thickness Feet
Shale, sandy	1802–1825	23
Limestone, hard, blue	1825–1845	20
Shale, sandy	1845–1850	5
Limestone, gray	1850–1865	15
Shale, sandy	1865–1870	5
Limestone, gray	1870–1880	10
Sand, gray, containing water	1880–1883	3
Shale, blue, sandy	1883–2095	212
Limestone	2095–2100	5
Shale, blue	2100–2153	53
Limestone, hard	2153–2210	57
Shale, blue	2210–2475	265
Sand, gray, hard	2475–2500	25
Shale	2500–2760	260
Sand, light gray	2760–2976	216
Shale, dark blue	2976–3000	24
Sand, gray	3000–3025	25
Shale, dark gray-blue	3025–3040	15
Sandstone, gray	3040–3055	15
Shale, blue-gray	3055–3110	55
Sand, light gray, containing white quartz grains mixed with grains of black chert	3110–3175	65
Total thickness, top of Garner formation to top of Smithwick		2155

Paleontology and correlation.—No marine fossils of any value have been identified from samples of the lower Strawn strata. The oldest strata that outcrop in the Brazos River valley in the vicinity of Dennis and Kickapoo Falls carry a mid-Pennsylvanian fauna about equivalent to the Cherokee shale of Missouri and to the basal Gaptank of the Marathon region. The most diagnostic fossils are *Paralegoceras brazosense* Plummer and Scott, n. sp. (MS.) and *Fusulina meeki* Dunbar and Condra. The latter fossil occurs in the Dennis Bridge limestone at Dennis in Parker County; in a limestone just above the Rich Hill coal seam, Rich Hill, Missouri; and in the basal Gaptank formation, two miles south of Gaptank, Pecos County, Texas. The ammonoid, *Paralegoceras brazosense,* is related to, although possibly somewhat younger than, *Paralegoceras iowense* Meek and Worthen from Iowa. The correlation of the lower 1500 feet of the Strawn section in Texas has not been worked out.

STRUCTURAL GEOLOGY[75]

Regional Structure

The surface and subsurface strata above the top of the Bend group dip toward the northwest at an angle of about 2 degrees or at the rate of about 65 feet per mile, and they strike about N. 40° E. The dip in different parts of Palo Pinto County is shown on the map, Plate III, and in the cross-section, figure 6. The rather uniform northwesterly dip, together with the action of erosional agencies on alternating hard and soft formations, has produced the striking "staircase" topography. The limestones and indurated sandstones resist erosion much more than do the soft shales and stand out as resistant ledges that cap conspicuous escarpments. The escarpments slowly recede through weathering away of the shales and undermining of the resistant ledges. The result is a series of eastward-facing escarpments flanking long, gentle, westward-dipping slopes. Each escarpment and each slope is held up by a hard capping ledge. These striking ridges and broad structural west slopes are especially conspicuous to one traveling from east to west along Highway No. 1 across the country, and they also stand out strikingly in aeroplane photographs of the region.

The subsurface strata beneath the top of the Bend group dip eastward and strike north and south. The amount of east dip is about 50 feet per mile, as shown in the map, Plate IV. This discordance in direction of dip between the Strawn strata and those below the top of the Bend group denotes a profound unconformity at the top of the Smithwick shale formation.

---

[75] *Literature.*—Pepperburg, L. J., Structural features in Palo Pinto County, Texas: Western Engineering, vol. 6, No. 6, pp. 252–254, Dec., 1915. Pratt, Wallace E., Geologic structure and producing areas in north Texas petroleum fields: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 44–70, 1919. Reeves, Frank, Geology of the Ranger oil field, Texas: U. S. Geol. Survey Bull. 736, pp. 111–170, 1922. Shaw, E. W., Gas in the area north and west of Fort Worth: U. S. Geol. Survey Bull. 629, pp. 42–51, 1916. Wegemann, C. H., A reconnaisance in Palo Pinto County, Texas, with special reference to oil and gas: U. S. Geol. Survey Bull. 621, pp. 51–59, 1915. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. of Texas Bull. 2132, pp. 198–204, 1921. Adams, H. H., Geological structure of Eastland and Stephens Counties, Texas: Bull. Am. Assoc. Petrol. Geol., vol. 4, pp. 159–167, 1920. Cheney, M. G., Stratigraphic and structural studies in north-central Texas: Univ. of Texas Bull. 2913, pp. 1–29, 1929. Kennedy, William, Report on Palo Pinto and Stephens Counties: Bureau of Economic Geology Library M.S., pp. 1–110, (Typewritten) 1916. Esgen, W. K., Relation of accumulation of petroleum to structure in Stephens County, Texas; Am. Assoc. Petrol. Geol. "Structure of typical American oil fields," vol. 2, pp. 470–479, 1929.

Minor Structural Features

Two types of minor abnormal structure occur in Palo Pinto County:

1. Normal faults
2. Small plunging folds or "noses."

The normal faults are small. The displacements are only one to fifty feet, and the lengths are only from one to three miles. The fault planes are nearly vertical, and the displacements occur commonly in a series of three to six or eight faults arranged *en échelon.* Three series of these faults are shown on the structure map of Palo Pinto County, Plate III, as follows:

1. Graford faults, located 5 miles west of Graford, in the north-central part of the county.
2. Palo Pinto faults, located northwest of the town of Palo Pinto in the central part of the county.
3. Strawn faults, located southwest of the town of Strawn, in the southwest corner of the county.

Most of the faults trend N. 40° W. to N. 50° W. and are spaced from one-eighth to one-quarter of a mile apart. Most fault planes are mineralized by calcite and limonite, rarely by hematite. Unless badly weathered, fault planes generally show slickensides. The faults appear to be a part of an *en échelon* system that extends in a northeast-southwest direction across Jack and Palo Pinto counties and into Erath County.

The origin of these faults has caused much speculation among geologists. Some believe they were the result of differential settling and compacting of sediments over uneven surfaces, such as lenticular sand bodies. Others, influenced by Fath,[76] think they were produced by deep-seated lateral thrusts in the basement rocks, which results in a tearing apart of the strata above and formation of *en échelon* faults at the surface. Still others, including the author, are inclined to assign the cause to a northward creep of the rocks in the middle of the Mineral Wells geosyncline over the thick, fissile, more or less mobile shales. A lack of such movement on top of the

---

[76]Fath, A. E., The origin of the faults, anticlines, and buried "granite ridge" in the northern part of the Mid Continent oil and gas field: U. S. Geol. Survey Prof. Paper 128-C, pp. 75-84, 1930.

Bend arch where the Bend shales are thin and more compact produced a slight tearing apart of the strata along the flanks of the Bend arch and resulted in northwest-southeast trending faults.

Small plunging folds or wrinkles are common throughout Palo Pinto County. The folds range in size from three-quarters of a mile to one and one-half miles wide and are from two to eight miles long. Most of such folds trend northwest parallel to the dip. A few strike west, and one or two strike north. The best examples of these minor folds are: (1) the structure northwest of Graford, (2) the folds in the vicinity of Brad, (3) those west of Strawn, (4) and the one west of Lone Camp (Pl. III). Some of the folds have abnormally steep dips on the northwest side and are flat or nearly flat on their southeast ends. Such features produce a terrace type of structure that is supposed to be favorable for the accumulation of oil. The origin of these minor folds is not fully understood. Some of them, at least, are due to uneven settling of thick sediments. The "highs" are anticlines, having settled least, and the "lows" are synclines, having settled most.

Under certain favorable conditions these minor folds may form traps for oil, and they have yielded oil at Strawn and Lone Camp. For this reason the folds have been mapped in great detail by oil geologists, so that most of the minor abnormal structures in Palo Pinto County are known.

The following list includes the more prominent abnormal structural features:

Name	Map Co-ord.
West Graford "nose"	K & L–2
Allen and Ritchie Ranch "nose"	H–2
Northwest Palo Pinto structure	J–10
West Strawn series of folds	B–18 & 19
Seaman Ranch "nose"	B–9
Brad structure	C & D–13
Hart Ranch terrace	A–11
Mineral Wells gas field structure	R & S–11

ECONOMIC GEOLOGY

PETROLEUM DEPOSITS[77]

HISTORY OF OIL AND GAS DEVELOPMENT

The first gas discovered in Palo Pinto County was encountered at a depth of 471 feet[78] in a water well drilled at the town of Gordon in 1882. A beer keg was turned over the well, a gas pipe and burner inserted, and the gas was allowed to burn continuously for several weeks at a time with a gas flame twelve inches high. A second well, drilled the following year three-quarters of a mile east of Gordon, struck salt water and gas at 360 feet. Between 1890 and 1895 other small flows of gas were encountered: one in a water well near Thurber at a depth of 480 feet, another in a diamond drill hole for coal five miles west of Strawn, and a third in a water well five miles north of Palo Pinto on Dalton's ranch at a depth of 384 feet. The Dalton well caught fire and burned for several hours with a spectacular flame.

The first oil was struck about 1895 in a boring for coal near Strawn. The first test for oil in the county was drilled by Thompson, about 1901, near the Dalton gas well. It struck gas at depths of 365, 440, and 740 feet, and a show of oil in a salt water sand at 1075 feet. It was finally abandoned at 1430 feet. In spite of these early discoveries, no oil development took place for nearly twenty years. It was not until 1915 that the first commercial oil well was completed, at a depth of 825 feet west of the town of Strawn. Once started, however, the new field developed rapidly. In June, 1915, twenty wells were yielding 575 barrels of oil daily,[79] and by the

---

[77]*Literature.*—Kennedy, William. Report on Palo Pinto and Stephens counties: Bureau of Economic Geology Library MS., pp. 1-110 (typewritten), 1916. Phillips, W. B., Texas Petroleum: Univ. Texas Bull. 5 (Mineral Survey Series Bull. 1.) p. 30. 1900. Shaw, E. W., Gas in the area north and west of Ft. Worth: U. S. Geol. Survey Bull. 629, pp. 12-51, 1916. Pratt, Wallace E., Geologic structure and producing areas in north Texas petroleum fields: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 44-70, 1919. Hornberger, Joseph, Jr., The Mineral Wells gas field: Bureau of Economic Geology Library MS. (typewritten), 1931. Matteson, W. G., A review of the developments in the new central-Texas oil fields during 1918: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 163–211, 1919; Econ. Geol., vol. 11, pp. 98-116, 1919.

[78]Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey, Second Ann. Rept., p. 525, 1891. According to Cummins, the depth of the well was 471 feet; but in a letter from Alex Jameson to J. A. Udden, June 19, 1913, it is stated that the well was drilled to a depth of 485 feet.

[79]Report by Leon Pepperburg, June 18, 1915.

end of 1916, seventy-eight holes were completed. Sixty-one were producing wells, and seventeen were dry holes. The total production during 1916 was 155,950 barrels.

The Mineral Wells gas field, located two and one-half miles south of Mineral Wells, was discovered in February, 1916, by the completion of Bob Jordan's Edmonson No. 1 on the C. B. Edmonson farm. This well, completed at a depth of 1122 feet, yielded 970,000 cubic feet of gas daily. Other wells were soon drilled until a field four miles long and one mile wide was developed, with a yield of about 9,000,000 cubic feet of gas daily from twelve to fifteen wells (Pl. V).

Shortly after the Mineral Wells gas field was opened, operations moved farther south: Empire Gas and Fuel Company struck gas in a deep test well on the Chestnut farm five miles south of Mineral Wells. On January 10, 1917, this well was completed at a depth of 4167 feet and yielded 17,000,000 cubic feet of gas. It opened up a new deep producing sand for Palo Pinto County. At about the same time the Sinclair Oil Company, while drilling on the Holt ranch four miles west of Graford, at a depth between 1200 and 1230 feet struck gas estimated to be 2,000,000 cubic feet. The first deep well south of Brazos River was the Empire Gas and Fuel Company's R. A. Wheeler No. 1, completed in 1918, and yielding 2,000,000 cubic feet of gas and 140 barrels of oil at a depth of 4040 feet.

These successes led to the drilling of deeper wells in other parts of the county. The Empire Oil and Gas Company drilled a test on the Watson farm near Fortune Bend of Brazos River, but it was abandoned at a depth of 4055 feet in 1918. The same year Roxana Petroleum Company drilled two deep tests, one located on the Seaman ranch, four miles north-northwest of Brad, and the other on the Dye farm one and one-half miles east of Graford. The Seaman test, drilled to a total depth of 4535 feet, encountered several horizons in the Marble Falls limestone containing oil and a little gas, bailed ten to fifteen barrels per day, and was finally shot with 500 quarts of nitroglycerine. Part of the charge exploded prematurely in the casing and completely ruined the hole. The well on the Dye farm was drilled with a National portable drilling machine to a depth of 3930 feet. It struck about half a million cubic feet of gas in the Marble Falls limestone but was abandoned without shooting. because tools were lost in the hole. The same year (1918) T. W. Owen. of Owen, Wilson, and Palmer, completed a dry hole on the J. Oakes farm, near Oakes Crossing south of Mineral Wells. This hole, drilled with a National portable drilling machine, attained the record depth of 4450 feet. The next year operations were more successful. The Sinclair Oil and Gas Company completed a deep well on the Holt ranch five miles west of Graford. The well yielded 3,000,000 cubic feet of gas and 20 barrels of oil at a depth of 4200 feet. On January 1, 1920, Owens, Burkett, and Wheeler completed the Wheeler No. 1, one mile northwest of the town of Brazos, at a depth of 3801 feet and with a yield of 6,000,000 cubic feet of gas and 15 barrels of oil. The oil production later increased to 50 barrels daily. The Empire Oil and Gas Company's T. R. Gilbert No. 1, drilled in 1920, was another interesting well. It was completed at a total depth of 3837 feet and made 14,000,000 cubic feet of gas and 140 barrels of oil, and it bid fair to be the best well south of Brazos River. The well was closed in, however, and in less than forty minutes it blew out, ruining the well head and losing a large amount of gas and oil.

The most interesting well north of Brazos River was completed in 1920 on the Dalton ranch, six miles southwest of Graford, by Jack Dalton Oil Company. This well came in making 4000 barrels of oil daily and much gas from a depth of 3970 feet in the Marble Falls limestone. It was expected confidently that another large oil pool had been opened up, but the three off-set wells failed to find oil in paying quantities. Altogether twenty-two or more wells were drilled in the vicinity without encountering the same productive sand that yielded oil in the discovery well, and operations were finally abandoned, although some of the wells have produced a little oil and considerable gas.

In 1920 oil was encountered on the Hart ranch, in the extreme western edge of the county and four miles west of Brad, between depths 3200 and 3250 feet. About thirty wells were drilled. and a pool three miles long and one mile wide was developed, which yielded a daily production of about 1500 barrels of oil. The next year the Mid-Kansas and Pender developed a number of wells from the same horizon along Ioni Creek south of Brad. All these wells south of Brad derived their oil from a porous limestone in the Bend group. The subsurface structure was small, the flow of oil erratic, and the production-decline rapid, so that development was not very profitable, and further operations ceased.

The next pool to be brought in was located one and one-half miles west of Lone Camp. The first well was drilled by Lou Ladd in 1927. It encountered oil and gas in the Strawn strata at a depth of 520 feet and produced 15 barrels daily. Altogether, more than twenty test wells were completed. The sand was thin and poorly saturated, many of the wells made only gas, and the total production of oil proved to be disappointing.

The last noteworthy developments since 1927 are the Costello field, one and one-half miles northwest of Pickwick; the Allen and Ritchie field, four miles northeast of Pickwick on the Allen and Ritchie ranch; and the Strawn Townsite field, in and around the town of Strawn (map, Pl. V).

In all, about 450 wildcat wells have been drilled in the county during the past twelve years. Of these about 175 have produced oil or gas, or both, in sufficient quantity to mark them as producing wells of some sort. More gas than oil has been developed, and the county is now looked upon as a very favorable gas-producing country. The gas, because of its richness in gasoline and its proximity to the large industrial centers of Fort Worth and Dallas, is an especially outstanding resource.

Summary of developments in Palo Pinto County from 1931 to 1933.

Year	Producing wells	New completions	New oil wells	New gas wells
1931	197	49	15	17
1932	180	29	3	26
1933	211	43	9	16

The following summary gives the data of discovery, location, depth, and relative importance of each of the pools in Palo Pinto County.

Summary of data on oil and gas fields in Palo Pinto County.

Field	Map coord.	Date of discovery	Depth of oil sand	Approximate No. of producing wells drilled	Average production per well, first year
Strawn	P-2	1915	900	118	20 bbls. oil
Mineral Wells, shallow field	I, J-13, 14	1916	1120	50	3,000,000 cu. ft. gas
Brazos	L, M-14	1918	4050	26	3,000,000 to 5,000,000 cu. ft. gas 20 bbls. oil
Holt Ranch	C-8	1918	4200[80]	2	20 bbls. oil
Hart Ranch	G-1	1918	3250	22	100 bbls. oil
Dalton Ranch	E-8	1920	4700	12	Majority of wells dry
South Brad	K, L-3, 4	1920	3250	10	50 bbls. oil
Lone Camp	L-9	1926	520	17	10 bbls. oil
Costello	D-4	1930	1400 & 2500	6	20 bbls. oil
Allen-Ritchie	B-7	1930	......	4	25 bbls. oil
Strawn Townsite	P, Q-3	1931	......	15?	7,000,000 cu. ft. gas

STRAWN OIL AND GAS FIELD

Location.—The Strawn oil and gas pool is located just west of Strawn in the southwestern portion of Palo Pinto County (Pl. V). The main producing area extends from the southeast corner of the Thomas Court Survey west over the B. B. B. & C. R.R. Survey, the William J. Betterton Survey, and section 1 of the H. & G. N. R. R. Survey to section 94 of the T. & P. R. R. Co. Survey, Block 4. It is approximately six miles long and one to two miles wide. Another producing area, known as the Thomas Court pool, lies in the north end of the Thomas Court Survey northeast of the main producing area. A third minor pool, known as Little gas field, lies in the James Little and Mary Fury surveys, south of the main field. Thus the Strawn field proper comprises three rather separate pools that extend over an area six miles long and two miles wide.

Development.—The Strawn field was leased for coal by the Texas and Pacific Coal Company several years before oil was discovered. Sometime during 1914, oil was struck in a hole in the northwest corner of the Thomas Court Survey by company agents while prospecting for coal. The first test for oil was completed by the Texas and Pacific Coal Company in January, 1915, at a depth of 829 feet.

[80]Also some oil in Strawn sands at depth of 1320±.

The well made 50 barrels the first day and flowed by heads for several days. Other wells were started immediately, and by June, 1915, 23 wells were yielding 575 barrels daily.[81]

The following table shows the production of the Strawn oil field from the shallow sand during its first eight years:

Year	Total Production[82] *Bbls.*
1915	50,496
1916	175,147
1917	340,950
1918	185,520
1919	101,300
1920	512,260
1921	262,055
1922	602,180

Geology.—The surface strata in the Strawn pool are the Palo Pinto limestone, which forms a prominent escarpment across the western part of the producing area, and the underlying shales, sandstones, and limestones of the Mineral Wells formation. The wells penetrate the Mineral Wells and Garner formations and obtain the oil and gas in sands in the Millsap Lake formation 300 feet below the Thurber coal, as shown by the following generalized section:

Generalized section penetrated in the Strawn field.

	Depth *Feet*	Thickness *Feet*
Mineral Wells formation—		
Shale, gray	0–39	39
Sand	39–45	6
Shale, blue	45–57	12
Limestone, white	57–70	13
Shale, blue gray	70–155	85
Limestone	155–165	10
Shale, blue, containing one streak of red shale between 195 and 198 feet	165–245	80
Sand, gray, coarse	245–255	10
Shale	255–284	29
Sand	284–290	6
Shale, blue	290–400	110

[81]Pepperburg, L. J., personal communication, June 18, 1915.

[82]*Oil Weekly*, January 20, 1922.

	Depth *Feet*	Thickness *Feet*
Garner formation—		
Sand, coarse	400–415	15
Shale, bluish gray	415–515	100
Sand and shale	515–530	15
Thurber coal, black (0.9 inches thick)	530–531	1
Millsap Lake formation—		
Shale, blue	530–570	40
Limestone	570–575	5
Shale, blue	575–720	145
Sand, containing a little gas	720–735	15
Shale and sand	735–825	90
Oil sand, brown	825–829	4

Two producing sands occur in the pool. The upper sand averages fifteen feet in thickness and carries a small quantity of gas. The lower sand is from 90 to 100 feet deeper and contains oil and salt water. The oil is in the upper ten feet of the sand with salt water below. Throughout the whole pool, water is in close association with the oil. The gas pressure was low and declined rapidly. Only the first few wells flowed, and these had to be put on the pump within two months. The rest of the wells were tubed and pumped at once.

The structure of the Strawn oil field consists of three parallel, plunging folds, which extend from the William C. Dykes and Thomas Court surveys N. 45° W., a distance of about four miles (fig. 7). The northwest plunge of the strata is steep in the north ends of the folds and less steep to almost flat on the southeast ends. Most of the oil production is on the steeply dipping northwest ends and on the northwest portions of the flattened parts of the structure. The gas wells are located southeast of the oil wells at the extreme southeast ends of the folds. The oil and gas accumulation is not confined wholly to the folds, although it is clearly associated with, and related to, the folding. The best production appears to be on the northwest side of the structure (fig. 7).

The oil is light green, 38° Baumé gravity, and contains about 25 per cent gasoline. Typical analyses of oil and gas from the Strawn field are shown in the following tables:

Analyses[83] of samples of gas from three wells in the Strawn field.

	Stewart No. 5	Stewart No. 10	T.&P.Coal Co. No. 15
CH_4	78.0	79.0	78.2
C_2H_6	7.0	13.9	12.9
N_2	15.0	7.1	8.9
Sp. gr.		0.65	0.60
B.T.U.	886	1,100	1,072

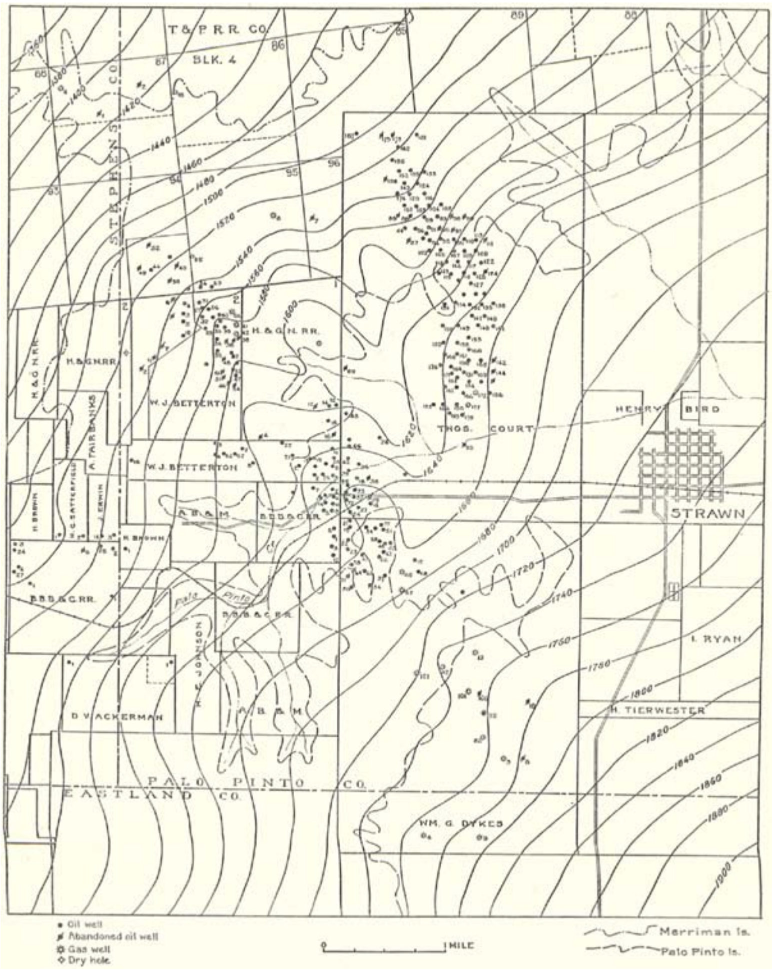


FIG. 7.--Surface structure in the Strawn oil and gas field. Contours are drawn on the Palo Pinto limestone, and elevations are given in feet above sea level.

---

[83]Shaw, E. W., Gas in area north and west of Fort Worth: U. S. Geol. Survey Bull. 629, p. 15, 1916.

Tests[81] on oil from the Strawn pool.

Viscosity (Universal viscosimeter)	49 sec.
Gravity	30.2° B.
Flash point	60° F.
Fire point	105° F.
Cold test	15° F.
Boiling point	170° F.

Distillation tests on oil from the Strawn pool.
(400 cc. over open flame)

	Per cent	Baumé
Fraction up to 350° F.	19	15.4°
Fraction 350° F.–600° F.	35	33.7°
Fraction 600° F.–750° F.	32.5	29.2°
Residue containing paraffin	13.5	----

MINERAL WELLS GAS FIELD

Location.—The Mineral Wells gas field is located two and one-half miles south of Mineral Wells and extends over most of the D. Mahoney, D. Bourne, J. Dimpkin Survey A-151, and J. Dimpkin Survey A-152, a distance of four and one-half miles in a northeast-southwest direction and a width of about one mile (Pl. V).

Development.—The field was discovered early in 1916, drilled during 1916 and 1917, produced gas until 1930, and was finally abandoned in 1930. The following individuals and companies have operated in the field:

Bob Jordan
Empire Oil and Fuel Company
Lone Star Gas Company
Owen and Wilson
Allied Gas Company
Consumers Oil and Gas Company
Brazos River Gas Company

Bob Jordan discovered the field in 1916 when he completed a well on the Edmonson land. The Empire Gas and Fuel Company took over his leases in 1916 and began an active drilling program. The remaining land in the field was held by Owen and Wilson, who organized under the name of Consumers Gas Company. This company obtained a franchise on the sale of gas in Mineral Wells and constructed a six-inch pipe line into the city.

[81] Kennedy, William, Report on Palo Pinto and Stephens counties: Unpublished manuscript, p. 86. The analysis was made by Dr. McKenzie, consulting chemist for The Texas Company.

By January, 1917, fifteen wells had been completed in the field, seven of which were producing between 1,000,000 and 5,000,000 cubic feet of gas. The gas was handled by the Empire Gas and Fuel Company and the Consumers Gas Company. In 1918 the Consumers Gas Company sold out to the Allied Gas Company, who in 1920 sold to D. A. Upham of Brazos River Gas Company. In 1924 Brazos River Gas Company obtained the holdings of Empire Gas and Fuel Company.

After 1920 the gas pressure declined rapidly, and a number of wells had to be abandoned each year. In 1925 and 1926 only three wells were connected to pipelines, and these last three were abandoned in 1930. The following table is a record of the pressures and capacities of the wells in December, 1919:

Pressures and capacities of gas wells in the Mineral Wells field, during December, 1919.

Well	Total depth	Closed-in pressure, end of 15. min.[55]	Rock pressure[56]	Volume of open flow in 24 hrs.
	Feet	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Cu. ft.*
Edmonson No. 1	4492	270	360	475,000
Edmonson No. 2	1168	210	325	825,000
Taylor No. 1	----	?	310	375,000
Gill No. 1	1014	260	290	2,000,000
J. E. Hess No. 1	1045	265	310	1,225,000
J. E. Hess No. 2	1040	290	310	5,700,000
Clover No. 1	--------	250	300	4,500,000

All wells were drilled with Star or National drilling machines, and no derricks were erected for most operations. The casing program consisted of 400 feet of 10-inch, 800 to 850 feet of 8¼-inch, and 1000 to 1100 feet of 6⅝-inch casing set on top of the gas sand. All the casing except the 6⅝-inch was pulled when the well was completed. The gas was produced through the 6⅝-inch casing until the pressure declined, and then the holes were tubed with 2-inch tubing. No cement was used in most of the wells, but in some mud was pumped around the 6⅝-inch casing after the outer casing was pulled.

Geology.—The surface strata in the gas field are the shales at the base of the East Mountain shale member of the Mineral Wells

[55] Taken with 1,000-lb. spring gauge, specific gravity of gas 0.72.

[56] Pressure at well head before blowing.

formation, and the sands at the top of the Brazos River sandstone member of the Garner formation. The wells penetrate the Garner formation and the upper part of the Millsap Lake formation to a depth of about 1100 feet below the top of the Brazos River sandstone. A typical section in the field is as follows:

Log of the Jacques No. 2, drilled by Consumers Gas and Fuel Company on A. E. Jacques' farm, D. Bourne Survey, A–32, Mineral Wells gas field.

	Depth *Feet*
Garner formation—	
Sand, gray, hard, carrying some water	0–185
Shale, blue	185–205
Sand, gray, carrying water	205–215
Shale, blue	215–310
Millsap Lake formation—	
Limestone	310–325
Shale	325–360
Sand	360–390
Shale	390–440
Sand, calcareous	440–480
Shale	480–560
Limestone	560–580
Shale	580–690
Limestone	690–710
Sand, carrying water	710–730
Shale	730–755
Limestone, sandstone, sandy shale	755–880
Shale, light blue	880–910
Sand, carrying gas	910–1008

The gas sand is a coarse-grained, calcareous, argillaceous, quartz sand partly cemented by calcite. It varies in thickness from 25 to 100 feet.

The structure of the surface sandstone strata has not been determined. The structure of the gas sand is shown in the subsurface map, figure 8. The structure consists of a west-plunging fold about two miles wide and five miles long. The shape of the surface of the sand body is due in part to folding and in part to eastward thinning of the sand.

Production.—The decline in pressure was rapid, due to the small size of the gas reservoir and to relatively large-sized holes through which the gas was allowed to flow. Initial production of the wells ranged from one-half million up to six million cubic feet daily; the average was between one and two million. Table 3 shows the pressure and production of all wells in the field in 1929.

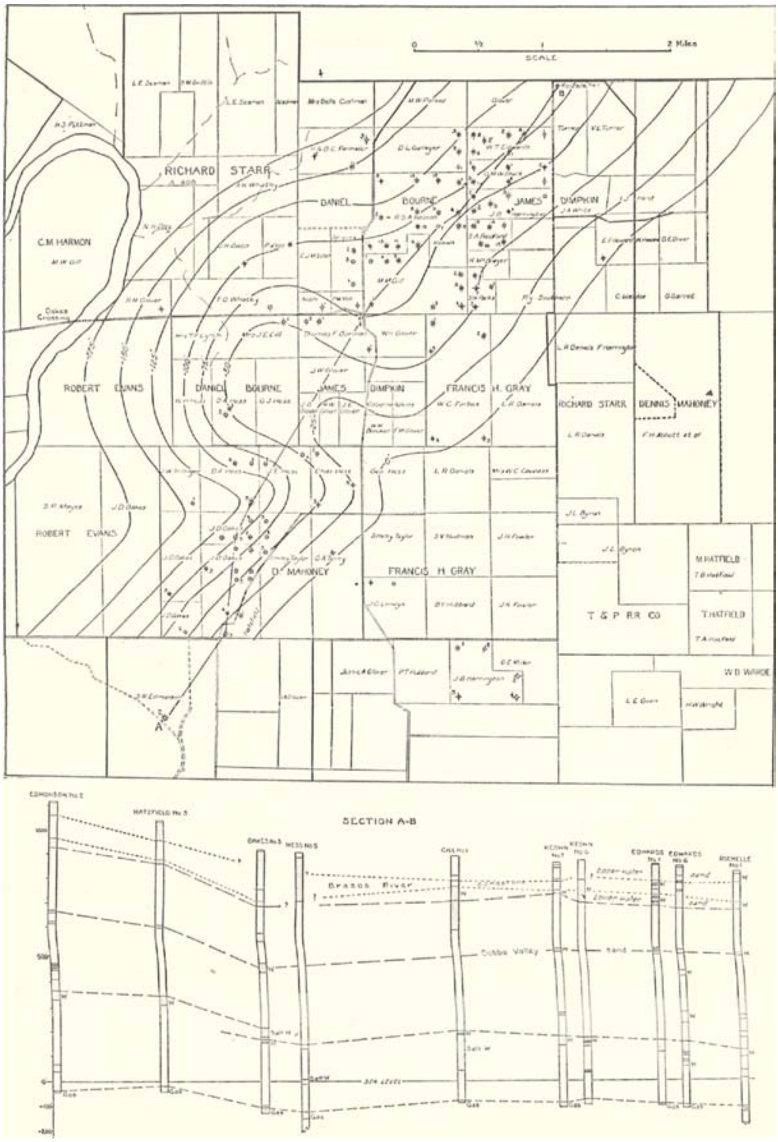


FIG. 8.—Structure of the gas sand in the Mineral Wells gas field. Contour elevations are in feet below sea level.

TABLE 3.—*Pressure and production of gas in wells in the Mineral Wells gas field, 1929.*

Lease	Well No.	Survey	Size of casing *Inches*	Rock pressure *Inches*	Size of opening *Inches*	Reading date	Liquid used	No. of days well used	Potential daily capacity *Cu. ft.*	Amount of gas taken from well per month *Cu. ft.*
Palo Pinto County—										
J. A. Chestnut	1	Geo. Green	5-3/16	650	3	3/10	Mercury	31	1,200,000	—
Do.	2	Do.	5-3/16	1200	2	5/10	Water	31	200,000	2,389,000
Costello	1	T. E.&L.Co. ?	2	475	2	—	—	0	1,500,000	—
Jack Dalton Oil Co.	6	T.&P.R.R.Co. ?	5-3/16	750	2	1	Mercury	31	500,000	4,416,000
C. B. Edmonson	2	D. Mahoney	6-5/8	225	2	2/10	Do.	0	250,000	—
Do.	3	Do.	5-3/16	225	2	3	Water	0	275,000	—
Do.	4	Do.	5-3/16	225	2	6/10	Mercury	0	475,000	—
Ferris-Givens	1	T.&P.R.R.Co. ?	3	920	3	2/10	Do.	31	610,000	7,231,000
D. A. Hess	1	D. Bourne	4	128	1	1	Do.	0	158,000	—
Do.	2	Do.	3	128	1	1	Do.	0	158,000	—
Do.	3	Do.	2	128	1	1	Water	0	42,000	—
Do.	6	Do.	2	128	1	5/10	Mercury	0	110,000	—
Jacques	1	Do.	3	110	1	3	Water	0	70,000	—
Do.	3	Do.	2	110	2	2/10	Do.	0	70,000	—
McGar-Dalton	1	T.&P.R.R.Co.	6-5/8	920	3	3	Water	31	650,000	8,275,000
Mid-Dalton	1	Do.	6-5/8	925	2	6	Mercury	0	1,500,000	—
Miller-Dalton	1	Do.	6-5/8	925	3	6	Do.	31	2,000,000	23,419,000
J. D. Oakes	6	D. Bourne	2	128	1	3/10	Mercury	0	85,000	—
S. Taylor	2	D. Mahoney	2	128	2	2/10	Water	0	72,000	—
Do.	3	Do.	3	125	3	1/10	Do	0	112,000	—
Do.	4	Do.	3	125	1	5/10	Do.	0	30,000	—
Do.	5	Do.	3	125	3	3/10	Do.	0	200,000	—
C. von Hatzfield	1	D. Bourne	2	128	1	3/10	Mercury	0	85,000	—
Do.	2	Do.	3	128	2	4/10	Do	0	223,000	—
Do.	3	Do.	2	128	2	4/10	Do.	0	112,000	—
Do.	4	Do.	2	128	2	4/10	Do.	0	112,000	—
Wester	1	T.E.&L.Co.	3	540	3	—	—	0	6,000,000	—
Do.	2	Do.	6-5/8	560	3	—		0	11,000,000	—
Do.	3	Do.	6-5/8	475	2	—	—	0	2,000,000	—
W. W. Wharton	1	Geo. Green	5-3/16	1225	2	—	—	31	2,800,000	31,054,000
Parker County—										
Morton	4	T. E.&L.Co.	2	35	1	8/10	Water	31	35,000	2,333,000
Do.	6	Do.	2	35	1	1	Do	31	44,000	2,333,000
Do.	11	Do.	2	35	2	2/10	Do.	31	72,000	—

The gas was rich in gasoline, and approximately one-half gallon of gasoline per million cubic feet of gas was extracted from all the gas produced from the field.

BRAZOS GAS FIELD

Location.—The Brazos gas field is located near the town of Brazos in the southeastern part of Palo Pinto County. It extends from the southwestern corner of section 49, T. & P. R. R. Co. Survey, Block A, south of the town of Brazos, northward to the James Dimpkin Survey north of the river, a distance of three and one-half miles (Pl. V). It lies just south of the Mineral Wells gas field but is, however, on a separate structure and obtains its production from a zone much deeper than the producing sand of the Mineral Wells field.

Development.—The field was discovered by the Empire Oil and Gas Company when they completed, on January 10, 1917, their Chestnut No. 1 well in the George Green Survey to a total depth of 4064 feet. It came in producing 17,000,000 cubic feet of gas and spraying about 100 barrels of oil. The next year, 1918, T. W. Owens and Wilson drilled the second well in the field three miles north of the discovery well, to the depth of 4575 feet without obtaining gas. The Empire Oil and Gas Company, however, moved south and drilled a test on the Wheeler tract, south of Brazos River, to a depth of 4040 feet, which obtained 2,000,000 cubic feet of gas and about 140 barrels of oil. On January 1, 1920, Owens, Burkett, and Wheeler completed Wheeler No. 1, just east of the Empire's second well, with a yield of 6,000,000 cubic feet of gas and 15 barrels of oil at a depth of 3824 feet. The same group then drilled Wheeler No. 2 to 3922 feet the same year and obtained 2,000,000 cubic feet of gas and 25 barrels of oil. This well continued to flow for three years. The same year, 1920, the Empire Oil and Gas Company drilled the T. R. Gilbert No. 1 to 3820 feet, and it came in producing 14,000,000 cubic feet of gas and 140 barrels of oil. The well has yielded over $130,000 worth of gas at ten cents per thousand and is still producing. The next two wells to be started in the Brazos River bottoms were known as the Scott and McClure wells and were drilled by Dittman Drilling Company. No. 1 was drilled to the producing horizon, a string of casing was dropped into the hole, and the well was ruined. No. 2 was started immediately, but

TABLE 4.—*Well data for the Brazos gas field.*

COMPANY	WELL	LOCATION	SURFACE ELEVATION *Feet*	TOTAL DEPTH *Feet*	DEPTH OF PRODUCING SAND *Feet*	RESULT
Brazos River Co.	T. R. Ennis	T.&P.R.R.Co. Surv., Blk. A, sec. 49	----	3875	3717 3736	4,000,000 cu. ft. gas 10 bbls. oil.
Empire Gas & Fuel Co.	T. R. Gilbert No. 1-A[a]	T.&P.R.R.Co. Surv., Blk. A, sec. 39	884	3824	3803	11,500,000 cu. ft. gas
Do.	T. R. Gilbert No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 37	870	3820	----	14,000,000 cu.ft. gas 140 bbls. oil
Do.	Chestnut No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 39	1114	4130	4064	17,000,000 cu. ft. gas
Do.	J. H. Wharton No. 1	Geo. Green Surv., A-207	822	3904		750,000 cu. ft. gas
Do.	R A. Wheeler No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 36	874	4040	4006 4020	2,000,000 cu. ft. gas 140 bbls. oil
Do.	R. A. Wheeler No. 2A	T.&P.R.R.Co. Surv., Blk. A, sec. 36	887			
Do.	R. A. Wheeler No. 2	T.&P.R.R.Co. Surv., Blk. A, sec. 37	952 ?	3929	2902 2911	1,000,000 cu. ft. gas 25 bbls. oil
Do.	R. A. Wheeler No. 3	Do.	844	3812	3785 3995	Gas well
Do.	R. A. Wheeler No. 4	Do.	1095	4185	----	Dry
Do.	R. A. Wheeler No. 6	Do.	870	4131		?
Owens, Burkett, & Wheeler	T. R. Gilbert No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 39	884	3843	3833	4,200,000 cu. ft. gas
Owens & Burkett	R. A. Wheeler No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 37	857	3730	3824	6,000,000 cu. ft. gas 15 bbls. oil
Do.	R. A. Wheeler	T.&P.R.R.Co. Surv., Blk. A., sec. 36	872	4105	4078	Dry
Scott & McClure	Wheeler No. 1	T.&P.R.R.Co. Surv., Blk. A., sec. 37		3706	3692	Hole lost
T. G. Shaw Int.	J. A. Chestnut No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 40	900	5123		Dry
Do.	E. R. Gilbert No. 1	M. Blood Surv., A-687		3340		(Incomplete)
Do.	E. R. Gilbert No. 2	Allen Williams Surv.	882	3896	3858 3860	
Do.	J. H. Gilbert No. 1	Geo. Green Surv., A-207	797	3790		Water
Do.	Jones No. 1	Do.	798	2406		
Do.	Mosley No. 1	Allen Williams Surv., A-886	812	3375		Dry
Do.	Do.	Do.	887	2470		(Incomplete)
A. T. Strong	Do.	Do.	805	3805		Dry
Thompson & Sands	Townsite Well	Brazos Townsite, Lot 7, Blk. 8	803	3780		Dry
Upham Oil Co.	Bleeker No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 50	800	3740	3726	2,500,000 cu. ft. gas
Do.	Bradford No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 49	774	3725		Dry
Do.	J. A. Chestnut No. 1	Geo. Green Surv., A-207		4318	2985	3,000,000 cu. ft. gas
Do.	Ennis No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 49, SW. cor. NE. ¼	773	3840		
Do.	J. Gilbert No. 1	Geo. Green Surv., A-207	824	3752	3737 3752	Little gas and salt water
Do.	Reasoner No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 49, SW. ¼	----	3750	3750	33,000,000 cu. ft. gas 200 bbls. oil
Do.	J. H. Wharton No. 1	Geo. Green Surv., A-207	824	4057	4036 4057	3,250,000 cu. ft. gas

[a]Originally drilled by Owens.

again misfortune interrupted operations when Mr. McClure was killed.

In 1923, Owens, Burkett, and Wheeler purchased all the holdings of the Empire Gas and Fuel Company and sold them in 1926 to T. G. Shaw, who is still (1933) operating some of the wells. The gas is handled by the Lone Star Gas Company. It is piped to Brazos, where its gasoline content is removed in a casinghead plant and then delivered into the main gas lines of the Lone Star Gas Company for consumption in north Texas cities. Altogether, at least forty deep tests have been put down in the field. A list of the wells, depths, and results are given in Table 4.

Geology.—The surface outcrops in the Brazos gas field consist of the Garner formation and the Millsap Lake strata. The high escarpment of the Brazos River sandstone divides the field into two parts. Wells in the northern part, where the discovery well is located, start on the Brazos River sand; those in the Brazos River valley and south of the escarpment start on the Santo limestone or in the shales a few feet above it and about 250 feet lower in the section than the north wells. The holes penetrate the Millsap Lake formation into the Marble Falls limestone and obtain the oil and gas in porous sandy layers of the Marble Falls. A generalized section of the strata penetrated by the drill is as follows:

Generalized geologic section penetrated in the Brazos gas field.

	Thickness *Feet*
Brazos River sand, gray, coarse-grained, soft	50
Shale, dark blue-gray, containing few lentils of thin sand	200
Corn limestone	2
Shale, blue, soft, containing four or more layers of limestone 1 to 15 feet thick, separated by layers of shale and two sandstone layers, at least one containing water	800
Sand, gray, hard, containing water	25
Shale, dark, containing thin, flaggy, calcareous layers 1 to 5 feet thick	200
Shale, black, in a few wells containing one lentil of sand	500
Sand, gray	20
Shale, black, containing thin flaggy layers of dark gray limestone	250
Sand, containing small amounts of oil and gas in some wells	10
Shale, black, containing in some wells thin lentils of hard limestone	220

	Thickness Feet
Sand, containing oil or gas in small quantities in some wells	20
Shale, dark, containing thick beds of limestone	320
Sand, gray, massive, persistent	60
Shale, dark, containing one bed of sand about 20 feet thick	550
Sand, massive, calcareous, logged in some wells as a limestone	100
Smithwick shale, black, carbonaceous, fissile, hard, and containing lentils and layers of hard, dark-colored limestone	650
Marble Falls limestone, black, sandy, hard porous limestone, containing gas and small amounts of oil in upper porous layers	100±
Total average thickness	1087±

The gas and oil comes principally from the lower or Marble Falls zone. The wells produce mostly gas. Some have yielded 15 to 50, or even more, barrels of light oil per day. The initial production of most of the wells is shown in Table 4.

The subsurface structure in which the gas accumulates consists of a broad low plunging arch trending northeast, similar to, although less pronounced than, the Exray gas structure in Erath County and the Strawn Townsite structure in Palo Pinto County. The axis trends northeast and is slightly flattened north of Brazos in the vicinity of the gas wells. It is probable that the accumulation of gas is due as much to irregular porosity in the limestone as to abnormal structure. Figure 9 shows the shape and trend of the fold.

HOLT RANCH OIL POOL

Location.—The Holt Ranch pool is located five miles west of Graford. Operations have extended from the J. J. Metcalf Survey, Abstract 341, northward to section 1755 of the Texan Emigration and Land Company Survey, a distance of four and one-half miles. Most of the oil and gas has come, however, from wells in section 1723 of the Texan Emigration and Land Company Survey, located five miles west and one mile north of Graford (Pl. V).

Development.—The Holt Ranch structure west of Graford was first mapped and leased by the Slim Jim Oil Company (Dr. C. H. Taylor et al) of Oklahoma City. This company drilled its first test to a depth of 2060 feet in the southwest corner of section 1744 without obtaining oil or gas. Subsequently, the prospect was abandoned, and the leases were surrendered.

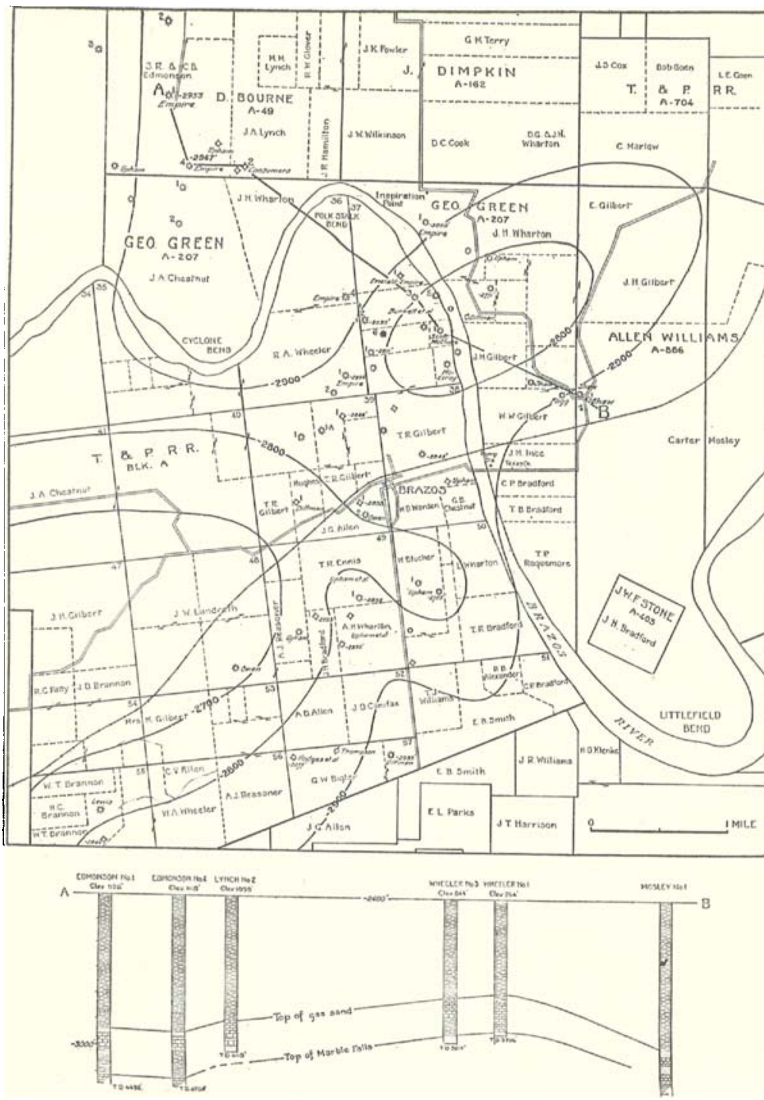


FIG. 9.—Structure of the Marble Falls limestone in the Brazos gas field.

In 1916, the area was again mapped by Roxana Petroleum Company and by Sinclair Oil and Gas Company. The Sinclair acquired a lease on the Holt ranch covering the southwestern part of the structure and started a test in section 1723. The first Sinclair well, Holt No. 1, was completed in June, 1917, at a depth of 1205 feet and with a production of 3,000,000 cubic feet of gas. The well caught fire and burned for several weeks before the fire could be extinguished. It was then deepened to 1426 feet and flowed steadily 20 barrels per day. In January, 1918, the Sinclair started a second test west of Holt No. 1, and the Plains Oil and Gas Company drilled a test to the south. The results of the second test drilled by Sinclair were disappointing, and the company deepened the hole to the producing zone in the Marble Falls limestone and completed it at a depth of 4200 feet, where a strong flow of gas was encountered. The well made about 6,000,000 cubic feet of gas daily and sprayed a little oil. As a result of the showings in the first three tests, ten or twelve more holes were drilled to various depths, as shown in Table 5.

Geology.—The surface formation in the Holt Ranch oil field is the Merriman limestone. All the wells start on this layer, penetrate 400 feet of marls and limestones belonging to the Canyon group, then pass through 1000 feet of the Strawn group, and reach the first producing horizon in a sand in the Millsap Lake beds. The deep sand, and main producing horizon, is the Marble Falls limestone at a depth of 4200 feet, in a zone thought to be about the same as that from which the gas is produced in the Brazos gas field. The section penetrated by the drill below the Brazos River sands is similar to that in the Brazos field. The section from the top of the Merriman limestone to the top of the Brazos River sandstone, as revealed by the drill, is as follows:

Geologic section penetrated in the Holt Ranch oil pool.

	Depth *Feet*	Thickness *Feet*
Merriman limestone, grayish blue, hard	0–40	40
Shale, blue	40–50	10
Sandstone, calcareous, hard	50–120	70
Shale, blue	120–285	165
Limestone	285–290	5
Sandstone and limestone	290–320	30
Shale	320–465	145
Palo Pinto? limestone	465–500	35
Shale, limestone and sand	500–598	98
Shale	598–608	10

	Depth	Thickness
	Feet	*Feet*
Village Bend? limestone	608–614	6
Shale	614–711	97
Hog Mountain sandstone	711–722	11
Shale	722–823	101
Brazos River sandstone, containing salt water and having one or two shale layers	823–944	111

The upper oil and gas zone lies 620 feet below the top of the Brazos River sandstone. The deep gas horizon lies about 3310 feet below the top of the Brazos River sandstone.

The structure of the field consists of a plunging fold having three or four normal faults spaced a few hundred feet apart and arranged *en échelon* on the southwest flank of the plunging fold (fig. 10). The producing wells are located in the faulted area. Tests drilled in the axis of the fold and on the north side of the fold were all unsuccessful. The locations of the tests and their relation to the structure is shown in figure 10.

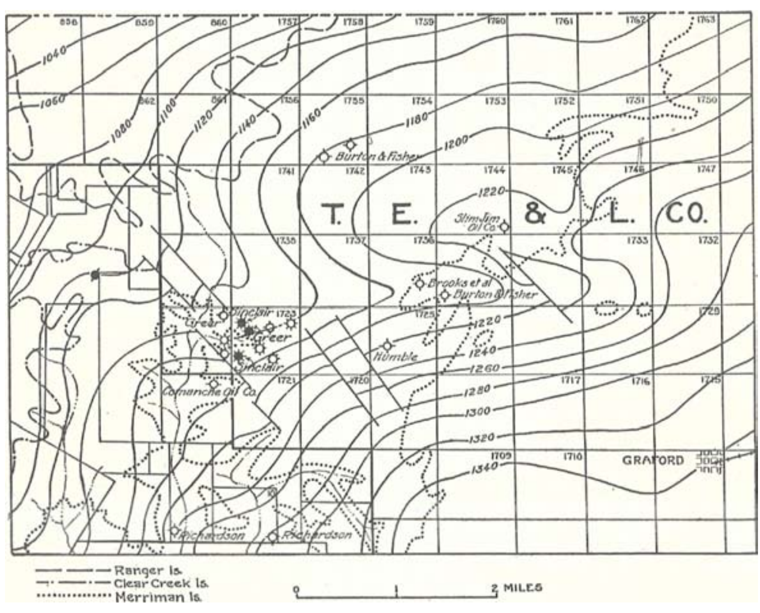


FIG. 10.—Surface structure of the Holt Ranch oil field. Contours are drawn on the Merriman limestone, and elevations are in feet above sea level. The interval between the Merriman limestone and the top of the Palo Pinto limestone in this area is 375 feet.

TABLE 5.—*Well data for the Holt Ranch field.*

COMPANY	WELL	LOCATION	ELEVATION *Feet*	DEPTH *Feet*	INITIAL PRODUCTION
Brooks, et al.	Holt No. 1	T.E.&L.Co. Surv., sec. 1736, SE. cor	1132	1951	Dry
Burton & Fisher	Green No. 1	T.E.&L.Co. Surv., sec. 1755	1183	4105	Dry
Do.	Green No. 2	T.E.&L.Co. Surv., sec. 1755	1132	1569	Dry
Do.	H. L. Sikes	T.E.&L.Co. Surv., A-510, sec. 1735	—	1550	Dry
Comanche Oil Corp.	Holt No. 1	J. Poitevant Surv., A-371	—	4387	Dry
J. H. Greer	Holt No. 1	T.E.&L.Co. Surv., sec. 1722, NE. cor	1078	1467	Dry
Do.	Holt No. 2	T.E.&L.Co. Surv., sec. 1723	1114	1415	Gas
Humble Oil & Refg. Co.	Holt No. 1	T.E.&L.Co. Surv., sec. 1725	—	1845	Dry
Owens & Burkett	Gary-Sanger No. 1	J. J. Metcalf Surv., SW. cor. of E.½	1003	4970	Dry
Richardson, et al.	Holt No. 1	B.B.&C.R.R.Co. Surv.	—	1800	Dry
Sinclair Oil & Gas Co.	Holt No. 1	T.E.&L.Co. Surv., sec. 1723	1100	1426	3,000,000 cu. ft. gas 20 bbls. oil
Do.	Holt No. 2	T.E.&L.Co. Surv., sec. 1723	1116	4220	50 bbls. oil 6,000,000 cu. ft. gas
Slim Jim Oil Co.	R. P. Lee	T.E.&L.Co. Surv., sec. 1744, SE. cor	1172	2060	Dry

DALTON RANCH FIELD

Location.—The Dalton Ranch oil field is located on, and adjacent to, the Dalton ranch, five miles southwest of Graford and from one to four miles north of Brazos River. Most of the test wells are located in the west tier of sections of the Texan Emigration and Land Company Survey and in adjacent surveys on the west (Pl. V).

Development.—Gas was encountered in a well drilled for water on the Dalton ranch in the early 80's. This gas discovery was recorded by Cummins,[87] and at least one well was put down to a depth of 854 feet during the 90's. Some gas was struck, and it is said[88] the gas burned at the casinghead for nearly one year. No further development took place until 1914, when the Crazy Oil and Gas Company drilled a shallow test near the old gas well.

The first deep test on the Dalton ranch was made by Jack Dalton Oil Company in 1921. This well was drilled to a total depth of 3970 feet, where it encountered 2,000,000 cubic feet of gas and a strong flow of oil. The well gauged over 1,000 barrels and flowed under a strong head of gas for many months. The production was found at a depth of 3970 feet in a gray, porous limestone in the Marble Falls formation. Other wells were started immediately, a small town laid off, roads built, and a pipeline laid to the new field. The off-set wells to the north, west, and south, however, failed to obtain oil, and the only encouragement out of six holes completed during 1920 was the Miller-Dalton Oil Company's R. S. Dalton No. 1, located one and one-half miles southeast of the producer. This well came in as a gas well, making one to three million cubic feet and a little oil. The results of all the tests are shown in Table 6.

During the present year (1933) two additional wells have been drilled northwest of the discovery well. Both tests struck some gas, and one is said to have yielded 50 barrels of oil.

Geology.—The Graford formation outcrops over the surface of the Dalton Ranch field and dips to the northwest at the rate of about

---

[87]Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., pp. 521–534, 1891.

[88]Wegeman, C. H., A reconnaissance in Palo Pinto County: U. S Geol. Survey Bull. 621-E, p. 53, 1915.

TABLE 6.—*Well data for Dalton Ranch oil field.*

COMPANY	WELL	LOCATION	ELEVATION *Feet*	TOTAL DEPTH *Feet*	DEPTH TO TOP OF MARBLE FALLS *Feet*	INITIAL PRODUCTION
Burkett & Owens	Pennington No. 1	NE. cor. S. F. Harding Surv.	1271	4380	4052	Dry
Do.	Sanger No. 1	1½ mi. N. of first Dalton well	1003	4970		Little gas at 3400′
California-Dalton Oil Co.	R. S. Dalton No. 1			4210		Dry
Cunningham	Poor No. 1	Sec. 1792, T.E.&L.Co. Surv.	949	4220	3740	Dry
Dalton-Clark Oil Co.	R. S. Dalton No. 1			4200		Shot little gas
Dalton & Clark	Green No. 1	S. edge sec. 1793, T.E.&L.Co. Surv. A-568	935	4105	3700	Dry
Bob Dalton Oil Co.	R. S. Dalton No. 1	Sec. 1788, T.E.&L.Co. Surv., A-563		2390		Dry
Jack Dalton Oil & Gas Co.	R. S. Dalton No. 1	Sec. 1790, 250′ S., 250′ W. of NE. cor. of N. ½, T.E.&L.Co. Surv.	931	3970	3700	2000 bbls. oil 2,000,000 cu. ft. gas
Do.	R. S. Dalton No. 2	Sec. 1790, T.E.&L.Co. Surv., A-565	931	3920	3800	Dry
Jack Dalton Oil Co.	R. S. Dalton No. 5	Sec. 1790, T.E.&L.Co. Surv., A-565	921	4055	3695	Little oil
Do.	R. S. Dalton No. 6	Sec. 1789, near cen., T.E.&L.Co. Surv., A-564	911	4203	3710	Little oil and gas
Do.	R. S. Dalton No. 7	Sec. 1789, T.E.&L.Co. Surv.	910	3938	3710	Gas
Mark Dalton Oil Co.	R. S. Dalton No. 1-A	810′ from W. line, 150′ from S. line of N. ½ of sec. 1790, T.E.&L.Co. Surv.	925	4073	3695	75 bbls. oil
Mark Dalton Oil Co.	R. S. Dalton No. 1	Sec. 1791, T.E.&L.Co. Surv., A-566	922	4015	3695	Dry
Hoffmeir & J. K. Dalton	Dalton No. 1	800′ N. and 300′ E. of N. ½ of sec. 1790, T.E.&L.Co. Surv.	921	4207	3710	Dry
Hughes-Craig	Jones No. 1	SE. cor. of W. T. O'Neal Surv. A-1055	931	4075	3710	Dry
Magnolia Petroleum Co.	Green No. 1	Sec. 1793, T.E.&L.Co. Surv.	941	4125	3725	10 bbls. oil
Do.	Pennington No. 1	NE. cor. of S. F. Harding Surv., off-set to Dalton No. 3 in NW. cor. sec. 1789, T.E.&L.Co. Surv.	946	4650	3650	Dry (drilled to top of Ellenburger)
Miller-Dalton Oil Co.	R. S. Dalton No. 1	NE. cor. sec. 1786, T.E.&L.Co. Surv., A-561	961	4133	3750	5 bbls. oil 1,000,000 cu. ft. gas
Phoenix Oil Trust Co.	R. S. Dalton No. 1			4050		2,000,000 cu. ft. gas
Producers Oil & Gas Co.	R. S. Dalton No. 1					Dry
Ross & Brooks	Pennington No. 1	SW. cor. sec. 1794, T.E.&L.Co., Surv., A-569	945	4105	3730	Dry
Thompson	R. S. Dalton No. 1			1430		Dry

93 feet per mile. The wells penetrate beneath the surface the following section:

Geologic section penetrated in the Dalton Ranch field.

	Depth *Feet*	Thickness *Feet*
Graford formation—		
Shale, blue, soft containing layers of limestone	0–140	140
Palo Pinto formation—		
Limestone, gray, hard; and light-colored gray marl	140–260	120
Mineral Wells formation—		
Shale, gray; blue sand and white and blue limestone	260–935	675
Garner formation—		
Sand, hard, containing water; blue shale	935–1025	90
Millsap Lake formation—		
Shale, sandy, gray, and blue; thin, light-colored limestone, and gray and brown calcareous sandstones	1025–3200	2175
Smithwick formation—		
Shale and slate, black and dark-gray limestone	3200–3700	500
Marble Falls formation—		
Shale and slate, black and dark-gray limestone	4000–4500	500

Water sands were encountered from 945 to 970, 1050 to 1060, and 3415 to 3420 feet; gas at 2500 and 2785 feet; and gas and oil at 3970 feet.

The structure of the Marble Falls limestone in the Dalton ranch area appears to be only slightly flatter than normal, with an eastward dip of 40 feet to the mile (fig. 11). The accumulation of gas appears to be due to irregular porosity in the limestone and not to any pronounced abnormal structure.

The oil is of light gravity (42° to 44° Baumé), is light green, and contains 25 per cent gasoline. The gas has a specific gravity of 0.6 and has a high content of casinghead gasoline.

HART RANCH OIL POOL

Location.—The Hart Ranch oil pool is located along the western boundary line of the county, two miles north of the Mineral Wells-Breckenridge highway and sixteen miles west and a little north of Palo Pinto. The pool includes the north portion of the Mrs. J. B. Hart ranch and the south end of the A. B. and J. M. Lane ranches,

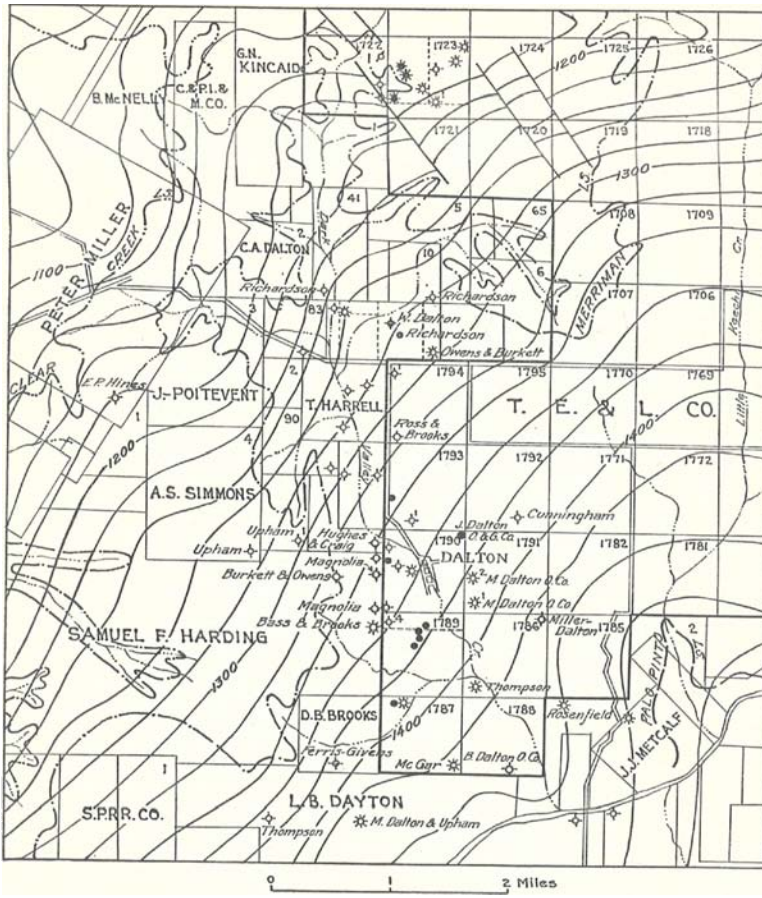


FIG. 11.—Surface structure in the Dalton Ranch oil field. Contours are drawn on the Merriman limestone. The Merriman limestone lies 75 feet below the Clear Creek limestone shown in northwest corner of the map and 375 feet above the Palo Pinto limestone, which outcrops in the southeast corner. Elevations are given in feet above sea level.

located in sections 23, 24, 13, 14, and 11 of the Texas and Pacific Railway Company Survey, Block 4 (Pl. V).

Development.—The discovery well was drilled by Whitesides et al. in the northeast corner of the southwest quarter of section 11, Texas and Pacific Railway Company Survey, Block 4, in 1918. It struck oil at the depth of 3400 feet in a hard limestone in the Smithwick formation and averaged a production of 50 barrels per day for the first year. About six wells were drilled during the next two years, some of which obtained 25 to 50 barrels of oil. Most of the wells, however, were not large, and the productive area was restricted. In September, 1921, the Hart Oil Company completed a well which came in for 14 barrels, but after being shot with 160 quarts of nitroglycerine, it flowed 1400 barrels of oil. This led to increased activity, and between 30 and 40 additional tests were completed by the end of 1923. The locations of some of the typical wells, their depths, and results are given in Table 7.

Geology.—The surface formations in the Hart Ranch field are the Caddo Creek and Brad formations. The Brad formation occupies the valley and the Caddo Creek formation, the uplands and tops of the benches. Beneath the surface the drill penetrates the following section:

Geologic section penetrated in the Hart Ranch field.

	Depth *Feet*	Thickness *Feet*
Graford formation—		
Shale, blue, and limestone, gray, with thick massive layers of limestone at the base	0–650	650
Limestone, gray	650–680	30
Mineral Wells formation—		
Shale, blue, with alternating layers of thin, hard limestone, and near its base one or two layers of sandstone carrying water	680–1370	690
Garner formation—		
Water sand, white, thick, overlying thick bed of shale and thin layers of limestone	1370–1515	145
Millsap Lake formation—		
Shale, blue, sandy, containing thin layers of hard limestone and thicker layers of calcareous sandstone, some of which contain water	1515–3005	1490
Smithwick formation—		
Slate, black, fissile; and black, dense, hard, cherty limestone	3005–3261	256

The oil occurs in the limestone (called "Caddo Lime" by the drillers) of the Smithwick formation mostly between depths of 3210 and 3260 feet. The formation is alternatingly soft and hard. The soft, porous streaks contain the oil, and the hard, cherty layers are barren. In places the rock is so impervious that most of the oil is

TABLE 7.—*Well data for the Hart Ranch oil pool.*

Company	Well	Location in T.&P.R.R. Survey, Block 4	Surface elevation Feet	Total depth Feet	Depth to top of Marble Falls Feet	Depth to top of oil sand Feet	Initial production
Palo Pinto County—							
Ashe Syndicate	Hart No. 1	NE. ¼ SE. ¼ sec. 23	1137	3277		3227	500,000 cu. ft. gas 400 bbls. oil
Do.	Hart No. 2	NW. ¼ NW. ¼ SW. ¼ sec. 24	1246	3295		3253	Dry
Do.	J. B. Hart Est. No. 3	Sec. 18	1336	4228	3770		Dry
Dixie Drilling Co.	Hart No. 1	W. ½ NW. ¼ sec. 18	1404	4195	3757	3295	15 bbls. oil
Do.	J. M. Lane A-1	Cen. E. line N. ½ sec. 13	1401	3845		3447	Dry
Hart-Mexia Synd.	Hart No. 1	NW. ¼ NW. ¼ sec. 23	1254	3261		3210	Pump
Hart Oil Corp.	Mrs. J. B. Hart No. 1	NW. cor. S. ½ sec. 13	1106	3133		3086	1400 bbls. oil
Do.	Mrs. J. B. Hart No. 2	Sec. 23	1245	3266		3225	1,000,000 cu. ft. gas 175 bbls. oil
Do.	Mrs. J. B. Hart No. 3	SW. ¼ NE. ¼ sec. 23	1233	3261		3210	150 bbls. oil
Do.	Mrs. J. B. Hart No. 5	NE. ¼ NE. ¼ sec. 23	1221	3268		3214	Dry
Do.	Mrs. J. B. Hart No. 6	NE. ¼ NW. ¼ sec. 23	1347	3885	3746		Dry
Do.	Mrs. J. B. Hart No. 7	NE. ¼ SW. ¼ sec. 13	1116	3141		3108	Dry
Do.	Mrs. J. B. Hart No. 8	SE. ¼ SW. ¼ sec. 13	1122	3161		3120	25 bbls. oil
Do.	Mrs. J. B. Hart No. 9	SW. ¼ SW. ¼ sec. 13	1241	3285		3240	Dry
Do.	Mrs. J. B. Hart No. 10	SW. ¼ SE. ¼ sec. 26	1312	3256		3218	Show
Hart Oil Corp. & Little Caddo Synd.	Mrs. J. B. Hart No. 4	SW. cor. N. ½ sec. 13	1104	3129		3088	200 bbls. oil
Little Caddo Synd.	Hart No. 3	Sec. 23	1250	3268		3228	2,500,000 cu. ft. gas 300 bbls. oil
Do.	J. B. Hart No. 1	Sec. 23	1246	3268		3223	1400 bbls. oil after shot
Pa.-Tex. Pet. Co.	A. B. Lane No. 1	Sec. 14	1064	3157		3098	Oil
Sun Company	J. M. Hart	Sec. 24		3183		3143	250 bbls. oil
Transcontinental	Lane No. 1	SE. cor. NE. ¼ sec. 14	1102	3128		3085	300 bbls. oil
Do.	Lane No. 2	NE. cor. S. ½ sec. 14	1104	3129		3080	Dry
Do.	Lane No. 4	Sec. 14	1102	3129		3089	300 bbls. oil
Do.	Lane No. 5	Sec. 14	1218	3236		3185	Dry
Do.	Lane No. 6	Sec. 14	1236	3245		3205	100 bbls. oil
Do.	Lane No. 7	Sec. 14	1102	3120		3080	5 bbls. oil
Do.	Lane No. 10	Sec. 14	1084	3495		3040	1,000,000 cu. ft. gas
R. B. Whitesides	Lane No. 1	NE. ¼ SE. ¼ sec. 11	1070	3730	3590	3137	Dry
Do.	Lane No. 2	Sec. 14	1103	3129		3080	Dry
Do.	Lane No. 3	SE. ¼ SE. ¼ sec. 14	1252	3255		3125	60 bbls. oil
Stephens County—							
Hart-Mexia Synd.	R. Q. Lee No. 1	SE. ¼ SE. ¼ sec. 15	1207	3225		3173	100 bbls. oil
Do.	J. B. Hart No. 6	Sec. 23	1329	3879			Dry
Little Caddo Synd.	Hart No. 2	SE. ¼ NW. ¼ sec. 23	1240	3248		3208	200 bbls. oil
Pa.-Tex. Oil Co.	J. M. Lane No. 2	SE. ¼ sec. 11	1076	3165		3078	Oil
Prairie Oil & Gas	R. Q. Lee No. 3	Sec. 3	1289	4050	3755	3275	Dry
Red Eagle	R. Q. Lee No. 4	Sec. 11		3782	3556	3100	Dry
T.P.C.&O.&P.O.&G.Co.	R. Q. Lee No. 2	Sec. 10	1302	3740		3256	Dry
Transcontinental	Lane No. 9	E. ½ NE. ¼ sec. 14	1103	4255	3500	3068	Dry
Do.	A. B. Lane No. 10	Sec. 14	1083	3660	3495	3040	1,000,000 cu. ft. gas

retained until the formation is shot and shattered by nitroglycerine. The wells flow from 50 to 1000 barrels daily after being shot, but soon settle to pumping wells yielding 50 to 200 barrels. The total production of the field does not average over 5000 barrels per acre. Recently production has been stimulated and increased somewhat by acid treatment of the limestone.

The surface structure consists of normal northwest dip modified by a small, narrow, westerly plunging fold and two small faults trending northeast-southwest.

The subsurface structure of the oil formation consists of a broad, east-plunging fold, which is flattened somewhat in sections 14 and 23 of the Texas and Pacific Railway Company Survey, Block 4 (fig. 12). The accumulation of oil and gas in this area is due evidently to irregular porosity in the Smithwick limestone, which pinches out westward and forms a trap or reservoir for the oil.

The oil is brownish green, has a gravity of 37.2° Baumé, a viscosity of 41 (Seybolt seconds at 100 degrees F.), and contains 30.5 per cent gasoline and naphtha, as shown by the following analysis made by the U. S. Bureau of Mines:

	Per cent
Naphtha and gasoline	30.5
Kerosene	12.9
Gas oil	15.7
Non-viscous lub.	11.2
Medium-viscous lub.	7.1
Residium	19.6
Sulphur	0.2

SOUTH BRAD OIL FIELD

Location.—The South Brad oil field is located south of the town of Brad in the western part of the county. Wells have been drilled over an area approximately four miles square located near the center of Texas and Pacific Railway Company Survey, Block 3. Some of the best wells are situated along Ioni Creek about three or four miles south of Brad (Pl. V).

Development.—The area south of Brad was first mapped by Leon Pepperburg in 1917 and leased by Wrightsman and Jordan in that year. A small fold was mapped by geologists of the Roxana Petroleum Company in 1918, and leases were acquired by Roxana and

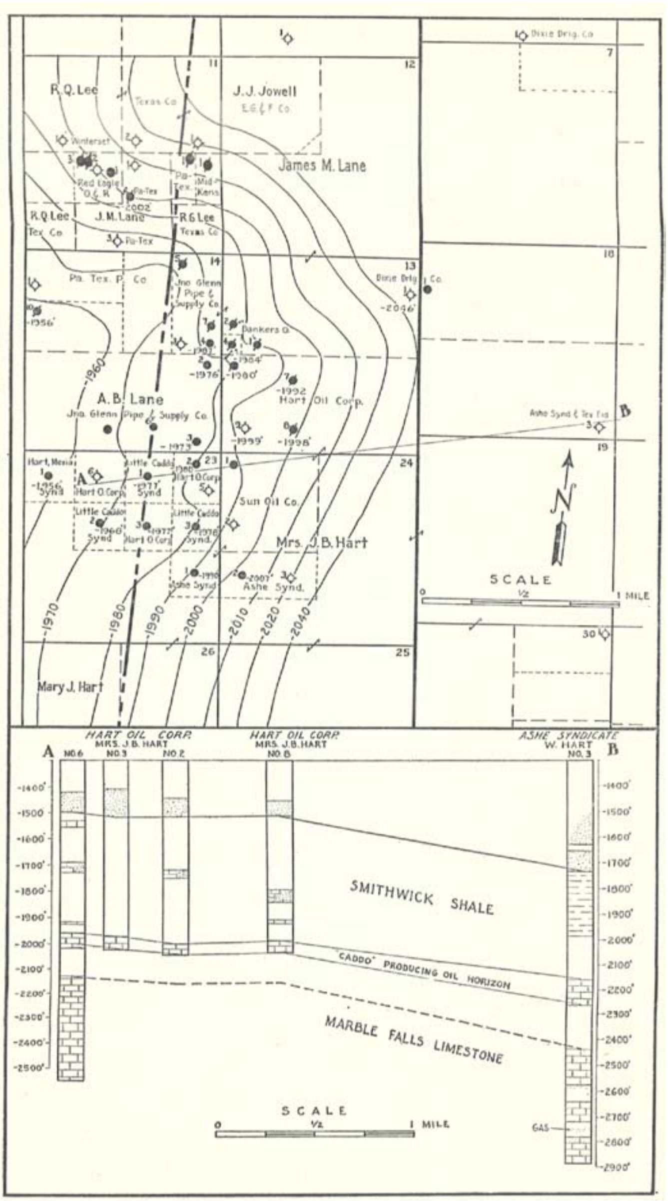


FIG. 12.—Subsurface structure of the Hart Ranch oil field. Contours are drawn on top of the producing zone of the limestone ("Caddo Lime" of the drillers) in the Smithwick formation. Contour elevations are given in feet below sea level.

Mid-Kansas Petroleum Company. The first test was drilled by Mid-Kansas in 1918 to a depth of 3420 feet without obtaining production. In 1920-1921, encouraged by the oil developments on the Hart ranch north of Brad, several tests were started along Ioni Creek southeast of Brad by Pender, Moore, Snebold, Mutual Oil Company, and others. The Hart Oil Company drilled also three tests southwest of Brad. All the tests obtained small quantities of oil or gas or both in the limestones in the Smithwick formation, and some of the wells produced 10 to 25 barrels of oil and considerable gas. Conditions, however, were apparently unfavorable for accumulation of oil in large quantities, and since 1922 only one or two wells have been completed. A record of the tests put down in the South Brad field is given in Table 8.

Geology.—The surface formations in the area of the South Brad field are the Brad and Palo Pinto formations. The subsurface section penetrated by the drill is the same as that in the Hart Ranch field. The oil and gas occur in a limestone in the Smithwick formation at a depth of 3400 feet and in a limestone in the Marble Falls formation at a depth of 3500 feet. The best production comes from the deeper zone.

The surface structure consists of a series of small plunging folds which appear not to be reflected in the subsurface structure of the oil strata. The subsurface structure is apparently normal for the most part, and accumulation of the oil is due probably to irregular porosity and not to pronounced folds or faults.

LONE CAMP GAS FIELD

Location.—The Lone Camp gas field is located one and one-half miles west of the town of Lone Camp and six miles south of Palo Pinto, in the central part of the county. The field covers an area of about one square mile extending over most of the Townsend Survey and the southern part of the M. J. D. McKissach Survey (Pl. V).

Development.—The field was discovered in 1926 by Lou Ladd. who struck an oil and gas sand at a depth of 526 feet while drilling a test in the southeastern part of the Townsend Survey. Immediately a number of drilling machines were brought in from Fort Worth and Breckenridge, and about 25 wells drilled to the sand at depths

TABLE 8.—*Well data for the South Brad oil field.*

Company	Well	Location in T.&P.R.R.Co. Survey, Block 3	Surface elevation *Feet*	Total depth *Feet*	Initial production
E. T. Hart	Cardwell No. 1	Sec. 31	1368	2003	Dry
Do.	Cardwell No. 2	Sec. 42, SW. ¼ NE. ¼	1302	3940	Dry
Do.	Laura Massie No. 1	Sec. 32, NE. ¼ NE. ¼	1229	3900	14 bbls. oil 1,000,000 cu. ft. gas
Pender Prod. Co.	Rasmussen No. 1	Sec. 46, SW. cor. NW. ½	1115	3600	Show of oil and gas
Do.	Slemmons No. 2	Sec. 39	1079	3510	Oil and gas
Moore, Snebold, and Erwin	Slemmons No. 1	Sec. 44, SE. cor. NE. ¼	1140	3307	Dry
Moore and Snebold	Slemmons No. 2	Sec. 44	1135	3647	Dry
Mutual Oil Co.	Huey No. 1	Sec. 52, NW. cor	1172	3742	Show of oil and gas
Do.	Robinson No. 1	Sec. 53	?	1577	Some gas at 1500
Mid-Kansas Pet. Co.	Slemmons No. 1	Sec. 38, NW. cor. SW. ¼	1173	3416	Dry
Upham Gas Co.	F. M. Watson	Sec. 25, SW. ¼	-	3519	2,500,000 cu. ft. gas 15 bbls. oil
Mingus Gas Co.	John Slemmons	Sec. 45, 365′ from N., 350′ from E. line of E. ½ NW. ¼	1140	3875	250,000 cu. ft. gas 10 bbls. oil
Texas Fidelity Oil Corp.	Ash Syndicate (formerly Hart No. 2)	Sec. 29, N. ½ SE. ¼	1364.5	3944	60 bbls. oil
Do.	Eddleman No. 1	Sec. 22, 150′ from N. and E. lines	- -	2505	Dry

ranging from 500 feet on the east to 625 feet on the west. The best wells yielded from 3 to 15 barrels of oil and some gas. The sand was thin, however, and contained water in its lower portion, and the pool was limited by dry holes so that operations were soon curtailed, and production declined rapidly. In 1930 there were only two producing wells, which yielded one-half million cubic feet of gas and a little oil. Table 9 is a list of typical wells with their depths, thickness of the oil sand, and initial production.

Geology.—The surface strata in the Lone Camp oil field consist of shales and sandstones of the lower part of the Mineral Wells formation. The Village Bend limestone member outcrops in the western part of the field and furnishes a good horizon marker on which the structure of the area has been mapped. Beneath the surface the wells penetrate the following section:

Geologic section penetrated in the Lone Camp oil field.

	Thickness *Feet*
Mineral wells formation—	
Shale and limestone, gray	50
Garner formation—	
Sandstone, gray in places, consolidated	20
Shale, dark gray or blue	190
Millsap Lake formation—	
Limestone	6
Sandstone, gray	12
Shale, sandy, containing thin layers of limestone and lentils of sand	210
Oil sand	20
Total section drilled	508

A typical driller's log of one of the wells is as follows:

Log of well drilled on Walls' land, Lone Camp oil field.

	Depth *Feet*	Thickness *Feet*
Soil	0–2	2
Rock	2–46	44
Sand (*Brazos River sandstone*)	46–59	13
Sand rock (*Brazos River sandstone*)	59–70	11
Shale	70–262	192

TABLE 9.—*Well data for the Lone Camp gas field.*

COMPANY	WELL	LOCATION	SURFACE ELEVATION Feet	TOTAL DEPTH Feet	DEPTH OF OIL SAND Feet	RESULT
Ladd et al.	Walls			530	510–530	Dry
Do.	Walls No. 4			1165	520–550	3,000,000 cu. ft. gas
Ladd et al.	Walls No. 1			530	530	20 bbls. oil
Do.	Lee No. 3			536	536	Dry
Nelson Oil Synd.	Jay Owen et al. No. 1	T.&P.R.R.Co. Surv., Blk. 1, sec. 47, 200′ from W., 1000′ from N. line	850	4094	3711–3732	1,000,000 cu. ft. gas
Do.	Mary Owen	T.&P.R.R.Co. Surv., Blk. 1, sec. 47, 150′ from N., 1500′ from W. line	865	3570	3406–3568	2,800,000 cu. ft. gas

	Depth *Feet*	Thickness *Feet*
Goen limestone	262–288	26
Sandy limestone	288–300	12
Shale	300–418	118
Limestone	418–423	5
Shale, sandy	423–495	72
Limestone	495–500	5
Shale	500–510	10
Sand, dry	510–530	20

The oil sand, which is a gray, medium-grained, quartz sand of high permeability and porosity, appears to be at about the same stratigraphic position as the shallow oil sand in the Strawn field. The sand is not completely filled with oil. The lower portion is either dry or contains salt water.

The surface structure is a small northwest-plunging fold, which appears to be on the same trend as the small folds in the Strawn oil field. It seems impossible that these slight folds can form in any way adequate traps for oil and gas. It is more probable that the accumulation is due to irregular porosity or to the lenticular shape of the sand in which the oil occurs.

The sand has produced more gas than oil, and at least two of the gas wells have produced gas for three or four years. The gas is sold to the Upham Gas Company.

COSTELLO FIELD

Location.—The Costello field is located on the Costello ranch in the Michael Castleman Survey and eastern part of the John P. Rohns Survey, three miles northwest of Pickwick. The producing area covers about one square mile (Pl. V).

Development.—The first oil well in this area was drilled by the North American Refining Company to a depth of 4300 feet. It had a good showing of oil in the Strawn sand at a depth of 2500 feet and in the Marble Falls limestone at 4000 feet. Encouraged by these showings, McBride and associates made a location east of the North American test, and at a depth of 2500 feet they struck a good

TABLE 10.—*Well data for the Costello field.*

Company	Well	Location	Elevation Feet	Depth Feet	Initial production
Brazos River Gas Co.	M. B. Costello No. 5	J. F. Smith Surv., 1400′ from N., 1269′ from W. line, 350-A. tract		2412	Dry
Bullington, et al.	M. Costello	J. F. Smith Surv., 150′ from S. and 150′ from E. line		1366	Show of oil Gas
Cline	McDowell	Waco Mfg. Co. Surv.		3957	Dry
W. D. Conway et al.	Ola Carter No. 2	M. Castleman Surv., 220′ from S., 2050′ from E. line, 246-A. tract	969	1392	15 bbls. oil
International Pet. Co.	E. P. Costello No. 3	M. Castleman Surv., 200′ S. of N. line, 2044′ W. of NE. cor.		1393	35 bbls. oil
Do.	E. P. Costello No. 4	M. Castleman Surv., 586′ from N. line, 1936′ W. of NE. cor.	962	1378	20 bbls. oil
Do.	E. P. Costello et ux No. 5	M. Castleman Surv., 2536′ W., 530′ S. of NE. cor	985	1405	33 bbls. oil
R. W. Lindsey Drililng Co.	M. P. Costello No. 1	J. F. Smith Surv.		1394	20 bbls. oil
Do.	Costello Bros. No. 1	M. Castleman Surv.	970	1391	50 bbls. oil
North American Ref. Co.	M. Costello	J. P. Rohns Surv., A-380			Oil
Prairie O.&G.Co. & H. R. Montgomery	E. P. Costello No. 1	M. Castleman Surv., 2262′ from NE. cor. and 809′ from S. line		1391	40 bbls. oil
Roddy, et al.	Carter	W. M. Lucky Surv., 250′ from N. and W. lines	1923	3509	Show
Root & Rhodes	M. B. Costello No. 1	R. R. Williams Surv., 160′ from Brazos R. and 450′ from N. Line		1375	5 bbls. oil
Do.	M. B. Costello No. 2	R. R. Williams Surv., 800′ from Brazos R. and 170′ from N. line		1416	20 bbls. oil
Do.	B. N. Long	R. R. Williams Surv., 400′ from W. line and 400′ from S. line, Long 72-A. tract		1482	Dry
Seaboard	Costello Bros.	Michael Castleman		3185	
Simms Oil Co.	E. P. Costello	J. W. Bunton Surv., 2784′ from W., 2377′ from N. line	1058	3415	Show
Skelly Oil Co.	W. L. Costello No. 1	John F. Smith Surv., 200′ from N. & W. lines	1250	2503	60 bbls. oil
Southern States (Taylor)	M. Costello No. 2	John F. Smith Surv.		3275	

oil sand, which produced 15 to 25 barrels daily. Skelly Oil Company then offset the well on the east and obtained a 60-barrel well in the same sand at a depth of 2503 feet. Following this development and during 1920–1924, about ten other wells were put down in the district. Most of these were dry, and, as the production in the original producing well proved to be unprofitable, development ceased for a time. In 1930 Root and Rhodes, two independent operators, drilled three tests on the R. R. Williams Survey just east of Brazos River. No. 1 obtained about 5 barrels of oil from a sand at a depth of 1375 feet, No. 2 produced about 25 barrels from the same sand, and No. 3 was dry. It is apparent that certain of the Strawn sands throughout this district contain some oil, but nowhere is the sand

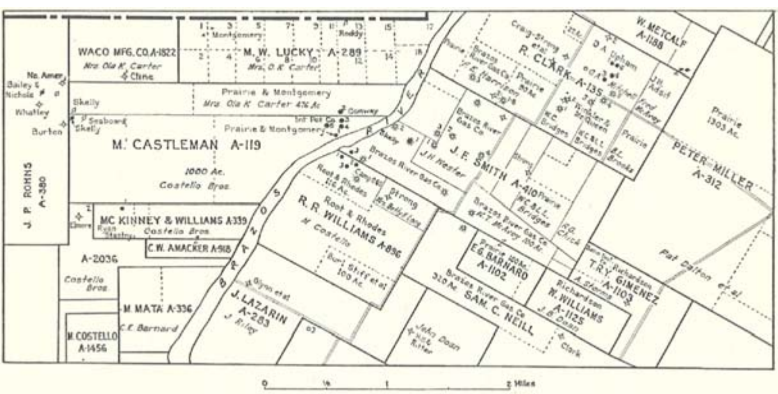


FIG. 13.—Map of the Costello oil field showing locations of wells.

fully saturated. The location, depth, and results of the tests in this district are shown in Table 10. The distribution of the wells in the Costello field are shown in figure 13.

Geology.—The surface formations in the Costello field are the Brad and Caddo Creek formations. The best producing wells start on the Clear Creek limestone, penetrate 800 feet of thick limestones, marls, and a few medium-grained, lenticular sands of the Canyon group, and 1700 feet of thin limestones, thick shales and coarse-grained sandstones of the Strawn. A log of a typical well is as follows:

Log of W. L. Costello No. 1, drilled by Skelly Oil Company, in the northwest corner of the W. L. Costello ranch, John M. Smith Survey, 3 miles northwest of Pickwick.

	Depth *Feet*
Canyon group—	
Caddo Creek formation—	
Home Creek limestone	0–80
Shale	80–180
Brad formation—	
Ranger limestone	180–205
Shale	205–215
Limestone	215–240
Shale	240–380
Limestone	380–385
Shale	385–395
Graford formation—	
Merriman limestone	395–470
Shale	470–620
Limestone	620–663
Shale	663–668
Wiles limestone	668–706
Shale	706–790
Palo Pinto limestone	790–810
Strawn group—	
Mineral Wells formation—	
Shale	810–850
Turkey Creek sandstone	850–870
Thin layers of limestone alternating with thicker beds of shale	870–1050
Shale, red	1050–1055
Shale	1055–1095
Garner formation—	
Brazos River sandstone, contains water	1095–1115
Shale	1115–1155
Millsap Lake formation—	
Goen limestone	1155–1165
Shale	1165–1285
Sandstone containing water	1285–1330
Limestone	1330–1380
Shale	1380–1392
Limestone	1382–1395
Sand	1395–1405
Shale, blue	1405–1510
Shale, red	1510–1525
Shale, black	1525–1565

	Depth *Feet*
Strawn gas sand; sand, dry, contains gas	1565–1585
Shale	1585–1780
Strawn oil sand; sand and shale, sandy	1780–1785
Shale	1785–2478
Sand, *oil*	2478–2503

The northwest dip of the Ranger and Home Creek limestones in the Costello field is modified by a slight plunging fold and is accompanied by slight flattening of the surface beds. The structure of the oil sand in the lower portion of the Strawn group is supposed to be approximately the same as that of the surface formations. In some places, however, small oil reservoirs are formed by the thinning out of the oil sand. The well logs indicate that the sand is of fairly uniform thickness, and that the amount of oil in it varies considerably from well to well.

The structure of the Bend strata has been found to be approximately normal. The Marble Falls limestone dips northeast at the rate of about 65 feet per mile (Pl. IV). At least five wells have been drilled into the Marble Falls limestone. Shows of oil and a little gas were obtained in each well, but no oil in commercial quantities.

SOUTH PICKWICK OR WELDON FIELD

Location.—The South Pickwick or Weldon oil field is located on the Weldon ranch two miles south of Pickwick. The producing area covers about one square mile in the east half of the A. J. Smith and west half of the C. E. P. I. & M. Company surveys located about one mile southwest of McAdams Peak (Pl. V).

Development.—The first well drilled in the Weldon area was the J. K. Weldon No. 1, drilled by the Zada Bell Oil Company. This test obtained one-half million cubic feet of gas at 2710 feet but drilled on to a total depth of 4700 feet. Following the discovery of the gas, about six other holes were put down in the district. Most of these failed to get oil or gas. At present (1933) two wells are producing gas and a little oil. The location, depth, and result of the principal wells are shown in Table 11.

TABLE 11.—*Well data for the Weldon (South Pickwick) field.*

COMPANY	WELL	LOCATION	ELEVATION *Feet*	DEPTH *Feet*	DEPTH TO TOP OF MARBLE FALLS *Feet*	INITIAL PRODUCTION
Inland Oil Co.	G. W. Weldon No. 1		1085	4390	3875	Dry
Do.	J. K. Weldon	R. Coupland Surv., A-120	—	4100	—	Hole lost
Johnson, et al.	J. K. Weldon	A. J. Smith Surv., 750' N. and W. of SE. cor. of Weldon 447 acres	—	—	—	—
Rinehart	Weldon No. 1		1101	4109	3800	Gas and oil
Simms & Meredith	E. P. Costello		—	4150	—	Dry
Zada Bell Oil Co.	J. K. Weldon No. 1		1078	3959	3880	Gas and oil
Do.	J. K. Weldon No. 2		1090	4800	3786	500,000 cu. ft. gas

Geology.—The surface strata in the South Pickwick field belong to the Brad and Graford formations. Most of the Weldon tests start on the Clear Creek bed, which lies about 125 feet below the top of the Ranger limestone. Beneath the surface the bit penetrates the following formations:

Generalized geologic section penetrated in the South Pickwick field. (Compiled from the best well logs available.)

	Depth *Feet*	Thickness *Feet*
Brad formation—		
Limestone and shale containing lentils of sandstone. (Exposed on outcrop.)		110
Graford formation—		
Limestone, gray, massive, hard (5 feet exposed in outcrop)	0–170	175
Shale, dark, fossiliferous	170–420	250
Palo Pinto formation—		
Limestone, gray, hard	420–445	25
Mineral Wells formation—		
Shale, dark, containing at least two layers of sandstone and four thin layers of limestone	445–920	475
Garner formation—		
Sandstone, hard, medium to coarse grained; probably Brazos River sandstone	920–940	20
Shale, dark, thin bedded	940–955	15
Millsap Lake formation—		
Alternating beds of shale, sandy shale, and sand, about seven layers of limestone and four layers of sand containing salt water	955–2855	1900
Smithwick formation—		
Black shale containing thin layers of black limestone	2855–3605	750
Marble Falls formation—		
Hard, black limestone interbedded with layers of black shale	3605–4520	915
Barnett formation—		
Shale, brown, soft	4520–4620	100
Ellenburger[89] formation—		
Limestone, white, porous, containing sulphur and salty water	4620–4680	60

The gas occurs in a sand in the Millsap Lake formation at a depth of 2710 feet below the top of the Merriman limestone, which is the

[89]Depth in Zada Bell Oil Company Weldon No. 2.

surface rock in the south edge of the area. The sand is fine grained, free of water and has a thickness of 20 feet. No oil, gas, or water was encountered in the Marble Falls formation.

The structure of the surface strata in the field is that of a small, northwest-plunging anticline, best described as a wrinkle somewhat flattened, in the western part of the Weldon Tract where the wells have been drilled. It is doubtful whether the fold is large enough to form an adequate reservoir. Any accumulation of oil or gas in the area is due probably to irregular porosity or to an eastward pinching out of the sandstone layers. Possibly wells drilled west of the Weldon gas well may encounter some oil.

ALLEN AND RITCHIE OIL FIELD

Location.—The Allen and Ritchie oil field is located six miles northeast of Pickwick in the extreme northwest corner of Palo Pinto County. The producing area covers about two square miles in section 2 of the T. W. Moore Survey, section 1 of the Southern Pacific Railroad Company Survey, A-421, D. C. Coffman Survey, A-1251, and the west half of B. McNelly Survey, A-320 (Pl. V).

Development.—The first well was drilled by the States Oil Corporation in 1929 and obtained oil in a Strawn sand at a depth of 764 feet. The Prairie Oil and Gas Company drilled a second well which had an initial production of 10 barrels at a depth of 1750 feet. Since these two initial wells were completed about twelve additional tests have been put down with varying success as shown by Table 12.

Geology.—The surface outcrops in the Allen and Ritchie field consist of Brad formation on the uplands and upper part of the Graford formation along the creek valley that crosses the south end of the field. The Caddo Creek formation outcrops just north of the producing area. An interesting feature in the north part of the field is a natural flowing spring, which has its source in a porous layer in the Ranger limestone and furnishes an excellent supply of water. Beneath the surface the wells penetrate 600 feet of Canyon strata and obtain the oil in the Strawn. There are three producing oil and gas sands in the section, as follows:

3. Shallow sand, at a depth of about 760 feet below the surface, near the base of the Mineral Wells formation. This has yielded 50 barrels. The wells are restricted to a very limited area.

2. Middle oil sand, at a depth between 1150 and 1250 feet below the surface, in the Millsap Lake formation at about the horizon of the shallow Strawn sand in the southern part of the county. This horizon produces mostly gas.
1. Deep oil sand, at a depth of 1750 feet below the surface, in the Millsap Lake formation at about the horizon of the producing sand of the Buttram oil field in southwestern Jack County.

The producing area of the shallow sand appears to be of such limited extent and local occurrence, that it is thought the accumulation of oil in it may be due to vertical migration along a fault or other passageway from the deep Strawn oil sands below. No oil has been found in the Mineral Wells formation in other fields in the county. A section of a typical shallow well is as follows:

Section of States Oil Corporation Allen-Ritchie No. 1, northwest corner of section 2, S.P.R.R. Company Survey.

	Depth *Feet*
Limestone	6–18
Shale	18–23
Merriman limestone	23–45
Shale, blue	45–84
Limestone, blue, gray	84–90
Shale	90–101
Limestone	101–156
Shale, blue	156–180
Limestone	180–183
Shale	183–199
Limestone	199–204
Shale, blue	204–552
Palo Pinto limestone	552–570
Shale	570–574
Limestone	574–635
Shale	635–639
Limestone	639–644
Shale	644–652
Limestone	652–672
Shale	672–680
Limestone	680–684
Shale	684–693
Limestone	693–704
Shale	704–763
Oil sand	763–764
Total thickness of section	764

TABLE 12.—*Well data for Allen and Ritchie oil field.*

Company	Well	Location	Surface elevation *Feet*	Total depth *Feet*	Depth of oil sand *Feet*	Initial production
Christie Bros.	Allen-Ritchie No. 1	T. J. Braford Surv., A-1628, 200′ from W., 200′ from S. line	1094	4575	Absent	Dry
Do.	Allen-Ritchie No. 2	T. J. Bradford Surv., 450′ from S., 450′ from W. line	1312	1316	1313–1316	Little gas
Clay & Lancaster (Clay Bros.)	Allen-Ritchie No. 1	S.P.R.R. Surv., A-421, 450′ from NW., 200′ from NE. line, A. & R. 160-A. tract	—	1771	—	Dry
International Pet. Co.	Allen & Ritchie No.2	C.T.R R.Co. Surv., A-140 (450′ N. of No. 1)	—	1775	—	Dry
Transcontinental	C. A. Dalton	T.E.&L. Surv., sec. 857, 330′ from E., 330′ from S. line	1240	3035	—	Dry
Sinclair-Prairie & Amerada	Mary Bridges No. 1	Wm. Metcalf Surv., 330′ from N. line, 330′ from E., 1755′ from W. line of M. Bridges tract	1038	2602	Absent	Dry
Do.	C. A. Dalton	A.B.&M. Surv., A-915, 330′ from S., 330′ from W. line	—	3105	Absent	Dry
Do.	Ritchie	S.P.R.R.Co. Surv., A-421, sec. 1, 800′ from S., 320′ from W. line	1066	1757	1742–1749	Show oil
Do.	Allen & RitchieNo. 1	C.T.R.R.Co. Surv., A-140, sec. 1, 1467′ from NE., 1352′ from SE. line	1131	1557	—	175 bbls. oil
Do.	Allen & Ritchie No. 2	C.T.R.R.Co. Surv., A-140, sec. 1, 1269′ from NE., 750′ from SE. line	1238	1674	—	100 bbls. oil
Do.	Allen & Ritchie	C.T.R.R.Co. Surv., A-140, sec. 1, 1525′ from NE., 626′ from NW. line	1081	2383	—	Dry
Do.	E. B. Ritchie No. 1	C.T.R.R.Co. Surv., A-140, 330′ from S., 350′ from S. line	—	1704	1700–1704	40 bbls. oil
States Oil Corp.	Allen & Ritchie No. 1	T. W. Moore Surv., A-1651, sec. 2, 450′ from N., 450′ from W. line	1099	1793	—	20 bbls. oil
Do.	Allen & Ritchie No. 2	T. W. Moore Surv., A-1651, sec. 2, 450′ from N., 550′ from W. line, 160-A. tract	—	1288	1260–1268	600 bbls. oil 10,000,000 cu. ft. gas
Do.	Allen & Ritchie No. 3	T. W. Moore Surv., sec. 2, A-1651, 200′ from NW., 850′ from most northerly N. cor. (about 500′ W. of No. 1)	1083	1275	—	20,000,000 cu. ft. gas
Do.	Allen & Ritchie No. 4	T. W. Moore Surv., sec. 2, A-1651, 450′ from NE., 950′ from NW. line	—	1795	1792–1795	30 bbls.

The surface structure of the field is a slight terrace over an area of about one mile in which the normal northwest dip is arrested (fig. 14). The oil accumulation is due probably to irregular distribution of the sand body or irregular porosity rather than to folding. Small faults may be present, although they have not been recognized at the surface.

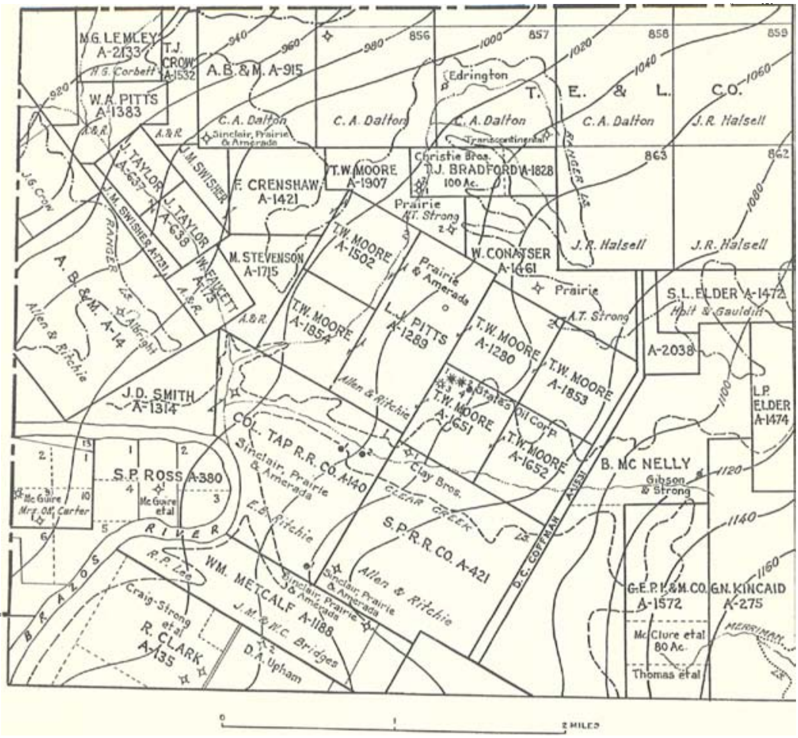


FIG. 14.—Surface structure in the Allen and Ritchie oil field. Contours are drawn on the Merriman limestone, and elevations are given in feet above sea level.

STRAWN TOWNSITE FIELD

Location.—The Strawn Townsite field is the last oil and gas producing area to be developed in Palo Pinto County. It is located in the townsite of Strawn and extends to the north and east of town over an area of about nine square miles mainly in the Henry Bird, Isaac Ryan, and Burleson County School Land surveys (Pl. V). The field is not an eastward extension of the old Strawn field, as one might suspect. The oil and gas in most of the wells come from a sand 3000 feet deep, 2000 feet below the production in the old Strawn pool: and it is on a separate structure.

Development.—Burton and McKee drilled the first wells that obtained oil from the 3000-foot horizon in the Strawn townsite district. Their first well was located near the center of the A. Ashworth Survey, three miles east-northeast of Strawn. It was completed in 1925 and flowed about 100 barrels daily from a gray sandy limestone in the Bend group at a depth of 3036 to 3044 feet. The well flowed steadily under strong gas pressure. As a result of this success, Burton and McKee drilled five other wells in the A. Ashworth Survey and two in the Isaac Ryan Survey during the next two years. The two tests in the Ryan Survey were located near the Strawn cemetery one-half mile south of town. All eight wells were comcompleted during 1926, 1927, and 1928. The four tests in the Ashworth Survey were abandoned, but the test located just north of the Strawn cemetery produced about 40 barrels of oil and much gas. The oil production was not large and the new discovery did not arouse much outside interest, consequently it was nearly two years before the main gas pool in the city itself was developed. The first well within the city limits was completed in 1930 at the depth of 3002 feet and made about 6,000,000 cubic feet of gas under a rock pressure of 1250 pounds. The gas was rich in casing-head gasoline, and the next year (1931) about twenty wells were completed. Most of these proved to be good gas wells and a few made a little oil. The depth of the gas ranges from 2950 to 3050 feet and the initial production from 1,000,000 to 15,000,000 cubic feet daily. The rock pressure ranges from 1200 to 1350 pounds per square inch, and the pressure and rate of flow hold up well. Tables 13 and 14 give the locations, depths, initial production, and initial pressures of most of the wells in the field.

TABLE 13.—*Well data for the Strawn Townsite field.*

COMPANY	WELL	LOCATION	ELEVATION *Feet*	TOTAL DEPTH *Feet*	DEPTH OF GAS SAND *Feet*	INITIAL PRESSURE *Lbs. per sq. in.*	INITIAL PRODUCTION
Britton & Gordon	Strawn Coal Co. No. 2	I. Ryan Surv., 2000′ from N., 3200′ from W. line	1031	3081	3053–3065	1200	500,000 cu. ft. gas 20 bbls. oil
Do.	Strawn Coal Co. No. 3	I. Ryan Surv., 550′ from N., 3100′ from W. line	1017	3051	3044–3051	1300	1,500,000 cu. ft. gas 1½ bbls. oil
Do.	Strawn Coal Co. No. 4	I. Ryan Surv., 175′ from N., 2500′ from W. line	--	3067	----	----	Dry
Do.	Strawn Coal Co. No. 5	I. Ryan Surv., 350′ SW. of SW. corner of cemetery	1020	3271	3053–3057	----	40 bbls.
Burton-McKee Oil Company	C. E. Allen No. 1	200′ from N., 200′ from E. line of Allen 15-A. tract, I. Ryan Survey	1000	3022	2954	----	7,000,000 cu. ft. gas
Do.	M. G. Vernon No. 1	Bird Surv., cen. Lot 16, original Strawn Subdiv.	997	3015	2985	-	4,000,000 cu. ft. gas
Do.	Strawn Coal Co. No. 9	Bird Surv., cen. Blk. 4, original Strawn Subdiv.	1003	2995	2990	--	12,500,000 cu. ft. gas
Do.	Strawn Mdse. Co. No. 1	Strawn Townsite, Blk. 4, 138′ S. and E.	1003	2995	2989–2995	--	12,000,000 cu. ft. gas
Do.	Vernon, et al. No. 1	Strawn, Lot. 6, Blk. 16, 29′ from N., 11′ from W. line	997	3017	3010–3017	--	14,000,000 cu. ft. gas
Burton-McKee and Palo Pinto Oil Co.	Smith No. 1	Strawn Townsite, cen. Lot 4, Woodlawn Subdiv.	984	2988	2975	--	16,000,000 cu. ft. gas Show oil
Dunkel and O'Donnell	F. P. Simmons No. 1	H. Bird Surv., cen. Blk. 1, original Strawn Subdiv.	997	3014	2997	--	750,000 cu. ft. gas 35 bbls. oil
Ralph Dunkel	A. F. Hartman No. 1	Strawn Townsite, 151′ from E., 151′ from N. line	998	3014	3011–3014	1200	1,500,000 cu. ft. gas 50 bbls. oil
Frazar and O'Donohue	Housley and Frazar No. 1	H. Bird Surv., 184′ N. and 159′ W. of SE. cor. Frazar lot, 340′ N. of Nelson's	1024	3086	----	----	5,000,000 cu. ft. gas 15 bbls. oil
Gibson and Lucas	Cromeans and Pollard No. 1	Strawn Townsite, Lots 23 and 25, Woodlawn Addition	984	2996	2884–2996	1270	7,000,000 cu. ft. gas
Do.	Harbin and Thomas No. 1	Cen. Harbin and Thomas 2-A. tract, Strawn city limits	--	3015	2998–3013	1270	7,100,000 cu. ft. gas
C. F. Gibson, et al.	J. Pollard No. 1	H. Bird Surv., cen. Lot 1 on W. line central Add., approx. 500′ N. of T.P.'s Colcard No. 1	984	2998	2980	--	14,000,000 cu. ft. gas Show oil

TABLE 13.—*Well data for the Strawn Townsite field.*—(*Continued*)

COMPANY	WELL	LOCATION	ELEVATION *Feet*	TOTAL DEPTH *Feet*	DEPTH OF GAS SAND *Feet*	INITIAL PRESSURE *Lbs. per sq. in.*	INITIAL PRODUCTION
C. F. Gibson et al.	S. W. Watson No. 1	Strawn Townsite, Blk. 1, Woodlawn subdiv., 150′ from E., 200′ from N. lines	984	2998	2986–2999	1300	15,000,000 cu. ft. gas
Do.	Williams and Thomas No. 1	Henry Bird Survey, 153′ N. of cen. of Church St., W. of cen. Lamar Street	1004	3013	2995		6,500,000 cu. ft. gas
Do.	Witwisky	Henry Bird Surv., 145′ from S. line of Blk. 25 Woodlawn Add.	----	2993	2975		7,000,000 cu. ft. gas
Goodwin & White	A. C. Anderson No. 1	Henry Bird Surv., cen. Blk. 2, orig. Strawn Townsite Subdiv.	989	2998	2930		11,500,000 cu. ft. gas
Do.	Housley No. 1	Henry Bird Surv., cen. Blk. 3, orig. Strawn Townsite Subdiv.	1000	3000	2998		11,000,000 cu. ft. gas
J. B. Gordon	Watson Bros. No. 1	Henry Bird Surv., 2850′ from S., 4650′ from W. line	994	2996	2775	1350	13,000,000 cu. ft. gas
R. E. Grounds	W. N. Gilson, et al.	Strawn Townsite, Blk. 9, 140′ from N., 150′ from W. line	1012	3043	3027–3043	1375	3,500,000 cu. ft. gas
R. E. Grounds, et al.	Watson and Robinson No. 1	Henry Bird Surv., cen. Blk. 5, Jones Add., city of Strawn	1006	3036	3007		6,000,000 cu. ft. gas 24 bbls. oil
Hoffman and Page Co.	Mary Galena No. 1	I. Ryan Surv., 240′ from N., 240′ from E. line of Galena tract	988	3006	2955–2965		8,500,000 cu. ft. gas
Do.	Mrs. J. B. Hash No. 1	Henry Bird Surv., 2520′ from S., 4650′ from W. line	994	3035	3002–3035		8,500,000 cu. ft. gas 100 bbls. oil
Do.	Jackson	250′ S., 500′ E. of SE. cor., Blk. 4, Jones Add.	995	3025			6,500,000 cu. ft. gas
Do.	L. P. Strawn No. 1	Henry Bird Surv., 163′ from S. 163′ from W. line, Strawn 6½-A.	1005	3055	3005–3021		500,000 cu. ft. gas
Do.	S. B. Strawn Estate No. 1	Henry Bird Surv., 361′ from E., and 140′ from S. of 12-A. tract	1015	3040	3022–3036		11,000,000 cu. ft. gas
Do.	Strawn Heirs No. 1	Henry Bird Surv., 100′ from E., 200′ from S. line, 7½-A. tract	991	3270	2932–3008	1365	300,000 cu. ft. gas
King & Grounds	Gibson No. 1	Henry Bird Surv., 160′ from E., 160′ from N. of most northerly NE. cor. of Stuart 23-A. tract	1011	3048	3018		3,500,000 cu. ft. gas
Mineral Wells Oil & Gas Co.	Simmons No. 1	Henry Bird Surv., 3460′ from S., 4070′ from W. line	----	3032	3005–3010		----
Nelson Oil Syndicate	C. L. Link No. 1	Henry Bird Surv., cen. Blk. 2, Tierns Add. 2 blks. N. of Blk. 4, original Strawn subdiv.	1002	3020	3003		6,500,000 cu. ft. gas

Do.	P. P. Pierce No. 1	Strawn Townsite, cen. Blk. 2	900	3020	3003–3020	1320	7,000,000 cu. ft. gas
Do.	Rogers No. 1	Cen. Blk. 8, Jones Add., Henry Bird Surv.	----	----	----	----	----
Do.	Hattie Stages No. 1	135′ from S., 125′ from E. line of 2nd blk. N. of Blk. 4, Jones Add.	1024	3032	3016–3032	--	15 bbls. oil 1,000,000 cu. ft. gas
Nelson Oil Synd.	L. P. Strawn, et al.	128′ from S., 131′ from W. line of Blk. just N. of Blk. 5, Jones Add.	1018	3052	----	----	8,000,000 cu. ft. gas 200 bbls. oil
Owen & Dudley, et al.	Hattie Stages No. 1	Henry Bird Surv., cen. Blk. 19, original Strawn Subdiv.	1001	3041	2995–3011	----	6,000,000 cu. ft. gas
Pace & Ward	Jackson No. 1	Henry Bird Surv., 3250′ from S., 4600′ from W. line of surv., 190′ W. and 20′ S. of NW. cor. Lot 25, Woodlawn Add.	995	3043	3013–3019	----	6,500,000 cu. ft. gas Show of oil
Palo Pinto Oil & Gas Co.	C. E. Allen No. 1	Henry Bird Surv., 10′ from W. and cen. N. and S. of Blk. 36, original Strawn Subdiv.	1002	3034	2950–2973	1350	7,000,000 cu. ft. gas
Do.	C. E. Allen No. 1-A	Henry Bird Surv., cen. Blk. 20., original Strawn Subdiv.	1001	3014	2987–2993	1300	8,000,000 cu. ft. gas
Do.	E. S. Britton No. 1	Henry Bird Surv., 220′ from E. line, and 295′ from N. of creek bank	996	3075	3000–3063	----	1,500,000 cu. ft. gas 40 bbls. oil
Do.	E. S. Britton No. 2	360′ from N., and 330′ from W. line 16-A. tract; 5950′ from S., 2880′ from W. line of H. Bird Survey	993	3053	2983–3018	----	4,000,000 cu. ft. gas
Do.	Cornelia Crocker, et al.	Strawn Townsite, Lots 1 to 16, 25′ from E. and S. lines	987	3026	2992–3012	1150	3,000,000 cu. ft. gas
Do.	A. F. Disharoon No. 1	Henry Bird Surv., 165′ from E., 182′ from S. line of tract (T.P.)	993	3050	3002–3011	----	2,000,000 cu. ft. gas Spray oil
Do.	E. W. Smith, et al. No. 1	Strawn Townsite, Blk. 2, 175′ from E. and N. lines Woodlawn Add.	982	2990	2975–2990	----	16,000,000 cu. ft. gas
Do.	T. P. Ry. Co., et al.	Strawn Townsite, Lot 10, 10′ from N. and W. lines	998	3034	2988–2992	1300	10,000,000 cu. ft. gas
C. L. Peters	W. L. Stephens No. 1	Stephens tract, 140′ from N., 150′ from E. line	997	3036	3011–3033	1350	6,000,000 cu. ft. gas
Texas Pacific Coal & Oil Co.	R. E. Colcord No. 1	H. Bird Survey, Woodlawn Add., Blk. 23	978	2998	----	----	10,000,000 cu. ft. gas
Do.	T. P., Fee No. 1	H. Bird Surv., 2500′ from E., 3500′ from S. line	1010	2988	2975–2988	1325	2,500,000 cu. ft. gas
Do.	Henry Bird (Fee) No. 2	H. Bird Surv., A-26, 1000′ from S., 2875′ from E. line	983	2996	----	----	9,000,000 cu. ft. gas

TABLE 13.—*Well data for the Strawn Townsite field.*—(*Concluded*)

COMPANY	WELL	LOCATION	ELEVATION *Feet*	TOTAL DEPTH *Feet*	DEPTH OF GAS SAND *Feet*	INITIAL PRESSURE *Lbs. per sq. in.*	INITIAL PRODUCTION
Texas Pacific Coal & Oil Co.	T. P., Fee No. 3	350′ E. of P.P.O.&G. Smith No. 1, 4460′ from S., 182′ from W. line of Bird Surv.	981	3001	2994–3001		3,000,000 cu. ft. gas Show oil
Do.	T. P., Fee No. 4	H. Bird Surv., 330′ from E., 990′ from S. line	1001	3051	3005–3051	1150	15,000,000 cu. ft. gas 10 bbls. oil
Do.	S. J. Stuart, et al., No. 1	Woodlawn Add., Lot 33, 62′ from S., 250′ from W. line lot; 500′ from E., 2700′ from S. line, of Bird Fee, S. line being N. line of R.R.R.W.	980	2998	2995		9,500,000 cu. ft. gas
R. B. Thomas, et al.	Thomas No. 1	I. Ryan Surv., No. 338, 200′ from N., 4000′ from E. line of survey	991	2999	2996		2,000,000 cu. ft. gas
F. L. Walker	Binnings No. 1	Strawn Townsite, cen. Blk. 14	1001	3017	2994		24,000,000 cu. ft. gas
Do.	D. V. Loflin Est. No. 1	50′ E. of original Townsite E. line, 650′ N. of Corporate S. line	992	3231	2967		11,500,000 cu. ft. gas
Do.	Stuart Hrs. No. 1	Bird Surv., cen. Blk. W. of Blk. 6, Janes Add.	1019	3066	3024		750,000 cu. ft. gas
Wickens, et al.	W. L. Ready No. 1	H. Bird Surv., 150′ S. and 150′ W. of SE. cor. Blk. 39, Woodlawn Add.	995	3035	2998		6,000,000 cu. ft. gas 25 bbls. oil
Do.	Watson Bros. No. 1.	Strawn Townsite, cen. Blk. 5	1003	2996			5,500,000 cu. ft. gas

TABLE 14.—*Data for wells east of Straun Townsite field.*

COMPANY	WELL	LOCATION	ELEVATION Feet	TOTAL DEPTH Feet	DEPTH OF GAS SAND Feet	INITIAL PRESSURE Lbs. per sq. in.	INITIAL PRODUCTION
Fred A. Bond	Baker Estate	A. Ashworth Surv., cen. S. 120-A. of 142-A. tract	966	2970	2966	1360	4,000,000 cu. ft. gas
Burton-McKee Oil Co.	Strawn Coal Co. No. 1	A. Ashworth Surv., 5530′ S. and 6120′ W. of NE. cor.	990	3044	3036–3044	--	100 bbls. oil Some gas
Do.	Strawn Coal Co. No. 2	A. Ashworth Surv., 3800′ S. and E. from NW. cor.	1019	3268	3065–3075	--	Little gas Water at 3075′
Do.	Strawn Coal Co. No. 3	A. Ashworth Surv., near center	1016	3100	3055–3065	--	--
Do.	Strawn Coal Co. No. 4	1000′ SW. of No. 1, A. Ashworth Surv.	1016	3121	3042	--	Some gas
Do.	Strawn Coal Co. No. 6	A. Ashworth Surv., SE. cor. 320-A. tract	992	3014	3010–3014	--	Little gas Water
Do.	Strawn Coal Co. No. 7	A. Ashworth Surv., 300′ N., 75′ E. of 141-A. tract	984	3014	3003	--	2,000,000 cu. ft. gas
Do.	Strawn Coal Co. No. 8	415′ E., 4822′ S., of NE. cor. of A. Ashworth Surv.	966	2995	--	--	1,700,000 cu. ft. gas
Cousins and Wickens	J. K. Williams No. 1	A. Ashworth Surv., NW. cor. Williams 120-A. tract	987	3233	3004–3015	--	1,000,000 cu. ft. gas Water at 3015′
Gordon, et al.	Caine	450′ from N., 1350′ from W. line Lot 32, Blk. 2, Burleson Co. Sch. Lds.	911	3142	3120	--	--
W. K. Gordon	Mrs. M. L. Askew	1320′ from S., 990′ from E. Lot 33, Burleson Co. Sch. Lds.	915	3420	3150	--	Dry
W. M. Gordon	J. L. Ringo	425′ from S., 880′ from E. line sec. 36, Burleson Co. Sch. Lds.	965	2551	3215	--	2,000,000 cu. ft. gas
Gordon and Britton	Johnson (Mrs. Croker)	1200′ N., 1000′ from E. line John Bird league	982	3553	3220	--	Dry
Gordon and Gholson	Mrs. M. L. Askew	450′ from S., 750′ from W. line of Lot 33, Burleson County Sch. Lds.	921	3132	3125	--	7,700,000 cu. ft. gas
Hoffman and Page Co.	B. B. Chisholm	330′ from S., 600′ from E. line Lot 80, Burleson Co. Sch. Lds.	945	3905	2950	3300	1,750,000 cu. ft. gas (Now abandoned)
Moore and Snebold	C. V. Pruitt	Lot 68, Burleson County Sch. Lds.	1003	3585	3025	--	Dry

TABLE 14.—*Data for wells east of Strawn Townsite field.*—(*Concluded*)

Moore and Snebold	Strawn Coal Co. No. 9	A. Ashworth Surv., 7050′ from S., 1000′ from E. line	976	2977		1275	14,500,000 cu. ft. gas
Do.	Strawn Coal Co. No. 10	A. Ashworth Surv., 6255′ from S., 2400′ from E. line	992	3000	2968	2978–3000	7,000,000 cu. ft. gas
Rockmill and Snebolt	T. S. Rector	N. ½ Lot 66, Burleson Co. Sch. Lds.	999	3065	3033		2,000,000 cu. ft. gas
Texas Pacific Coal & Oil Co.	Ashworth-Fee "Palmer"	3150′ from E., 3850′ from S. line A. Ashworth Survey	979	3200	2987		
F. L. Walker	M. Ready	3670′ from S., 670′ from E. line A. Ashworth Surv.	989	3001	2995		
F. L. Walker, et al.	C. Crocker	3130′ from S., 5800′ from W. line John Bird Survey	893	3532	3220		Dry
Do.	M. W. Smith	S. ½ Blk. 82, Burleson Co. Sch. Lds.	954	2984	2980		Some gas
Ward, et al.	P. A. Chapman	800′ N., 1500′ W. of N. cor. Lot 35, Burleson Co. Sch. Lds.	936	3430			
Ward and Gibson	K. G. Shoor	300′ from SE. cor. Lot 35, Blk. 2, Burleson Co. Sch. Lds.	942	3219	3168		1,500,000 cu. ft. gas
Bob Wickens, et al.	Baker No. 1	A. Ashworth Survey	959	2999	2974		1,100,000 cu. ft. gas
Wilkens, et al.	Jones No. 1	SW. cor. sec. 72, Burleson Co. Sch. Lds.	955	3206	2998		2,100,000 cu. ft. gas
Do.	Wilbar	1320′ N., 330′ from W. line of subdiv. 59, Burleson Co. Sch. Lds.	988	3045	3023		

Geology.—The surface rocks in the Strawn Townsite field belong to the Mineral Wells formation. The strata are made up of shales containing lentils of thin calcareous sandstones, and a few fairly thin, hard, impure limestone layers. The surface in places is covered by considerable terrace gravel. Beneath the surface the drill penetrates about 2450 feet of blue and gray shale, hard blue limestones, and about six or seven widely separated layers of calcareous sandstone. A geologic section of a typical well is as follows:

Geologic section penetrated in the Strawn Townsite field.

	Thickness *Feet*
Mineral Wells formation—	
Shale, dark bluish gray	175
Garner formation—	
Brazos River sand, sandstone gray, fine grained, soft, shaly, and unconsolidated. Upper layers hard, lower layers more or less consolidated. Contains no water	34
Shale, dark bluish gray	170
Thurber coal	2
Millsap Lake formation—	
Shale, dark blue, and grayish blue, sandy, containing five or six layers or lentils of sandstone, and about six layers of hard dark-blue limestone and having a thick sand at its base	2005
Smithwick formation—	
Shale, black fissile, splintery	534
Marble Falls? formation—	
Limestone, gray, soft, porous, containing oil and gas	36

The producing zone is a gray, sandy limestone that drills fairly easily and has an average porosity of 11 per cent and a probable thickness of 30 to 50 feet, although it has been penetrated in most wells only 10 to 20 feet. Three of the sandstone layers in the Strawn group carry shows of oil and gas or much water. In most wells the water in the two shallow sands is under sufficient hydrostatic head to flow. The following table shows the occurrence of sands in a typical well:

	Depth *Feet*
Coal	375–377
Sand, five 10-inch bailers of water per hour	430–440
Sand, hole fills up with water	880–885

	Depth *Feet*
Sand, dry	1395–1410
Sand, calcareous, dry	1540–1645
Sand, and sandy shale, dry	1780–1815
Sand, dry	2040–2050
Sand, black and white, containing show of oil in some wells, two bailers per hour	2316–2455
Limestone, sandy, porous, containing oil and gas	2990–3025

The subsurface structure of the Strawn Townsite field as mapped on the producing gas formation is a broad, plunging fold trending east-northeastward through the south part of the Henry Bird and Burleson County School Land surveys (fig. 15). A dome about two miles in diameter and having a closure of about 50 to 60 feet is developed on the west end of this fold in the vicinity of the town the Strawn Coal Company land in the Abner Ashworth and adjoining the structure is east of Strawn High School in Block 36 and in the northeast corner of the William Allen Estate. A second somewhat lower dome occurs on the east part of the fold in the vicinity of Block 81, Burleson County School Land, and supports good wells on the Strawn Coal Company land in the Abner Ashworth, an adjoining survey (fig. 15). The wells in the Townsite dome produce only gas. Wells north and northeast of the township somewhat lower on the structure yield some oil with the gas. Gas, however, is the main product from the field.

The oil is of amber color, is 44° A. P. I. gravity, and has a viscosity of 3.203 centipoise at 33° C. The gas pressure at the well head is about 1205 pounds per square inch and declines very slowly. The production of the wells during the last twelve months is shown in Tables 15 and 16 and in the graph, figure 16.

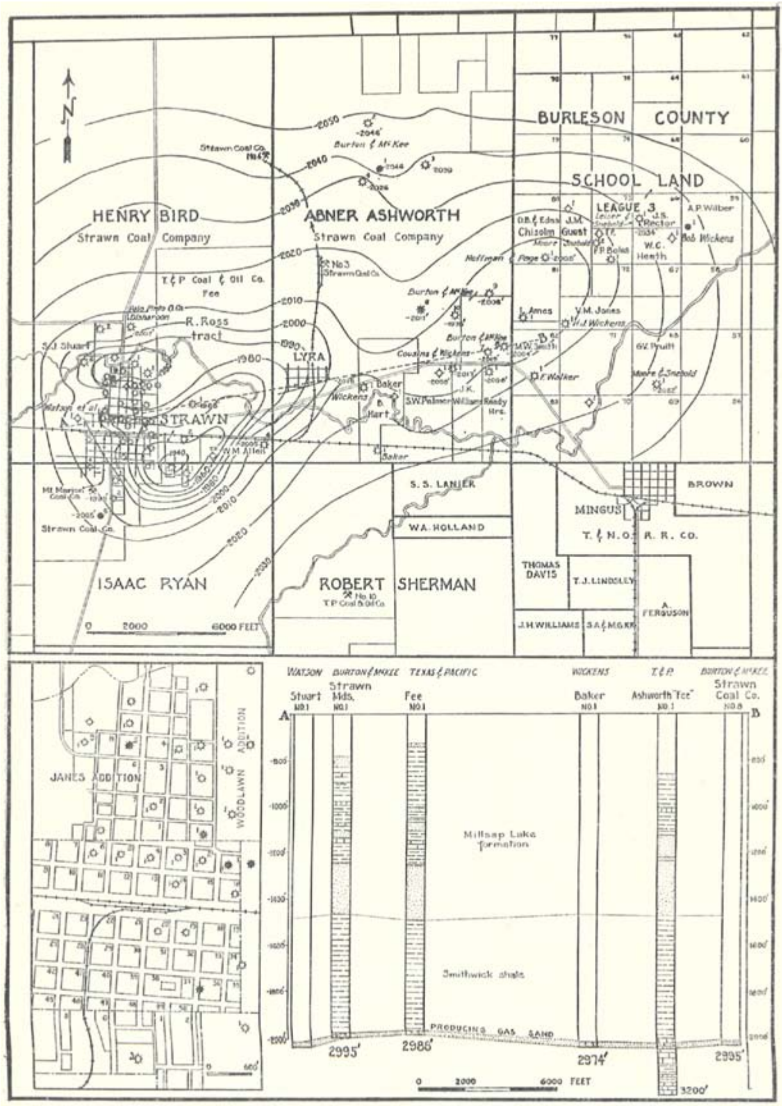


FIG. 15.—Subsurface structure of the Strawn Townsite field. Contours are drawn on the producing gas "sand" in the top of the Marble Falls formation, and elevations are given in feet below sea level. (Map furnished by Texas and Pacific Coal and Oil Company.)

TABLE 15.—*Production of gas in Strawn district, in thousands of cubic feet.*
Oct. 1, 1932, to June 1, 1933

Wells in Strawn Townsite

OWNER	WELL NAME	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	TOTAL PRODUCTION MARCH, 1934 *M. Cu. Ft.*
Palo Pinto O. & G. Co.	C. E. Allen No. 1a		11,678	12,289	6,859	13,538	11,489	8,076	11,635	221,903
Do.	C. E. Allen No. A-1	12,507	13,360	26,441	13,620	14,828	16,357	15,208	8,483	278,309
Do.	Cornelia Crocker No. 1[b]				-			2,721	10,585	66.770
Do.	Smith No. 1	27,373	27,188	25,184	9,513	12,306	15,470	15,763	10,354	336,245
Do.	Strawn Mdse. Co. No. 1	12,234	17,055	27.751	14,284	10,989	10,324	8,539	10,328	348,803
Do.	T &P.Ry.Co. No. 1[c]		11.212	26 208	23,957	6,518	11,896	11,749	14,835	224,115
Do.	M. G. Vernon No. 1	8,513	13,059	24,925	16,733	24,433	25.358	15,437	13,179	421,334
Hoffman & Page	Meri Galena No. 1	13,785	5,956	14,083	13,663	8,411	10,447	13,811	9,860	231,769
Do.	J. B. Hash No. 1	6,7[illegible]8	6,948	16,496	11,948	15,134	9,239	7,060	9,719	250,200
Do.	Jackson No. 1	11,398	10,5[illegible]2					-	- -	170,037
Do.	L. P. Strawn No. 1	4.744	4,347	2 741	3,172	3,379	4,530	4,053	4,571	94,250
Do.	Strawn Est. No. 1	5,708	3,746	2 983	3,655	4,869	5,761	5,280	6.197	123,561
John Hassen, Tr.	A. C. Anderson No. 1	9,21[illegible]	10,212	13,802	5,1[illegible]3	12.123	1 518	5,537		116,337
Frank Walker et al.	Binnings No. 1	19.295	31,686	23,813	9,233	20,625	13,218	7,287		291,100
C. F. Gibson et al.	Cromeans No. 1	1,948	6,080	10,047	3,010	4,991	3,423	1,957	———	51,709
W. M. Gibson, Tr.	Gibson Hrs. No. 1[d]			11,660	2,642	6,606	1,201	7,048	- -	51,165
C. F. Gibson et al.	Annie Harbin No. 1		4,554	7,387	4,906	8,323	1,023	2,038	-	53,904
John Hassen, Tr.	Housley No. 1	3,934	3,498	15,375	3,308	9.221	2,815	3,850		76,391
Frank Walker et al.	Loflin Est. No. 1	2,082		6,048	1,497	6,532	3,128	2,895	- —	147,801
Britton & Gordon	Mt. Marion No. 2			18			-	-	- -	-
Do.	Mt. Marion No. 3	209	2,677	1,337	932	2,610	743		-	
Nelson Oil Syn.	P. P. Pierce No. 1[e]	554	6,3[illegible]7	6,164	6,007	6,091	1,719	476	- -	49,082
R. D. Hinkson	Ready Heirs No. 1[f]				3,106	1,847	3,410	1,264		34,112
W. M. Gibson, Tr.	Robinson et al No. 1[g]		-	5,423	2,076	4,814	2 216	1.705	-	35.223
Dunkle et al.	Simmons No. 1[h]					488	1,905	551	- -	13,118
Leo Kahn et al.	Stephen No. 1	5,8[illegible]3	6.021	2,294	2,522	8,676	464	2,194	- -	98,212
C. F. Gibson et al.	Watson No. 1	10 877	13,166	11,699	7,749	2,572	7,981	5.116		106,269
J. B. Gordon et al.	Watson Bros. No. 1	9.362	16,331	12,000	5,214	7,968	5,001	3,693	-	139.131
R. B. Thomas et al.	Thomas No. 1		6 489	6 818	2,869	3.700	1.423	3,331		52,874
Wells outside Strawn Townsite										
Strawn Coal Co.	Strawn Coal Co. No. 6	3,007	2,913	2,586	2,350	1,784	1,550	1,815	2,304	-
Do.	Strawn Coal Co. No. 7[i]	1,307		- -	———	- — -	— ——	———	—— -	-
Do.	Strawn Coal Co. No. 8	9,162	12,654	5,474	11,071	8,655	6,261	9,069	9,269	- -
MONTHLY TOTAL	----- -- --- -- -- -	180,614	253,020	327,849	191,042	232,037	182,900	167,456	121,319	- -----

[a]Connected 11-1-32 [b]Connected 4-1-33 [c]Connected 11-17-32 [d]Connected 12-3-32 [e]Connected 10-3-32
[f]Connected 1-11-33 [g]Connected 11-28-32 [h]Connected 1-26-33 [i]Disconnected 3-27-33

TABLE 16.—*Open-flow capacities and rock pressures of gas wells in the Strawn district.*

Owner	Well	Test at date of connection			Present test				
		Date	Volume	Rock pressure	Date	Volume	Date	Rock pressure	Open flow Mar.,'34
			Thousands cu. ft.	*Lbs. per sq. in.*		*Thousands cu. ft.*		*Lbs. per sq. in.*	*Thousands cu. ft.*
Palo Pinto O. & G. Co.	C. E. Allen No. 1	11-1-32	5,000	1,200	4-1-33	5,000	5-9-33	1,170	7,100
Do.	C. E. Allen No. A-1	10-1-32	7,100	1,270	4-1-33	7,100	5-9-33	1,175	7,100
Do.	Cornelia Crocker No. 1	4-1-33	3,045	1,170	4-1-33	3,045	4-20-33	1,150	3,045
Do.	Smith No. 1	10-1-32	15,890	1,300	4-1-33	15,890	5-9-33	1,155	15,890
Do.	Strawn Mdse. Co. No. 1	10-1-32	12,560	1,240	4-1-33	12,560	5-23-33	1,170	12,560
Do.	T.&P.R.R.Co. No. 1	11-17-32	9,730	1,200	4-1-33	9,830	6-13-33	1,175	9,730*
Do.	M. G. Vernon No. 1	10-1-32	14,100	1,240	4-1-33	14,100	5-9-33	1,175	14,100
Strawn Coal Co.	Strawn Coal Co. No. 6	10-1-32	500	1,000	4-1-33	500	4-1-33	1,000	—
Do.	Strawn Coal Co. No. 7	10-1-32	750	1,100	(Well plugged)				
Do.	Strawn Coal Co. No. 8	10-1-32	4,029	1,100	4-1-33	4,029	3-8-33	1,215	
Hoffman & Page	Meri Galena No. 1	10-1-32	7,000	1,245	4-1-33	7,000	4-20-33	1,175	7,000
Do.	J. B. Hash No. 1	10-1-32	8,520	1,240	4-1-33	8,520	6-12-33	1,115	8,520*
Do.	Jackson No. 1	10-1-32	6,650	1,320	4-1-33	6,650	5-9-33	1,125	6,650
Do.	L. P. Strawn No. 1	10-1-32	200	1,240	4-1-33	200	4-1-33	1,175	200
Do.	Strawn Est. No. 1	10-1-32	224	1,290	4-1-33	224	4-1-33	1,175	224
T. & P. Coal & Oil Co.	Fee No. 1	—	—	—			—	—	2,400
Do.	Fee No. 2	—	—	—	—		—	—	9,000
Do.	Fee No. 3		—	—			—	—	3,000*
Do.	Fee No. 4		—	—	—	—	—	—	15,180*
Do.	Colvard et al.	—	—	—	—	—	—	—	9,730*

*Produced also some oil.

The gas reserves in the Strawn Townsite field are huge. The rock pressure in the field has dropped only from 1350 to 1205 pounds per square inch or only 145 pounds per square inch from April 1, 1931, to January 1, 1933. During this time it is estimated that 4,630,271,000,000 cubic feet of gas have been produced. This amounts to a production of 31,933,000,000 cubic feet per pound drop in pressure. For 1150 pounds per square inch drop it would be equal to 36,704,850,000,000 cubic feet. This means that nearly 37 trillion cubic feet of gas are left in the ground (Jan., 1933), and

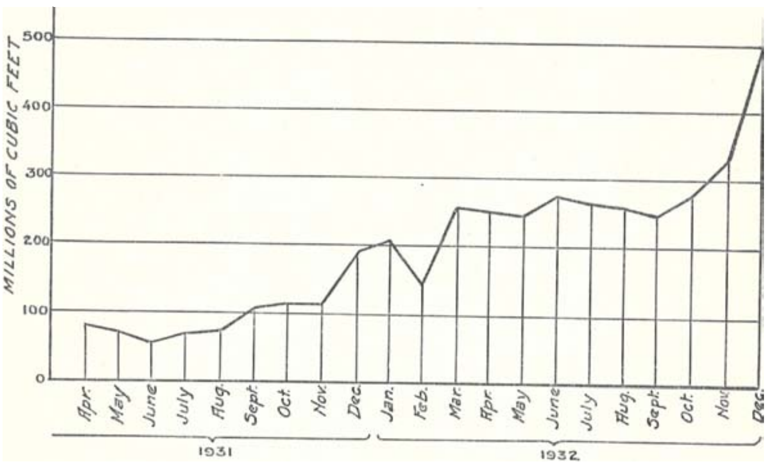


FIG. 16.—Graph of production of oil in the Strawn Townsite field.

at the present rate of production of 10 million cubic feet per day the supply should last 14 years.

WILDCAT DRILLING OPERATIONS[90]

Records of 538 completed oil tests have been compiled for Palo Pinto County. It is probable, however, that at least 600 tests have been drilled altogether. Of these, about 350 were producing oil or gas wells[91] and 250 dry holes or non-commercial wells. The drilling operations have been carried on in every part of the county, with the largest number per square mile in the southwestern quarter.

---

[90]*Literature.*—Year Book, National Oil Scouts Association of America, p. 275, 1931; p. 202, 1932; p. 100, 1933; p. 94, 1934.

[91]In 1933 a total of 211 oil and gas wells were producing in the county.

Record of wildcat operations during the last four years.

Year	Total completions	Producing oil wells	Total initial production *Bbls.*	Producing gas wells	Total production gas *Cu. ft.*	Dry holes
1930	49	15	372	17	45,000,000	17
1931	45	3	210	26	155,000,000	16
1932	43	9	496	16	86,000,000	18
1933	29	5	295	12	65,000,000	12

The results indicate that gas is more prevalent than oil, that it is fairly widespread, but that it exists in the largest pools in the southern and southwestern part of the county. The most important new discoveries since the opening up of the Strawn Townsite field in 1929 have been as follows:

Outstanding wildcat wells in Palo Pinto County since 1929.

Date	Map Co-ord.	Farm	Company	Initial production	Depth *Feet*
1930	....	D. G. Vick	Prairie Oil & Gas and Amerada Oil Co.	124 bbls. oil	1550
1931	H-19	J. L. Ringo	W. K. Gordon et al.	2,000,000 cu. ft. gas	3285
1932	H-2	E. B. Ritchie	Prairie Oil & Gas and Amerada Oil Co.	68 bbls. oil	1704
1932	E-21	W. R. Baker	Strawn Dev. Co.	2,100,000 cu. ft. gas	2972
1933	T-12	E. Bleeker	O. P. Coffin et al.	1,700,000 cu. ft. gas	710

At the end of 1933 about 30,000 acres of oil land (the smallest amount in many years) was under lease to six major oil companies. The Lone Star Gas Company holds most, having a total of 14,000 acres. Several small blocks are under lease to small companies and individuals not included in the estimate.

The chief obstacle to more rapid development of the gas resources is lack of adequate market. The county has a potential production of 382 million cubic feet of gas per day. At present (1933), however, only 20 millions of cubic feet are handled daily by Lone Star Gas Co., Texas & Pacific Coal & Oil Co., and the Upham Gas Co. The new shallow gas wells developed southeast of Mineral Wells on the eastern line of the county furnish a small amount of gas to mineral crystal plants for production of crystals, and gas is burned in the Mineral Wells brick yards. Most of the gas sold is run to casing-head gasoline plants, where the gasoline is extracted before marketing the gas. Three casing-head plants are located in the county, as follows:

1. Texas and Pacific Oil Co., one mile southwest of Strawn.
2. Lone Star Gas Co., Dobbs Valley plant, one mile east of Brazos.
3. Lone Star Gas Co., 1.3 miles east of Gordon.

Table 17 presents the locations, depths, elevations, and results of all significant Palo Pinto County wells.

TABLE 17.—*Well data for Palo Pinto County.*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
H. H. Adams	O. W. Pollard No. 1	T.&P.R.R.Co. Surv., A-773, Blk. 3, sec. 43, 250′ E., 1250′ S. of W. and N. lines	B-14	1310	4075
Anderson et al.	Anderson No. 1	Sec. 337, 500′ E. of SE. cor. of J. A. Hines Surv.	L-3		2340
Will Anderson, C. W. Hicks et al.	Mrs. W. P. Anderson	Mary Morris Surv., A-316	L-8		4217
Ashe Syndicate No. 2	Edgar T. Hart No. 1	T.&P.R.R.Co. Surv., A-1962, Blk. 4, sec. 36, 330′ from S., 330′ from W. line	A-13	1455	4065
Do.	Mrs. J. B. Hart No. 1	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, NE. ¼ SE. ¼	A-12	--	3177
Do.	Mrs. J. B. Hart No. 2	T.&P.R.R.Co. Surv., A-1435, Blk. 4, sec. 24, NW. ¼ SW. ¼	A-12	1246.42	3391
Do.	J. B. Hart Est. No. 2	T.&P.R.R.Co. Surv., A-895, Blk. 3, sec. 29, 330′ E. of W. line, 330′ S. of N. line, 10-A. tract	C-12	1332	4100
Do.	J. B. Hart Est. No. 3	T.&P.R.R. Surv., Blk. 3, sec. 18, E. ½ SE. ¼, 330′ from E. & S. lines. 80-A. tract	B-11	—	4228
Do.	L. E. Seaman No. 1	T.&P.R.R.Co. Surv., Blk. 3, sec. 3, 330′ from E. and S. lines	D-9	1191	4179
Atlantic Oil Producing Co.	Stuart No. 2	T.&P.R.R.Co. Surv., A-1432, Blk. 4, sec. 50, 1470′ from W., 1170′ from S. line	A-15	1461.7	1853
Atlas Oil Co.	Stuart No. 1	T.&P.R.R.Co. Surv., A-1499, Blk. 4, sec. 84, 200′ N. of center.	B-18	1456	1901
Bailey-Nichols Co.	Costello No. 1	J. P. Rohns Surv., A-380, SE. cor. NE. ¼	D-3	1235	4318
S. N. Beatty et al.	L. C. Slemmons No. 1	T.&P.R.R.Co. Surv., A-797, Blk. 3, sec. 53, 450′ from W., 300′ from S. line	C-15	1160	1640
Sadie Bell Oil Co.	Henry Belding No. 1	Mrs. A. R. Chacon Surv., A-1455	E-7	1000 ?	4007
Do.	J. K. Weldon No. 2	A. J. Smith Surv., A-393, E. part of Surv.	E-6	1136	3958
Do.	J. K. Weldon No. 2	A. J. Smith Surv., A-393, 750′ N. & W. of SE. cor. of 447-A. tract	E-6	1090	4700
A. S. Berry	Walker & Parks	T.&P.R.R.Co. Surv., A-1672, Blk. 2, sec. 35, 600′ from N. line, 150′ from W. line	H-12	1137	1970
Big Indian Royalty Pool	Big Indian Royalty Pool No. 1	T.&P.R.R.Co. Surv., Blk. 4	?	---	4002
C. E. Binnings et al.	C. E. Binnings No. 1	H. Bird Surv., Blk. 24, City of Strawn, cen. Blk. 24	C-21	1000	881
C. E. Binnings	R. C. Hinkson No. 1	W. W. Cochran Surv. in T.&P.R.R.Co. Surv., A-129, Blk. 3, sec. 81, 200′ from W. line, 40′ from S. line	D-18	1091	1280
Do.	R. C. Hinkson No. 2	T.&P.R.R.Co. Surv., A-1885, Blk. 3, sec. 86, 3654′ from N., 434′ from E. line	E-18	1183	1401
F. A. Bond	Baker Estate No. 1	A. Ashworth Surv., A-1, cen. S. 20-A. of 142-A. tract; 2½ mi. E. of Strawn	E-20	966	2970
Do.	B. F. & D. Stokes	T.&P.R.R.Co. Surv., Blk. A, E. of B., sec. 28, A-1547, 150′ from S. and 900′ from E. line. 100-A. tract	S-6	1101	1700

TABLE 17.—*Well data for Palo Pinto County.—(Continued.)*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
Brazos River Gas Co. (Upham)	W. C. Bridges & Wife No. 2	Reynolds Clark Surv., A-204, 600′ from N. and 800′ from W. line	G-3		1765
Do.	W. C. Bridges & Wife No. 3	R. Clark Surv., A-135, 425′ from N. and 1875′ from E. line	G-3		1777
Do.	J. A. Chestnut No. 3	G. Green Surv., A-207, 500′ from N. and W. line, 385-A. tract	Q-14		4075
Do.	Conklin No. 1	S. C. Neill Surv., A-355	G-5		1401
Do.	D. M. Crossland Est. No. 1	T.&P.R.R.Co. Surv., A-1848, Blk. 1, sec. 50, 500′ from N. and W. lines	J-14		4100
Do.	C. B. Edmonson No. 6	D. Bourne Surv., A-49, 1500′ from E., 500′ from S. line, SW. cor. SW. ¼	Q-14		4056
Do.	C. B. Edmonson No. 8	F. H. Gray Surv., A-208, 400′ W. from fence, 1000′ SW. of No. 4, 658-A. tract	P-15		1217
Do.	C. B. Edmonson No. 9	F. H. Gray Surv., A-208, 400′ W. from fence and 1000′ E. of No. 10, 658-A. tract	P-15		1200
Do.	C. B. Edmonson No. 14	D. Bourne Surv., A-49	Q-14		1211
Do.	C. B. Edmonson No. 17	F. H. Gray Surv., A-208, 1500′ NW. of No. 8	J-7	1112	1152
Do.	C. B. Edmonson No. 18	F. H. Gray Surv., A-208, 1200′ NW. of No. 17, and about 3000′ from river	P-15		1132
Do.	Ennis No. 2	T.&P.R.R. Surv., A-744, Blk. A, sec. 49, NW. ¼, 1200′ N. of No. 1	R-16		3875
Do.	Harrison No. 1	R Clark Surv., A-135, 600′ from E., 2692′ from S. line	G-3	1027	2725
Do.	Harrison No. 2	R. Clark Surv., A-135, 480′ from E., 375′ from S. line′ 100-A. tract	G-3		1050
Do.	Mrs. H. Harrison No. 2	R. Clark Surv., A-135, 1600′ from E. and 600′ from S. line, 100-A. tract	G-3	971	1459
Do.	Mrs. H. Harrison No. B-1	R. Clark Surv., A-135, SW. cor. 90-A. tract	G-3		1460
Do.	Mrs. H. Harrison No. C-1	R. Clark Surv., A-135, 2000′ from NE. line, 350′ from SE. line	G-3		1555
Do.	W. T. McAvey No. 1	J. F. Smith Surv., A-410, 600′ from S. and W. lines	G-4	1037.5	1379
Do.	W. T. McAvey No. B-1	E. G. Branard Surv., A-1527, 350′ from N., 572′ from W. line	G-4	1052	2048
Do.	Pat Owen No. 1	T.&P.R.R.Co. Surv., A-975, Blk. 1, sec. 45, 175′ from S. line, middle of 87½-A. tract	L-13		1210
Do.	Mrs. L. E. Slay No. 1	R. Clark Surv., A-135, 600′ from S., 600′ from W. line, 206-A. tract	G-3	825	1530
Do.	Mrs. L. E. Slay No. 3	R. Clark Surv., A-135, 625′ from S., 1280′ from W. line	G-3		1532
Do.	Mrs. L. E. Slay No. 4	R. Clark Surv., A-135, 1750′ from W., 1050′ from S. line	G-3		2233
Do.	Mrs. L. E. Slay No. 6	R. Clark Surv., A-135, 1200′ from N. and E. lines	G-3	1021	1721
Do.	Mrs. J. H. Wester No. 2	J. F. Smith Surv., A-410, 500′ from W., 400′ from N. line	G-3	1011	1365
Do.	Mrs. J. H. Wester No. 5	J. F. Smith Surv., A-410, 300′ from N. and E. lines	G-3		2396

Breathwit (?)	Dalton No. 1	J. H. Baker Surv., A-891	--	916	1430
Britton et al.	Strawn Coal Co. No. 1	A. Ashworth Surv., A-1	E-20	990.3	3044
Do.	Strawn Oil Co. No. 2	A Ashworth Surv., A-1	E-20	1031	3348
Do.	Strawn Coal Co. No. 4	I. Ryan Surv., A-388, NW. part Surv.	C-21	1012	3064
Britton & Gordon	Strawn Coal Co. No. 2	I. Ryan Surv., A-388, 2000′ from N., 3200′ from W. line (Strawn Townsite)	D-21	1031	3098
Do.	Strawn Oil Co. No. 3	I. Ryan Surv., A-388, 550′ from N., 3200′ from W. line (Strawn Townsite)	D-21	1021	3051
Broderick & Calvert	Moseley No. 1	Allen Williams Surv., A-885, Blk. 2	T-15	812	1060
Bullington et al.	M. Costello	J. F. Smith Surv., A-410, 150′ from S. and E. lines	F-4	--	1366
Do.	Mrs. J. H. Wester	J. F. Smith Surv., A-410, 150′ from N., 522′ from W. line of 100-A. tract	G-4	1017	1446
Burton & McKee Oil Co. and Palo Pinto O. & G.	Smith No. 1	Strawn Townsite, Lot 4, Blk. 2, Woodlawn Subdiv.	D-20	--	2954
Burton & McKee Oil Co.	Strawn Mdse. Co. No. 1	Strawn Townsite, 138′ from E. and S. lines Blk. 4	D-21	1002	2995
Do.	Vernon et al. No. 1	Strawn Townsite, Lot 6, Blk. 16, 29′ from N. line	D-21	997	3017
Do.	Strawn Coal Co. No. 1	A. Ashworth Surv., A-1, 5530′ S., 6120′ W. of NE. cor Surv.	E-19	990	3044
Do.	Strawn Coal Co. No. 2	A. Ashworth Surv., A-1, 3800′ from N. and E. lines	E-19	1019	3268
Do.	Strawn Coal Co. No. 3	A. Ashworth Surv., A-1, SW. cor. 889-A. tract	E-20	1016	3090?
Do.	Strawn Coal Co. No. 4	A. Ashworth Surv., A-1, NW. cor. 889-A. tract	E-19	1016	3797
Burton-McKee Oil Corp. (finished by Gordon & Britton)	Strawn Coal Co. No. 5	I. Ryan Surv., A-388, W. of Strawn Cemetery	C-21	1020	3271
Burton-McKee Oil Corp.	Strawn Coal Co. No. 6	A. Ashworth Surv., A-1, SE. cor. 320-A. tract	E-20	992	3015
Burton & W. A. Whatley	Costello Bros. No. 1	J. P. Rohns Surv.	D-4	--	2725
Cameron & Anderson	O. W. Pollard No. 2	T.&P.R.R.Co. Surv., A-773, Blk. 3, sec. 43., 250′ N. and W. of SE. cor. SE. ¼	B-14		1701
Camp Oil & Gas Co.	Mike Costello No. 1	R R. Williams Surv., A-896, 750′ from N. line, 1500′ E. of Brazos River	F-4	996	2413
Canadian Petroleum Co.	Pennington No. 1	S. F. Harding Surv., A-221	J-5	1000.5	4105
Chestnut & Smith	Belding No. 1	A.B.&M. Surv., A-19, sec. 3, SW. cor. N. ½	F-8	1216	2500
Do.	Seaman No. 1	NE. cor. Geo. Archy Surv., A-7 sec. 98	A-7	958	3838
Christie Bros.	C. E. Allen & E. B. Ritchie No. 1	T. J. Bradford Surv., A-1628, 200′ from W., 200′ from S. line sec. 2	H-1	--	4575
Do.	C. E. Allen & E. B. Ritchie No. 2	T. J. Bradford Surv., A-1628, 450′ from S. and W. lines	H-1	--	1312
Clark et al (Empire)	D. A. Hess No. 1	D. Bourne Surv., A-45, NE. part of 140-A. tract	Q-12	959	1045
Do.	D. A. Hess No. 2	D. Bourne Surv., A-45	Q-12	962	1040
Clark & Burch	Conklin No. 1	S. C. Neil Surv., A-355, 2 mi. E. of Pickwick, 4000′ from E., 330′ from N. line	G-5	1075	3885
O. P. Coffin, Trustee	Effie Bleeker No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 16, 300′ from N., 1696′ from W., and 860′ from S. line 70-A. tract	O-12	--	710
Do.	Bob Goen No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 19, NE. ¼, 1315′ from E., 1115′ from N. line	O-12	--	770

TABLE 17.—*Well data for Palo Pinto County.*—(*Continued.*)

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
O. P. Coffin, Trustee	J. S. Hatfield No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 16, SW. ¼, 300′ from N., 1696′ from W. line	O-12		815
Do.	H. W. Wright No. 1	T.&P.R.R.Co. Surv., A-1667, Blk. A, E. of B., sec. 18, 583′ from N., 407′ from W. line	N-11		-
Comanche Oil Corp.	Holt No. 1	J. Poitevent Surv.	J-3		4387
Do.	Mrs. S. J. Smith	T.E.&L. Surv., sec. 1728, A-503, 330′ from N. and E. lines	M-2	900	1650
Conway Bros. & Gholson	Hinkson No. 1	T.&P.R.R.Co. Surv., A-1400, sec. 71, Blk. 3, 320-A. tract	E-16		3802
Consumers	J. Drake No. 1	D. Mahoney Surv., A-310, NW. cor.	R-12		4515
Do.	C. A. Hess No. 2	D. Mahoney Surv., A-310, sec. 12, NW. cor.	R-12	969	1171
Do.	C. A. Hess No. 3	D. Mahoney Surv., A-310, sec. 12, SW. cor.	R-12	940	1170
Do.	Lynch No. 1	D. Bourne Surv., A-49, 200′ from S., 300′ from W. line	Q-14	1098	3250
Do.	Lynch No. 2	D. Bourne Surv., A-49, SW. cor. SE. ¼	Q-14	1098	4115–4053
Do.	D. A. Hess No. 2	D. Bourne Surv., A-45, central part of 130-A. tract	Q-12	959	1025
Do.	D. A. Hess No. 3	D. Mahoney Surv., A-310	Q-12		1015
Do.	D. A. Hess No. 4	D. Mahoney Surv., A-310	Q-12		1024
Do.	D. A. Hess No. 5	D. Mahoney Surv., A-310, SE. cor.	Q-12	933	1220
Do.	A. E. Jacques No. 2	D. Bourne Surv., A-32, SE. cor. SW. ¼	R-11	885	1003
Consumers (Owen & Wilson)	Parmeter No. 1	D. Bourne Surv., A-32, SW. cor. lse.	R-11	840	1045
Conway Bros. & Gholson	Brothers No. 1	T.&P.R.R.Co. Surv., A-1828, Blk. 3, sec. 62, NE. ¼	E-15	1161	3955
Costello & Burton (same as Monroe)	Costello Bros. No. 1	J. P. Rohns Surv., A-380, sec. 2, 4828′ N. and W. of oil well, 200′ from E. line of Surv.	D-4	1235	2706
Cousins & Wickens	(J. K. Williams (Herbin) No. 1	A. Ashworth Surv., A-1, NW. cor. 120-A. tract	E-20	987	3235
Cunningham	Poor No. 1	T.E.&L.Co. Surv., A-567, sec. 1792, SW. cor. SE. ¼	K-5	951	4220
Bob Dalton	R. S. Dalton No. 1	T.E.&L.Co. Surv., A-563, sec. 1788, Dark Valley, N. and W. of Brazos River	J-5		2390
Jack Dalton Oil Co.	R. S. Dalton No. 1	T.E.&L.Co. Surv., A-565, sec. 1790, 250′ from S. and W. lines of N. ½	J-5	987	3970
Do.	R. S. Dalton No. 2	T.E.&L.Co. Surv., A-565, sec. 1790, NW. cor. SW. ¼	J-5	986	3700
Do.	R. S. Dalton No. 3	T.E.&L.Co. Surv., A-565, sec. 1790, SW. cor. SW. ¼	J-6		1450
Do.	Dalton No. 5	T.E.&L.Co. Surv., A-565, sec. 1790, NE. cor. SW. ¼	J-5	921	4055
Do.	Dalton No. 6	T.E.&L Co. Surv., A-564, sec. 1789, near center	J-6	911	4203
Do.	Dalton No. 7	T.E.&L.Co. Surv., A-564, sec. 1789	J-6	910	3938
Mark Dalton Oil Co.	R. S. Dalton No. 1	T.E.&L.Co. Surv., A-566, sec. 1791, NW. cor. SW. ¼	J-5	921	4015
Webb Dalton	Edgin No. 1	J. J. Metcalf Surv., A-341, NW. cor. NW. ¼, N. of Dalton City Pool	J-4	981	1100
Dalton & Clark	Green No. 1	T.E.&L.Co. Surv., A-568, sec. 1793	J-5	940	4105
Dalworth Oil Co. (Fuller & Jones)	Corn No. 1 (M. H. Vick)	T.&P.R.R.Co. Surv., A-762, Blk. 1, sec. 23, 200′ S. of center	L-10	-	2860

Dalworth Oil Co., Werner et al.	Corn No. 1	T.&P.R.R.Co. Surv., A-762, Blk. 1, sec. 23	L-10		2860
Delta Oil & Rfg. Co. (Whiteside)	Caudle No. 1	W. H. Eggleston Surv. No. 94, A-691	B-6	919.4	3471
Miller Dalton	Dalton No. 1	T.E.&L.Co. Surv., A-561, NE. ¼, sec. 1786, 300′ from N. and E. lines of 70-A. tract	K-6	1018	4133
Mark Dalton	J. Dalton No. 2	T.E.&L.Co. Surv., A-561, sec. 1791	K-6	922	3915
Dixie Drilling Co.	Hart No. 1	T.&P.R.R.Co. Surv., A-1873, Blk. 3, sec. 18, NW. cor. NW. ¼	A-11	1404	4200
R. Dunkle	A. F. Hardman No. 1	Strawn Townsite, Blk. 1, 151′ from E. and N. lines original Townsite Surv.	D-20	998	3014
Eastland Oil Co. and Chestnut-Smith	J. K. Weldon No. 1	C.E.P.I.&M.Co. Surv., A-138, sec. 16, SE. cor. NW. ¼ 160-A. tract	F-6	1108	2187
Frank H. Edmunds et al	Johnson (Crocker) No. 1	John Bird Surv., A-27, NE. of Gordon	I-18	897	3707
Edrington et al.	Dalton No. 1	T.E.&L.Co. Surv., A-432, sec. 856, NW. cor.	H-1	1141	2862
Empire Gas & Fuel Co.	Chestnut No. 1	Geo. Green Surv., A-207	Q-14	1084	4131
Do.	Edmonson No. 1	D. Bourne Surv., A-49, central part of S. R. Edmonson lease	Q-14	1126	4492
Do.	Gilbert No. 1	T.&P.R.R.Co. Surv., A-845, Blk. A, sec. 37, NW. cor. J. R. Gilbert lease	R-15	870	3820
Do.	Gilbert No. 1	T.&P.R.R.Co. Surv., A-741, Blk. A, sec. 39, NW. cor. NE. ¼, about 1 mi. NW. of Brazos	R-15	884	3824
Do.	F. Watson No. 1	D. B. Brooks Surv., A-48, NW. cor. NE. ¼	H-8	1024	4055
Do.	J. H. Wharton No. 1	Geo. Green Surv., A-207, 1358′ W., 1053′ N. of NE. cor. 60-A. tract, N. of Cyclone Bend	Q-11	822	3984
Do.	Wheeler No. 1	T.&P.R.R.Co. Surv., A-2026, Blk. A, sec. 36, SE. cor., ½ mi. N. of Brazos	R-15	856	4010
Empire-McGarr	Edmonson No. 4	D. Bourne Surv., A-49, SE. cor. SE. ¼	Q-14	1115	4701
Empire-Murphy	Gill No. 1	D. Bourne Surv., A-32, SW. cor. of E. ½	R-12	924	1014
Fearis-Givens	Dalton No. 1	D. B. Brooks Surv., A-46	J-6	969	4180
Morris Frazer et al.	O. W. Pollard No. 2	T.&P.R.R.Co. Surv., A-773, Blk. 3, sec. 43, SE. ¼	B-14	1309.7	4076
Morris Frazier	Stuart No. 1	T.&P.R.R. Co. Surv., A-798, Blk. 3, sec. 55, W. ½	B-15	1238	2415
French, P. K.	Mary J. Taylor No. 1	T.&P.R.R.Co. Surv., A-761, Blk. 1, sec. 21, cen. W. ½	K-10	1107	1518
Fulcher, Morris & Howell	Hinkson No. 1	T.&P.R.R.Co. Surv., A-804 Blk. 3, sec. 82	E-18		842
Fuller & Jones	Naylor No. 1	T.&P.R.R.Co. Surv., A-1482, Blk. 3, sec. 80, 300′ W., 200′ S. of NE. cor.	C-18	1040	908
Gholson & Gordon	McCain-Ames No. 2	Burleson Co. Sch. Lds. A-29, Blk. 2, Lot 32, 550′ from N., 330′ from E. line	H-19		3347
Do.	T. K. Spear et al. No. 1	Burleson Co. Sch. Lds. Blk. 2, A-29, Lot 37	H-19		3317
C. F. Gibson et al.	G. W. Watson No. 1	Strawn Townsite, City Blk. 1, Woodlawn Subdiv. 150′ from E., 200′ from N. line	D-20	992	2999
Gillespie et al.	Anna F. Johnson No. 1	J. Bird Surv., A-27, 4½ mi. N. of Gordon	I-18		1505
Gordon et al.	Watson Bros. No. 1	Strawn Townsite, Blk. 41 and 42, 165′ from N., W., and S. lines, and 185′ from E. line	C-21	1004	2996
W. K. Gordon	McDonald No. 1	T.&P.R.R.Co. Surv., A-827, Blk. A, sec. 13, SE. cor. SW. ¼, SW. of Mineral Wells	N-11	951	3946

TABLE 17.—*Well data for Palo Pinto County.*—*(Continued.)*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
W. K. Gordon	J. K. Williams No. 1	A. Ashworth Surv., A-1	O-19	980	3235
Gordon & Britton	Johnson (Crocker) No. 1	Jno. Bird League, A-27, SW. cor. SW. ¼	I-19	1002	3549
Gordon & Gholson	Askew Heirs No. 2	Burleson Co. Sch. Lds., 500′ W. and 1530′ N. of SE. cor. 201-A. tract	?		3420
Do.	McDonald No. 2	T.&P.R.R.Co. Surv., A-831, Blk. 1, sec. 33, 1500′ from S., 500′ from E. line	L-13	1210	4868
Do.	Mariposa,, McDonald et al. No. 3	T.&P.R.R.Co. Surv., A-1998, Blk. 1, sec. 38	L-13		4295
Do.	Taylor No. 1	T.&P.R.R.Co. Surv., A-761, Blk. 1, sec. 21, 1320′ from N., 1000′ from W. line	K-10	1085 (?)	4792
Do.	Tkecz No. 1	T.&P.R.R.Co. Surv., A-974, Blk. 1, sec. 45, near Hoffler line in center of Surv., 1320′ from N., 2400′ from W. line	L-13	935	4076
Do.	Watson No. 1	T.&P.R.R.Co. Surv., A-814, Blk. 1, sec. 39, cen. W. ½	K-12	1195	4290
Arch Graham (Mid-Kansas)	Slemmons No. 1	T.&P.R.R. Co. Surv., A-1523, Blk. 3, sec. 38	D-13		3425
J. L. Graham	J. A. Caudle No. 1	J. Poitevent Surv., A-1058	B-6		1762
J. H. Greer	Holt No. 1	T.E.&L.Co. Surv., A-498, sec. 1723, NE. cor. NE. ¼	J-3	1113	1462
Grounds et al.	W. N. Gibson No. 1	Strawn Townsite, Jane's Addition, Blk. 9, 140′ from N., 160′ from W. line	C-20	1011	3043
Hamill & Chaffe	Wilbar No. 1	J. Latham Surv., A-279	H-21		3725
H. N. Harris et al.	Weldon No. 1	R. Copeland Surv., A-120, 300′ from S. and W. lines, 3 mi. SE. of Pickwick	G-6	1085	4390
Harrison & Eaton (T.&P. C.&O.Co.)	W. R. Ringo No. 1	T.&P.R.R.Co. Surv., A-842, Blk. 2, sec. 82, N. of Gordon	H-17	1006	4375
Hart, E. T.	Cardwell No. 1	T.&P.R.R.Co. Surv., A-806, Blk. 3, sec. 31, NE. cor. NW. ¼	B-12	1368	2005
Do.	E. A. Cardwell No. 2	T.&P.R.R.Co. Surv., A-954, Blk. 3, sec. 42, SW. ¼ NE. ¼	B-13	1303	3950
Do.	McDonald No. 1 (Walker & Parks)	T.&P.R.R.Co. Surv., A-1409, Blk. 2, sec. 24, NW. cor. NW. ¼	I-10		1330
Hart Oil Corp.	Hart No. 1	T.&P.R.R.Co. Surv., A-751, Blk. 4, sec. 13, NW. ¼ SW. ¼	A-11	1107.68	3128
Do.	J. B. Hart No. 2	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, 40-A. tract	A-11	1245.85	3266
Do.	J. B. Hart No. 3	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, SW. ¼ NE. ¼ 40-A. tract	A-11	1232.8	3261
Do.	J. B. Hart No. 5	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, NE. ¼ NE. ¼	A-11	1232	3257
Do.	J. B. Hart No. 7	T.&P.R.R.Co. Surv., A-751, Blk. 4, sec. 13, NE. ¼ SW. ¼	A-11	1110	3141
Do.	J. B. Hart No. 8	T.&P.R.R.Co. Surv., A-751, Blk. 4, sec. 13, SE. ¼ SW. ¼	A-11	1112	3161
Do.	J. B. Hart No. 9	T.&P.R.R.Co. Surv., A-751, Blk. 4, sec. 13, SW. ¼ SW. ¼	A-11	1240.89	3285
Do.	J. B. Hart No. 10	T.&P.R.R.Co. Surv., A-1519, Blk. 4, sec. 26, SW. ¼ SE. ¼	A-12	1307.50	3262
Do.	Laura Massie No. 1	T.&P.R.R.Co. Surv., A-1896, Blk. 3, sec. 32, NE. ¼ NE. ¼	C-12	1231.1	3915

Do.	Laura Massie No. 2	T.&P.R.R.Co. Surv., A-1896, Blk. 3, sec. 32, NW. ¼ NE. ¼	C-12	1294.66	1892
Do.	W. T. Orme and Caldwell	T.&P.R.R.Co. Surv., A-806, Blk. 3, sec. 31, SW. ¼	B-13	1368.74	2003
Do.	A. B. Smith No. 1	T.&P.R.R.Co. Surv., A-1650, Blk. 3, sec. 32, SE. ¼ SW. ¼	B-13	1255	2005
Hart Oil Corp. & Little Caddo Synd.	J. B. Hart No. 4	T.&P.R.R.Co. Surv., A-751, Blk. 4, sec. 13, 7-A. tract in SW. cor. N. ½	A-11	1104	3129
Hart Oil Corp. & A. T. Strong	L. E. Seaman No. 1	G.B.&C.N.G.R.R. Surv., A-1034	C-7	1255	3286
Hill & Ritter	Doan No. 1	P. Lout Surv., A-291, 150′ from NE., 150′ from SE. line of SW. 40-A. tract	F-5	1043	1587
Hodges et al.	Bigler No. 1-B	T.&P.R.R.Co. Surv., A-1286, Blk. A, sec. 57	R-17	--	3668
Hodges et al. (Dittman)	Bigler No. 2.	T.&P.R.R.Co. Surv., A-1286, Blk. A, sec. 57, 1400′ due W. of No. 1	R-17	--	4009
Hoffman & Page Co.	B. B. Chisolm No. 1	Burleson Co. Sch. Lds., A-26, Blk. 3, sec. 80, 600′ from E., 330′ from S. line	F-20	--	3905
Do.	Mrs. M. Gallina No. 1	Strawn Townsite, I. Ryan Surv., A-388, 216′ from N., 240′ from E., 196′ from S., 190′ from W. line	D-21	--	3006
Do.	J. B. Hash	Strawn Townsite, NE. cor. of City of Strawn, 147′ from N., 150′ from E. line	D-20	--	3035
Do.	L. P. Strawn No. 1	H. Bird Surv., 163′ from E. and W. lines, 290′ from S. line, 6½-A. tract, Strawn Townsite	D-20	--	3030
Do.	S. B. Strawn No. 1	City of Strawn, 12.6-A., 361′ from E., 140′ from S. line	D-20	--	3040
Do.	Strawn Heirs No. 1	H. Bird Surv., 188′ from E., 200′ from S. line, 7.1-A. tract (Strawn Townsite)	C-20	--	3270
Hofmeir (Jack Dalton Co.)	Dalton No. 1	T.E.&L.Co. Surv., A-565, sec. 1790, 880′ from S., 300′ from W. line of N. ½ of sec.	J-5	921	4207
Walter Holt	H. L. Singleton No. 1	T.E.&L.Co. Surv., A-607, sec. 2510, 150′ N. and W. of SE. cor.	R-5	990	4360
Do.	Sykes & Pollard No. 1	T.E.&L.Co. Surv., A-608, sec. 2511, SW. cor.	Q-5	--	2002
Hughes & Clifton	Perkins (Chick Bend) No. 1	Thomas Plat Subdiv., Blk. 5, NW. cor., Chick Bend	J-8	898	3805
Hughes & Craig	Jones No. 1	W. T. O'Neal Surv.	J-5	930	4075
Hughes et al.	Anderson No. 1	T.&P.R.R.Co. Surv., A-885, Blk. 1, sec. 11, NE. ¼ NW. ¼	L-9	1105	826
F. P. Hynes & E. W. Walton	Pat Dalton No. 1	Peter Miller Surv., 1057′ N., 1053′ W. of SE. cor.	H-4	1127.6	1402
Johnson et al.	Mrs. J. M. Baucom No. 1	T.&P.R.R.Co. Surv., Blk. A, sec. 11, NW. ¼, 940′ from E., 1150′ from N. line	--	--	920
Do.	Howard No. 1	T.&P.R.R.Co. Surv., A-869, Blk. A, E. of B., sec. 3, SW. ¼ NW. ¼	T-8		2560
Johnson Bros.	Smith No. 1 (Howard)	T.&P.R.R.Co. Surv., A-944, Blk. A., E. of B., sec. 14, SW. ¼ NE. ¼, 2½ mi. E. of Mineral Wells	T-9	854	4395
Johnson-Tibbits et al.	J. K. Weldon No. 1	A. J. Smith Surv., A-393, NE. cor.	F-5	--	3943
Jordan (Eddington et al.)	Bob Dalton No. 1	E. E. Pegus Surv., A-366, sec. 100, NW. cor., 6 mi. N. of Palo Pinto	K-8		2862
Jordan-Guy et al.	Edmonson No. 2	D. Bourne Surv., A-49, N. part of S. R. Edmonson lse.	Q-13	1129	1108
C. B. Lacey (Bateman, Chestnut & Smith)	Guest No. 1	Burleson Co. Sch. Lds., A-30, Blk. 3, sec. 73	F-20	993	3800
Ladd et al.	Lee No. 3	Lone Camp District	--	--	536

TABLE 17.—*Well data for Palo Pinto County.—(Continued.)*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
C. Lancaster	Allen Ritchie No. 1	S.P.R.R.Co. Surv., A-421, 450′ from NW. line, 200′ from NE. line	H-2		1771
W. W. Lange & Randall	Robinson & Collett No. 1	T.&P.R.R.Co. Surv., A-1385, Blk. 3, sec. 66, 250′ S. and W.	B-16	1115.3	1584
W. W. Lange	Robinson & Collett No. 2	T.&P.R.R.Co. Surv., A-1385, Blk. 3, sec. 66	B-16		1662
Do.	Robinson & Collett No. 3	T.&P.R.R.Co. Surv., A-1385, Blk. 3, sec. 66	B-16	1100.7	1562
LaSalle Oil Co.	Belding No. 1	T.&P.R.R.Co. Surv., A-1857, Blk. 2, sec. 8, NE. of Hart Ranch	F-9	1146	2297
Do.	Belding No. 2	T.&P.R.R.Co. Surv., A-1857, Blk. 2, sec. 8	F-9	1185	2110
L. E. Lasseter	Texas Pacific R. R. Co. No. 1	A.B.&M. Surv., A-21, sec. 5, 330′ from E., 548′ from S. line	J-20	946	5612
Lewis Oil Co.	Brannon No. 1	T.&P.R.R.Co. Surv., A-830, Blk. A., sec. 55, 1505′ N., 1698′ E.	Q-17	856	3931
Linderman Bros.	A. W. Johnston No. 1	S. Latham Surv., A-281, Blk. 1, S. 250–A, 1880′ from E., 580′ from S. line	A-4		2835
Lindsay Drlg. Co.	M. P. Costello No. 1	J. F. Smith Surv., A-410, NE. cor.	G-3		1394
Do.	Costello Bros. No. 1	M. Castleman Surv., A-119, sec. 2, NE. cor.	E-3	970	1391
Little Caddo Synd. (Hart)	Fitzgerald No. 1	T.&P.R.R.Co. Surv., A-1388, Blk. 3, sec. 28, SW. ¼ SW. ¼, 165′ S., 330′ E.	C-12	1242.7	1853
Do.	J. B. Hart No. 1	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, NE. cor. NE. ¼	A-11	1261.18	3268
Little Caddo Synd. (Stephens Co.)	Hart No. 2	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, SE. cor. NW. ¼	A-11		-
Little Caddo Synd.	Hart No. 3	T.&P.R.R.Co. Surv., A-752, Blk. 4, sec. 23, SE. cor. NE. ¼	A-11	1250	3268
Livin'ston et al.	Robinson & Collett No. 1	NW. cor. sec. 64, Blk. 3, T.&P.R.R.Co. Surv.	C-16	1120	4000
Lone Star Gas Co.	Brooks-Allen No. 1	D. B. Brooks Surv., A-53, in T.&P.R.R.Co. Surv., Blk. 3, sec. 63, 1250′ N. and W. of SE. cor. of lse.	D-16	1187	4075
Do.	W. T. Edwards No. 1	J. Dimpkins Surv., A-152, NW. cor. lse.	S-11	891	1000
Do.	W. T. Edwards No. 2	J. Dimpkins Surv., A-152, N. central part lse.	S-11	880	1010
Do.	W. T. Edwards No. 3	J. Dimkins Surv., A-152, NW. cor. lse.	S-11	891	1032
Do.	W. T. Edwards No. 4	J. Dimpkins Surv., A-125, 200′ N. and E. of SW. cor.	S-11	894	1010
Do.	W. T. Edwards No. 5	J. Dimpkins Surv., A-152, 589′ from S., 909′ from W. line	S-11	891	1035
Do.	W. T. Edwards No. 6	J. Dimpkins Surv., A-152, S. central part lse.	S-11	890	1014
Do.	W. C. Forbes No. 1	F. H. Gray Surv., A-206, NW. ¼ NW. ¼	R-12	976	1172
Do.	W. C. Forbes No. 2	F. H. Gray Surv., A-206, NE. ¼ NW. ¼	S-12	983	1300
Do.	W. C. Forbes No. 3	F. H. Gray Surv., A-206, SE. ¼ SW. ¼	S-12	995	1200
Do.	W. C. Forbes No. 4	F. H. Gray Surv., A-206, SW. ¼ SW. ¼	R-12	976	1315
Do.	J. B. Harrington No. 1	J. Dimpkins Surv., A-162, NE. cor. lse.	S-13	913	2565
Do.	J. B. Harrington No. 2	J. Dimpkins Surv., A-152, NW. ¼ lse.	S-13		1007
Do.	J. B. Harrington No. 3	J. Dimpkins Surv., A-152, N. central part lse.	S-13	912	1006
Do.	J. B. Harringotn No. 5	J. Dimpkins Surv., A-152, NW. ¼ lse.	J-13	912	1013
Do.	S. A. Keown No. 1	D. Bourne Surv., A-32, 187.2′ from S., 107.6′ from N. line, SW. cor. lse.	R-11	887	1000

Do.	S. A. Keown No. 2	D. Bourne Surv., A-32, SW. cor. lse.	R-11	871	1020
Do.	S. A. Keown No. 3	D. Bourne Surv., A-32, central part lse.	R-11	900	1024
Do.	S. A. Keown No. 4	D. Bourne Surv., A-32, NE. cor. lse.	R-11		1005
Do.	S. A. Keown No. 6	D. Bourne Surv., A-32, NE. cor. lse.	R-11	912	1014
Do.	S. A. Keown No. 7	D. Bourne Surv., A-32, SE. cor. lse.	R-11	900	1011
Do.	S. A. Keown No. 8	D. Bourne Surv., A-32, SE. cor. lse.	R-11	918	1008
Do.	S. A. Keown No. 9	D. Bourne Surv., A-32, SE. cor. lse.	R-11	903	1026
Do.	S. A. Keown No. 10	D. Bourne Surv., A-32, S. part lse.	R-11		1005
Do.	S. A. Keown No. 11	D. Bourne Surv., A-32, SW. cor. lse.	R-11		1001
Do.	S. A. Keown No. 13	D. Bourne Surv., A-32, SW. cor. lse.	R-11		1015
Do.	S. A. Keown No. 14	D. Bourne Surv., A-32	R-11		1016
Do.	S. A. Keown No. 15	D. Bourne Surv., A-32, NW. cor. lse.	R-11		1013
Do.	S. A. Keown No. 16	D. Bourne Surv., A-32	R-11		1010
Do.	S. A. Keown No. 17	D. Bourne Surv., A-32, NE. cor. lse.	R-11	900	1009
Do.	J. D. Oaks No. 1	D. Mahoney Surv., A-310, sec. 17, SE. cor. lse.	Q-13		1070
Do.	J. D. Oaks No. 2	D. Mahoney Surv., A-310, sec. 17, NE. cor. lse.	Q-13		1060
Do.	J. D. Oaks No. 3	D. Mahoney Surv., A-310, sec. 17, NW. cor. lse.	Q-13	937.3	1165
Do.	J. D. Oaks No. 4	D. Mahoney & R. Evans Surv., A-310, sec. 17, N. part lse.	Q-13	937	1032
Do.	J. D. Oaks No. 5	D. Mahoney Surv., A-310, sec. 17, SW. cor. lse.	Q-13	961	1111
Do.	J. D. Oaks No. 6	D. Mahoney Surv., A-310, sec. 17, SE. cor. lse.	Q-13		1075
Do.	J. Parks No. 1	D. Mahoney Surv., A-310, sec. 17	Q-13		1004
Do.	Parks No. 1	J. Dimpkins Surv.	I-15		1020
Do.	J. Parks No. 2	J. Dimpkins Surv.	J-15		1000
Do.	J. H. Robinson No. 1	T.&P.R.R.Co. Surv., A-801, Blk. 3, sec. 67, N. ¼ of W. ½	B-16	1417	1579
Do.	J. H. Robinson No. 2	T.&P.R.R.Co. Surv., A-801, Blk. 3, sec. 67, N. ¼ of W. ½	B-16	1392	1505
Do.	J. H. Robinson No. 3	T.&P.R.R.Co. Surv., A-801, Blk. 3, sec. 67, 1066′ from N., 400′ from E. line of W. ½	B-16	1376	1558
Do.	J. W. Watson No. 1	T.&P.R.R.Co. Surv., Blk. 3, sec. 13, A-784, 1980′ from S., 1780′ from W. line	E-11		
Do.	G. M. Withers No. 1	J. Dimpkins Surv., A-152, N. central part of lse.	S-14		1000
Do.	G. M. Withers No. 3	J. Dimpkins Surv., A-152, SW. cor. lse.	S-11		998
Do.	G. M. Withers No. 4	J. Dimpkins Surv., A-152, S. central part lse.	S-11		1004
Do.	G. M. Withers No. 5	J. Dimpkins Surv., A-152, NW. cor. lse.	S-11		1010
Do.	G. M. Withers No. 6	J. Dimpkins Surv., A-152, NW. cor. lse.	S-11		1000
Lucas & Gibson	Cromeans & Pollard No. 1	Strawn Townsite, Woodlawn Add. Lots 23 and 25, 155′ from E. and W. lines, 145′ from N. and S. lines	D-20		2996
Do.	Harbin & Thomas No. 1	Strawn Townsite, Harbin & Thomas 2-A. tract, 150′ from S. and E. lines, Jane's Addition	C-20		3015
McDowell & Casey	T. M. Carter No. 1	M. Castleman Surv., A-1622	E-3		3057
McGar	Dalton No. 1	T.E.&L.Co. Surv., A-562, sec. 1787, SE. cor. SE. ¼	J-6	960	4215
McGuire & Hinson	Carter-Moseley No. 1	Williams Surv., A-886, Blk. 9, 220′ from S., 160′ from E. line	S-15		1779
McLester Oil Co.	G. E. Allen No. 1	T. A. Howell Surv., Lot 7, E. ½ Surv.			3445
McPhail Oil Co.	Eubanks No. 1	J. Finley Surv., A-180, 2963′ from W., 2223′ from S. line	A-3	1219	2150
McQuire et al.	Carter No. 1	McKinney & Williams Surv., A-337, sec. 9, NW. cor.	F-2	982	1779
Magnolia Petroleum Co.	Fearis Dalton No. 1	S. F. Harding Surv., A-221, NE. cor. NE. ¼	J-5	998	4650

TABLE 17.—*Well data for Palo Pinto County.*—(*Continued.*)

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
Magnolia Petroleum Co.	Carl E. Teichman	T.&P.R.R.Co. Surv., A-1081, Blk. 2, sec. 65, SW. cor. NE. ¼	G-15	1108	3747
Do.	Turner & Green No. 1	T.E.&L.Co. Surv., sec. 1793, NW. cor. SW. ¼	J-5	943	4125
Merritt	F. H. Hill No. 1	Burleson Co. Sch. Lds., Lots 71 and 70, Blk. 3A-30, 100′ from S., 130′ from W. line	F-20	943	701
Mid-Kansas Oil & Gas Co.	J. N. Nushbaum No. 1	S.P.R.R.Co. Surv., sec. 445	—		3369
Do.	Slemmons No. 1	T.&P.R.R.Co. Surv., A-1523, Blk. 3, sec. 38, NW. cor. SW. ¼	O-13	1173.5	3418
Do.	Slemmons No. 2	T.&P.R.R.Co. Surv., A-794, Blk. 3, sec. 45, SW. cor. NE. ¼	D-14		3510
Midwest Oil Co.	Robinson No. 1	T.&P.R.R.Co. Surv., A-1387, Blk. 3, sec. 64, NW. cor. NW. ¼	C-16	1120	4002
Mingus Gas Co.	J. Slemmons No. 1	T.&P.R.R.Co. Surv., Blk. 3, sec. 45, A-794, 365′ from N., 350′ from E. line of E. ½ NW. ¼	E-13	1110	3875
H. R. Montgomery	A. Crocker No. 1	J. Bird, A-27, 5900′ from W., 3150′ from S. line 4108-A.	I-18	893.2	3532
Mook-Texas Oil Co.	E. P. Costello No. 1 (Caudle)	W. H. Eggleston Surv., A-691, Blk. "P," sec. 94, 450′ E., 150′ N. of SW. cor. 46.3-A. tract	B-6	1100	4040
Do.	Roxreat No. 1	B. F. Maye Surv., A-1186, 1595′ S., 435′ W. of NE. cor. 80-A. tract	—		3605
Moore & Snebold	F. P. Boles No. 1	Burleson Co. Sch. Lds., A-30, Blk. 3, sec. 73, NW. cor. S. ½	F-20	1017	3444
Do.	F. P. Boles No. 2	Burleson Co. Sch. Lds., A-30, Blk. 3, sec. 73, NW. cor. SE. ¼	F-20	1009	3418
Do.	Slemmons et al. No. 1 (L. L. Brown)	T.&P.R.R.Co. Surv., A-1996, Blk. 3, sec. 44, NE. cor. NE. ¼	C-14	1139.5	3307
Do.	Slemmons et al. No. 2 (L. L. Brown)	T.&P.R.R.Co. Surv., A-1996, Blk. 3, sec. 44, SE. cor. NE. ¼	C-14	1135	3647
Do.	Stuart No. 1	T.&P.R.R.Co. Surv., A-809, Blk. 4, sec. 49, NW. cor. SW. ¼	A-15	1316	1854
Morris et al.	Hinkson No. 1		O-3		842
Do.	Scudder No. 1	T.E.&L.Co. Surv., A-485, sec. 1710, SE. cor.	L-3	1002	650
Mountain Oil Co.	Costello No. 1	J. F. Smith Surv., A-410, 200′ from S., 1600′ from W. line of N. 160-A. tract, E. of Brazos River	F-4		3967
Mutual Oil Co. (Hedrick)	J. H. Robinson No. 1	T.&P.R.R.Co. Surv., A-797, Blk. 3, sec. 53, NW. cor. SW. ¼	C-15	1186	1578
Nash & Windfohr	Ben Eubanks No. 1	J. Finley Surv., A-181	A-3	1222	4305
Neeley & Halbert	Ettie Neal No. 1	Collingsworth Surv., A-121 sec. 14, 660′ from N., 660′ from E. line	Q-21	1069	4418
Nelson Oil Synd.	Finch No. 1	N. Dickerson Surv., A-151, Blk. 39, 810-A. tract, S. of Gordon	I-22	975	3244
Do.	Finch No. 2	N. Dickerson Surv., A-151, Blk. 44, SW. cor.	I-22	970	3390
Do.	Owens No. 1	T.&P.R.R.Co. Surv., A-766, Blk. 1, sec. 47, NW. cor. NW. ¼	L-13	851	2214

Do.	Reasoner No. 1	N. Green Surv., A-209, sec. 12, 2 mi. S. of Gordon	I-22	955	3570
Do.	Harlin No. 1	Burleson Co. Sch. Lds., Blk. 2, A-29, sec. 29, 200′ from E. and S. lines	H-20	870	814
Do.	J. Owens No. 1	T.&P.R.R.Co. Surv., Blk. 1, sec. 47, A-766, 200′ from W., 1000′ from N. line	L-14	860	4094
Do.	M. Owens No. 1	T.&P.R.R.Co. Surv., Blk. 1, sec. 47, A-766, 150′ from N. and 1500′ from W. lines	L-13	865	3570
Do.	P. P. Pierce No. 1	Jane's Addition, Blk. 2, Strawn Townsite, 150′ from block lines	D-20	900	3020
Owens & Burkett	Gary-Sanger No. 1	J. J. Metcalf Surv., A-341, SE. cor.	J-4	986	4790
Owens, Burkett & Wheeler	R. A. Wheeler No. 1	T.&P.R.R.Co. Surv., A-845, Blk. A, sec. 37, NW. cor.	R-15	857	3730
Do.	Wheeler No. 2	T.&P.R.R.Co. Surv., A-845, Blk. A, sec. 37, SW. cor. N. ½ lse.	R-15	969.53	3929
Owens & Burkett	Wheeler No. 3	T.&P.R.R.Co. Surv., A-845, Blk. A., sec. 37, NE. cor. N. ½ lse.	R-15	844	3812
Do.	Wheeler No. 4	T.&P.R.R.Co. Surv., A-845, Blk. A, sec. 37, NE. cor. S. ½ lse.	R-15	1095	4185
Owen & Wilson	D. A. Hess No. 1	D. Mahoney Surv., A-310, NE. cor. lse.	Q-12	--	1079
Owen, Wilson, & Palmer	J. Oaks No. 1	D. Mahoney Surv., A-310	Q-12	951	4450
Owens	T. R. Gilbert No. 1	T.&P.R.R. Surv., Blk. A, sec. 39, 900′ from S., 450′ from E. line	R-16	884	3843
Owens, Burkett & Wheeler	Wheeler No. 1	T.&P.R.R.Co. Surv.. Blk. A, A-2026, SE. cor. N. 160-A. tract	R-15	872	4105
Owens	H. Stages No. 1	Strawn Townsite, Lot 13, center (Original town)	D-21	--	3041
Owens & Burkett	Pennington No. 1	S. F. Harding Surv., A-341, SE. cor. NE. ¼	J-5	1271	4380
Pa-Tex Oil Co.	Lane No. 1	T.&P.R.R.Co. Surv., A-750, Blk. 4, sec. 11, NE. cor. NE. ¼ Hart Ranch area	H-1	1064.2	3098
Palo Pinto Oil Co.	Stuart No. 1	T.&P.R.R.Co. Surv., A-1538, Blk. 4, sec. 62, E. ½	A-16	1326	1657
Do.	Stuart No. 2	T.&P.R.R.Co. Surv., A-1538, Blk. 4, sec. 62, E. ½	A-16	1323	1704
Do.	C. E. Allen No. 1	I. Ryan Surv., A-388, 200′ from N. & E. lines 15-A. tract (Strawn Townsite)	D-21	1000	3022
Do.	C. E. Allen No. 1-A	Strawn Townsite, Blk. 20, 150′ from E. and N. lines 2½-A. tract	D-21	997	3013
Do.	C. Crocker No. 1	H. Bird Surv., Strawn Townsite, Lots 1 to 16, Woodlawn Add., 25′ from E. and S. lines Lot 11	D-20	985.5	3016
Do.	E. W. Smith No. 1	Strawn Townsite, Woodlawn Add. Blk. 2, 175′ from E., 185′ from N. line	D-20	982	2990
Do.	T. & P.R.R.Co. No. 1	Strawn Townsite, Blk. 36, Bird Subdiv., Lot 10, 10′ from N. and W. lines	D-21	998	3034
Palo Pinto Oil & Gas Co.	Strawn Coal Co. No. 9	A. Ashworth Surv., A-1, 1050′ from E., 7000′ from S. line	E-20	976	2977
Pender Production Co.	Rasmussen No. 1	T.&P.R.R.Co. Surv., A-1140, Blk. 3, sec. 46, SW. cor. NW. ¼	D-14	1115	3600
Do.	Rasmussen No. 2	T.&P.R.R.Co. Surv., A-1140, Blk. 3, sec. 46, NW. cor. SW. ¼	D-14	--	4245
--	Slemmons No. 2	T.&P.R.R.Co. Surv., A-851, Blk. 3, sec. 39, 330′ N., 330′ W. of SE. cor.	D-13	1078.8	3510

TABLE 17.—*Well data for Palo Pinto County.*—*(Continued.)*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
C. L. Peters	W. L. Stephens No. 1	Strawn Townsite, 140′ from N. line, 150′ from E. line, 155′ from S. line, and 250′ from W. line	D-20	997.3	3036
A. W. Phillips	Caudle No. 1	W. H. Eggleston Surv., A-691, sec. 94, SE. cor. NW. ¼, just E. of county line on Brazos River, 1400′ S., 1800′ E.	B-6	1031.6	3616
Phillips Petroleum Co.	Alex Stringer No. 1	J. Poitevent Surv., A-1931, sec. 2, 600′ from W., 150′ from N. line, E. ½ SW. ¼	B-5	1075	2200
Phillips & Burkett	J. S. Wilson No. 1	T.E.&L.Co. Surv., A-5[illegible]5, sec. 2703, SW. cor.	Q-1	986	4293
Phoenix Co. (Rosenfeld)	Dalton No. 1	A. S. Simmons Surv., A-1120, NW. cor.	K-6	968	3970
Prairie Oil & Gas Co.	Allen-Ritchie No. 1	C.T.R.R. Surv., A-1289, sec. 2, 1467′ from N., 1352′ from E. line	H-1		1557
Do.	Allen-Ritchie No. 2	C.T.R.R. Surv., A-1289, sec. 2, 750′ from E., 1260′ from N. line	H-1 ?		1671
Do.	O. K. Carter No. 1	McKinley & Williams, Blks. 9 & 10, A-339, 560′ from E., 214′ from S. lines	G-2		2315
Do.	E. P. Costello No. 1	M. Castleman Surv., A-119, 2262′ from NE. cor., 809′ from S. line	F-4		1391
Do.	Edmonson No. 1	S. R. Barker Surv., A-106	O-11		4275
Do.	E. B. Ritchie No. 1	C.T.R.R. Surv. A-140, sec. 1, 350′ from N. line	G-2		1701
Do.	Rogers & McRea No. 1	C. C. G. Eberling Surv., A-166, SE. of Judd., S. part of SW. ¼	M-21	975	1052
Do.	S. B. Strawn No. 1	T.&P.R.R.Co. Surv., A-804, Blk. 3, sec. 83, NW. cor.	E-17	1223.7	3715
Do.	Stuart No. 1	T.&P.R.R.Co. Surv., A-810, Blk. 4, sec. 59	A-15	1331	3552
Richardson	Holt & Gauldin No. 1	B.B.B.&C.R.R.Co. Surv., A-64, sec. 41, SW. cor.	J-4	988	1160
Joe Richardson	Holt & Gauldin No. 1	W. H. Lewis Surv., A-1013, sec. 10, 300′ from E., 150′ from S. line	J-4	1021	1510
Do.	A. Storm No. 1	T. R. Y. Giminez Surv., A-1103, 1100′ from E., 700′ from S. line	H-5	1121	1800
Richardson & Godley	Dalton No. 1	J. J. Metcalf Surv., A-341 ?	J-4	979	1124
Rinear	H. Howard No. 1	J. Dimpkins Surv., A-152, 2 mi. S. of Mineral Wells	S-11		1620
Rinehart	Weldon No. 1	C.E.P.I.&M.Co. Surv., A-133, sec. 12, 250′ from N. and W. lines, near Sadie Bell	F-6	1102	4109
Rochell et al.	Turner No. 1 (J. W. Smith, Trustee)	J. Dimpkins Surv., A-152, N.W. cor. lse.	S-10	882	4480
Roddy et al.	Carter No. 1	M. W. Lucky Surv., A-289, sec. 13, 250′ from S. and E. lines	F-3	1023	3509
Rogers & Barber	Smart No. 1	Lone Camp District	-------		700
Root & Rhodes	M. B. Costello No. 1	R. R. Williams Surv., A-896, 160′ from Brazos River, 450′ from N. line	F-4		1375
Do.	M. B. Costello No. 2	R. R. Williams Surv., A-896, 800′ from Brazos River, 170′ from N. line	F-4		1416

Do.	B. N. Long No. 1	R. R. Williams Surv., A-896, 400′ from W. and S. lines 72-A. tract	F-4		1482
Ross & Brooks	Pennington No. 1	S F. Harding Surv., A-221	K-15	945	4105
Roth & Faurot	Williams No. 1	T &P.R.R.Co. Surv., A-1945, Blk. 2, sec. 50, SE. cor. SE. ¼	I-14	1256	2012
Roxana Petroleum Co.	Dye No. 1	T.E.&L.Co. Surv., A-455, sec. 879, SE. cor. SE. ¼	N-4	940	3992
Richardson	Edgin No. 1	J. J. Metcalf Surv., A-311, 330′ from N., 150′ from W. line	J-4	982	1460
Roxana Petroleum Co.	L. E. Seaman No. 1	T.&P.R.R.Co. Surv., A-1874, Blk. 3, sec. 6, NW. cor. NW. ¼, 600′ N., 350′ W.	A-9	1248	4535
Schofield et al.	Dalton No. 1	E. E. Pegus Surv., 150′ from S., 3300′ from E. line	K-8	926	731½
Scott-McClure	Wheeler No. 1	T.&P.R R.Co. Surv., A-845, Blk. A, sec. 37, SE. cor., SW. of Mineral Wells	R-15	764	3706
Seaboard Oil Co.	Costello No. 1	M. Castleman Surv., A-119, 150′ from S., 1200′ from E. line	E-4		2725½–3185
T. G. Shaw Interests	J. A. Chestnut No. 2	T.&P.R.R.Co. Surv., Blk. A, sec. 40	Q-16	900 Est.	5123
T. G. Shaw	F. R. Gilbert No. 1	H. Blood Surv. No. 116, A-687, SW. cor.	O-17		3340
Do.	J. H. Gilbert No. 1	C. Green Surv., A-207, NW. cor. lse.	S-15	797	3790
Do.	J. H. Gilbert No. 2	A. Williams Surv.	S-15	882	3896
Do.	Jones No. 2	G. Green Surv.	S-15	798	2406
Do.	Moseley No. 1	A Williams Surv., A-886, sec. 4, NW. cor.	S-15	812	2375
Do.	Moseley No. 1 (Legion Well)	A. Williams Surv., A-886	S-15	887	2470
Simms Oil Co. (Meredith)	Costello No. 1	J. W. Bunton Surv., A-52, 2784′ W., 2377′ N. of E. and S. lines	E-5	1058	3416
Sinclair-Gulf Co.	Abrams No. 1	T.&P R.R.Co. Surv., A-743, Blk. A, sec. 43, SW. cor. NW. ¼	O-16	970	4675
Sinclair Oil & Gas Co.	Holt & Gauldin No. 1	T.E &L.Co. Surv., A-498, sec. 1723, NW. cor. W. ½	J-3	1168	1426
Do.	Holt & Gauldin No. 2	T.E.&L.Co. Surv., A-498, sec. 1723, SW. cor. W. ½	J-3	1164	4220
Sinclair Prairie	Mary Bridges No. 1	Wm. Metcalf Surv., A-1188, 330′ from N. and 350′ from E. line and 1755′ from W. line	H-3	1038	2602
Do.	C. H. Dalton No. 1	A.B.&M. Surv., A-915, 330′ from S. and W. lines 1600-A. tract	G-1		3105
Do.	South Ritchie No. 1	S.P.R.R. Surv. No. 1, A-121, 800′ from S. and 330′ from W. line	H-3	1066	1756
Singleton et al.	W. Holt No. 1	T.E.&L.Co. Surv., A-607, sec. 2510, SE. cor., 5 mi. N. of Mineral Wells	Q-5	1019	4360
H. L. Singleton Co.	Smith No. 1	T.&P.R.R.Co. Surv., A-707, Blk. A. East of B., sec. 29, NW. cor., 330′ from N., 200′ from W. line	R-7		3028
Skelly Oil Co.	Carter No. 1	M. Castleman Surv., A-119, 200′ from S. and W. lines	D-3	1246	2715
Do.	W. L. Costello No. 1	M. Castleman Surv., A-119, 200′ from N. and W. lines	D-4	1250	2503
Slim Jim Oil Co	R. P. Lee No. 1	T.E.&L.Co. Surv., A-519, sec. 1744, SE. cor.	L-2		2250
Smith	Seaman No. 1	S. Blythe Surv., A-33	A-9	1037	1780
Smith & Johnson	Stuart No. 1	T.&P.R.R.Co. Surv., A-1499, Blk. 4, sec. 84, 200′ E. and N. of SW. cor.	A-18	1444	1608
States Oil Corp.	Allen-Ritchie No. 1	S.P.R.R.Co. Surv. A-1230, sec. 2, 450′ from N. and W. lines 160-A. tract	H-2	----	764

TABLE 17.—*Well data for Palo Pinto County.*—(*Continued.*)

Company	Farm	Location	Map Co-ord.	Surface Elev. *Feet*	Total Depth *Feet*
States Oil Corp.	Allen-Ritchie No. 2	S.P.R.R.Co. Surv. A-1280, sec. 2, 450′ from N., 550′ from W. line 160-A. tract	H-2		1288
Strawn Petroleum Co.	Stuart No. 1	T.&P.R.R.Co. Surv., A-2076, Blk. 4, sec. 70, 330′ S. and W. of NE. cor.	A-16		1730
Do.	Stuart No. 1	T.&P.R.R.Co. Surv., A-780, Blk. 4, sec. 75	A-17		1707½
Do.	Stuart No. 3	T.&P.R.R.Co. Surv., A-780, Blk. 4, sec. 75	A-17		2500
Do.	Stuart No. 14	Blk. 4, T.&P.R.R.Co. Surv., sec. 70	A-17		1735
Do.	Stuart No. 20	T.&P.R.R.Co. Surv., A-2076, Blk. 4, sec. 70	A-17		1637
Do.	Stuart No. 21	T.&P.R.R.Co. Surv., A-2076, Blk. 4, sec. 70	A-17		1739
A. T. Strong	Moseley Ranch No. 1	Allen Williams Surv., A-886, Blk. 5, NW. cor.	S-15	805.1	3805
Do.	Seaman No. 1	S. Blythe Surv., A-33, NW. cor., N. of Hart Ranch	A-9	1038	3197
Sykes & Pollard	Holt Ranch No. 1	T.E.&L.Co. Surv., A-608, sec. 2511, SW. cor., 8 mi. NW. of Mineral Wells	Q-5	1128	2002
S. J. Taylor et al. (Southern States)	Costello No. 1	J. P. Rohns Surv., A-381, sec. A, SW. cor. Lot 1	D-3		4348
Do.	Costello No. 2	J. P. Rohns Surv., A-381, SW. cor. Lot A	D-3	1176	3275
Texas Co.	McDonald No. 1 (Hall Walker)	T.&P.R.R.Co. Surv., A-1077, Blk. 1, sec. 31, E. of Palo Pinto	J-12	1034	4665
Texas Fidelity Co. & Empire	Eddleman No. 1	T.&P.R.R.Co. Surv., A-2066, Blk. 3, sec. 22, NE. cor. NE. ¼	D-11	1295	2505
Texas Fidelity Oil	Ashe Synd. No. 2 (Hart)	T.&P.R.R.Co. Surv., Blk. 3, sec. 29, A-805, NW. cor. N. ½ SE. ¼	B-12	1364.5	3944
Texas Imperial Co.	Thomas No. 1	T.&P.R.R.Co. Surv., A-1662, Blk. 4, sec. 48, SE. cor. SE. ¼	A-14	1277	3608
Texas Pacific Coal & Oil Co.	Claude Allen No. 1 (R. D. Hinkson)	T.&P.R.R.Co. Surv., A-1110, Blk. 3, sec. 88, 1700′ from N., 300′ from W. line, Double Gates Dist., SW. cor. NW. ¼	C-18	1191	2010
Do.	Henry Bird "Fee" No. 2	H. Bird Surv., A-26, 1000′ from S., 2875′ from E. line (Strawn Townsite)	D-20	983	2996
Do.	S. R. Boggus No. 1	T.&P.R.R.Co. Surv., A-1951, Blk. 4, sec. 48, SW. cor. SW. ¼	A-14	1316	3630
Do.	E. P. Boles	Burleson Co. Sch. Lds., A-30, Blk. 3, sec. 57, W. part	G-20	1018	3191
Do.	S. A. Bradley No. 1 (Mrs. Blewett)	T.&P.R.R.Co. Surv., A-1781, Blk. 2, sec. 86, SW. cor. NW. ¼	H-18	1032.2	3578
Do.	R. E. Colvard No. 1	Henry Bird Surv., A-26, 250′ from W., 62′ from S. line, Woodlawn Add., Strawn Townsite	D-21	390	2998
Do.	F. Corne No. 1 (M. H. Vick)	T.&P.R.R.Co. Surv., A-1191, Blk. 1, sec. 12, SE. cor.	M-9		2881
Do.	Thos. Court No. 6	Thomas Court Surv., A-118	B-20	319	879
Do.	Thos. Court No. 21	Do.	B-20	501	1085
Do.	Thos. Court No. 54	Do.	B-20	1172	989

Do.	Thos. Court No. 103	Do.	B-20	1078.2	785
Do.	Thos. Court No. 139	Do.	B-20	1176	1172
Do.	Thos. Court No. 163	Do.	B-20	1029	709
Do.	Dykes No. 9	W. C. Dykes Surv., A-2018	—	1151.2	969
Do.	Dykes No. 22	Do.	B-21	1230	875
Do.	Dykes No. 23	Do.	B-21	1145	1000
Do.	Dykes No. 24	Do.	B-21	1030.2	760
Do.	Dykes No. G-31	Do.	B-21	1095	635
Do.	Dykes No. G-32	Do.	B-21	1082	630
Do.	Dykes No. G-33	Do.	B-21	1082	700
Do.	Dykes No. G-34	Do.	B-21	1110	856
Do.	Dykes No. G-35	Do.	B-21	...	688
Do.	Dykes No. G-36	Do.	B-21	...	1000
Do.	Dykes No. G-37	Do.	B-21	1152	695
Do.	Foreman No. 1	T.&P.R.R.Co. Surv., A-1646, Blk. 3, sec. 70, 230′ from E., 2310′ from S. line, 7 mi. N. of Strawn	E-16	1231	3537
Do.	Middleton No. 1	L. P. Sullivan Surv., A-397, S. part	M-11	...	2662
Do.	Naylor No. 1	T.&P.R.R.Co. Surv., A-1482, Blk. 3, sec. 80, NE. cor. NE. ¼	C-18	1040	910
Do.	F. Riebe No. 1	T.&P.R.R.Co. Surv., A-1213, Blk. 3, sec. 62, SE. cor. SW. ¼	E-16	1181	4015
Do.	E. V. Robinson No. B-1	T.&P.R.R.Co. Surv., A-1386, Blk. 3, sec. 56, 1320′ from W. and S. lines, cen. SW. ¼	C-15	1360	1750
Do.	J. H. Robinson No. 1	T.&P.R.R.Co. Surv., A-802, Blk. 3, sec. 77, NW. cor.	C-17	1225	1603
Do.	J. H. Robinson No. 3	T.&P.R.R.Co. Surv., A-802, Blk. 3, sec. 77, NW. cor.	C-17	1480.7	1646
Do.	J. H. Robinson No. 4	T.&P.R.R.Co. Surv., A-801, Blk. 3, sec. 67, SW. cor. W. ½	B-16	1427.9	1617
Do.	J. H. Robinson No. 5	T.&P.R.R.Co. Surv., A-801, Blk. 3, sec. 67, 265′ from N., 1929′ from E. line	B-16	1431	1911
Do.	J. H. Robinson No. 6	T.&P.R.R.Co. Surv., A-1300, Blk. 3, sec. 68	C-17	1409	1507
Do.	J. H. Robinson No. 7	T.&P.R.R.Co. Surv., A-1300, Blk. 3, sec. 68, 2420′ from N., 2650′ from E. line	C-17	1418	1512
Do.	J. H. Robinson No. 8	T.&P.R.R.Co. Surv., A-1300, Blk. 3, sec. 68	C-17	1418	1526
Do.	J. H. Robinson No. 9	T.&P.R.R.Co. Surv., A-1300, Blk. 3, sec. 68, 520′ SE. of No. 6, 520′ SW. of No. 7	C-17	1418.8	1510
Do.	Mary E. Robinson (R. D. Hinkson) No. 1	T.&P.R.R.Co. Surv., A-1919, Blk. 3, sec. 74, NW. cor. N. ½	E-17	1216.5	3583
Do.	Mary E. Robinson No. 1	T.&P.R.R.Co. Surv., A-1384, Blk. 3, sec. 78	B-17	1484.7	2103
Do.	Mary E. Robinson No. 2	T.&P.R.R.Co. Surv., A-1384, Blk. 3, sec. 78	C-17	1486.9	1165
Do.	Stuart Bros. No. 1	T.&P.R.R.Co. Surv., A-721, Blk. 4, sec. 73, 200′ N. of middle S. line	B-18	1415	1630
Do.	Stuart No. 1	T.&P.R.R.Co. Surv., A-811, Blk. 4, sec. 95, 1700′ E., 2150′ S. of NW. cor.	A-19	1153	3150
Do.	Stuart No. 1	T.&P.R.R.Co. Surv., A-780, Blk. 4, sec. 75	A-17	1153	3100
Do.	J. N. Stuart No. 13	W. J. Betterton Surv., A-1626, 1500′ N. of Swenson Est. N. line	A-20	1178	985
Do.	J. N. Stuart No. 22	2700′ W., 2350′ N.	—	1075	881

TABLE 17.—*Well data for Palo Pinto County.—(Continued.)*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
Texas Pacific Coal & Oil Co.	Stuart No. 38	W. J. Betterton Surv., A-1625, sec. 2, 1200′ from E., 2400′ from S. line	A-20	1199	1078
Do.	Stuart No. 50	T.&P.R.R.Co. Surv., A-1512, Blk. 4, sec. 94, cen. SE. ¼	A-19	1270	1161
Do.	Stuart No. 62	W. J. Betterton Surv., A-1626, 1000′ N., 1700′ W. of SE. cor.	A-20	1216	1131
Do.	Stuart No. 63	W. J. Betterton Surv., A-1626	A-20		2270
Do.	Stuart No. 64	Do.	A-20	1152	1035
Do.	Stuart No. 83	Do.	A-20		2270
Do.	Stuart No. 94	W. J. Betterton Surv., A-1625, sec. 2	A-20	1112	3231
Do.	Stuart No. 102	T.&P.R.R.Co. Surv., A-823, Blk. 4, sec. 61	A-16	1360	2057
Do.	Stuart No. 103	T.&P.R.R.Co. Surv., A-803, Blk. 3, sec. 79	A-17	1318	1657
Do.	Stuart No. 109	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71	A-17	1313.7	1706
Do.	Stuart No. 112	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 2310′ from N., 1650′ from W. line	A-17	1360	1718
Do.	Stuart No. 123	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71	A-17	1354	1720
Do.	Stuart No. 137	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71	A-17	1382.1	1642
Do.	Stuart No. 141	T.&P.R.R.Co. Surv., A-810, Blk. 4, sec. 59, SE. cor. SE. ¼	A-16		2588
Do.	Stuart No. 143	T.&P.R.R.Co. Surv., A-798, Blk. 3, sec. 55, NW. cor. NE. ¼	B-15	1338	1684
Do.	J. N. Stuart No. 144	T.&P.R.R.Co. Surv., A-798, Blk. 3, sec. 55	B-15	1344.8	1665
Do.	Stuart No. 153	W. J. Betterton Surv., A-1626	A-20		3776
Do.	Stuart	T.&P.R.R.Co. Surv., A-1496, Blk. 4, sec. 72, SE. cor. SE. ¼	B-17	1438.6	1512
Do.	Stuart	T.&P.R.R.Co. Surv., A-721, Blk. 4, sec. 73	B-17	1118.5	1683
Do.	Stuart	T.&P.R.R.Co. Surv., A-1558, Blk. 4, sec. 62, SW. cor., 8 mi. NW. of Strawn	A-16		1730
Do.	Stuart	T.&P.R.R.Co. Surv., A-808, Blk. 4, sec. 83	A-18	1114	1617
Do.	J. N. Stuart No. 151	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 2425′ from S., 2300′ from E. line	A-17	1312.8	1636
Do.	J. N. Stuart No. 157	T.&P.R.R.Co. Surv., A-1496, Blk. 4, sec. 72, 400′ from S. and W. lines	A-17	1385	3235
Do.	J. N. Stuart No. 158	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 3225′ from S., 2300′ from E. line	A-17	1336.8	1636
Do.	J. N. Stuart No. 160	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 1750′ from N., 1680′ from E. line	A-17	1310.8	1613
Do.	J. N. Stuart No. 161	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 1100′ from E., 2150′ from N. line	A-17	1113	1630
Do.	J. N. Stuart No. 162	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 1450′ from N., 1075′ from E. line	A-17	1329.8	1612
Do.	J. N. Stuart No. 163	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 1050′ from N., 1680′ from E. line	A-17	1332.6	1620

Do.	J. N. Stuart No. 164	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 1330′ from N., 2275′ from E. line	A-17	1335.4	1623
Do.	J. N. Stuart No. 165	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 1630′ from N., 2835′ from E. line	A-17	1332.8	1630
Do.	J. N. Stuart No. 166	T.&P.R.R.Co. Surv., A-824, Blk. 4, sec. 71, 680′ from N., 2190′ from E. line	A-17	1319.1	1670
T. & P. and Prairie	Stuart No. 1	T.&P.R.R.Co. Surv., A-810, Blk. 4, sec. 59, SW. cor. SW. ¼	A-16	1331	3550
Do.	S. J. Stuart No. 2	T.&P.R.R.Co. Surv., A-941, Blk. 4, sec. 60, NW. cor. NW. ¼	A-15	1375	2005
Do.	S. J. Stuart No. 3	T.&P.R.R.Co. Surv., A-1432, Blk. 4, sec. 50, NW. cor. NW. ¼	A-15	1425	1855
Texas Pacific C. & O. Co.	A. Ashworth Fee No. 1	A. Ashworth Surv., A-1, 2150′ from S., and 3150′ from E. line 126-A. tract, S. part Surv.	E-21	979.4	3200
Do.	T.&P.C.&O.Co. Fee (H. Bird) No. 1	H. Bird Surv., A-26, 2500′ from E., 3500′ from S. line	D-20		2988
Do.	T.&P.C.&O.Co. Fee (H. Bird) No. 3	H. Bird Surv., A-26, 4460′ from S., 182′ from W. line	C-20	980.8	3012
Do.	E. V. Robinson "C" No. 1	T.&P.R.R.Co. Surv., A-800, Blk. 3, sec. 65, 2310′ from N. and W. lines, 330′ from E. line	C-16	1371.7	4295
Do.	Wagner No. 1 (M. H. Vick)	T.&P.R.R.Co. Surv., A-1389, Blk. A, sec. 12, SE. cor.	N-10		3780
Do.	Wilbar No. 1	J. Latham Surv., A-279, NE. ¼	H-21	1002	3725
Do.	Wilbar No. 8	J. Latham Surv., A-279, NW. cor. NW. ¼	G-21		1725
Do.	Wilbar No. 10	J. Latham Surv., A-279, SW. cor. NW. ¼	G-21		1820
Texhoma Oil & Refg. Co.	Robinson-Collette No. 1	T.&P.R.R.Co. Surv., A-1385, Blk. 3, sec. 66, SE. cor. SE. ¼	B-16	1428	1490
Do.	Robinson-Collette No. 1	T.&P.R.R.Co. Surv., A-800, Blk. 3, sec. 65, SW. cor. NW. ¼	C-16	1403.5	3595
Do.	Robinson-Collette No. 1	T.&P.R.R.Co. Surv., A-1384, Blk. 3, sec. 78, NW. cor. NW. ¼	B-17	1428	1525
Do.	Robinson-Collette No. 2	T.&P.R.R.Co. Surv., A-1384, Blk. 3, sec. 78, NW. cor. NW. ¼, 500′ W. of No. 1, 820′ from N., 815′ from W. line	B-17		1515
R. B. Thomas et al.	A. Fairbanks No. 1	A.B.&M. Surv. No. 1, 250′ N., 75′ E. of NE. cor. Jas. Ervin Surv.	A-21	1176	3430
Thomas et al.	R. B. Thomas No. 1	H. C. Satterfield Surv., A-1916, 275′ S. of NE. cor., 500′ W. of E. line of Surv.	A-19	1210	3516
Thompson	Couger No. 1, Patterson & Smith	L. B. Dayton Surv., A-153, Blk. 1, NE. cor., SE. of Pickwick	I-7		926
Do.	Dalton No. 1	T.E.&L.Co. Surv., A-563, sec. 1788, SW. cor. SE. ¼	K-6		2390
Thompson (Tom Owen, 1915)	Watson No. 1	T.&P.R.R.Co. Surv., A-1862, Blk. 2, sec. 8, SE. ¼, Ruff Place	G-10	919	1475
Wm. Thompson, 1910	W. H. Belding No. 1	T.&P.R.R.Co. Surv., A-1857, Blk. 2, sec. 8, SW. cor. NE. ¼, Sam Williams Place	F-10	922	1729
Do.	Watson No. 1	T.&P.R.R.Co. Surv., A-987, Blk. 2, sec. 9, SW. cor. (Near Harris Branch)	G-10	887	1647

TABLE 17.—*Well data for Palo Pinto County.—(Concluded.)*

COMPANY	FARM	LOCATION	MAP CO-ORD.	SURFACE ELEV. *Feet*	TOTAL DEPTH *Feet*
Thompson & Sands	Brazos Townsite No. 1	T.&P.R.R.Co. Surv., A-1112, Blk. A, sec. 38, Lot 7	R-16	803	3780
Transcontinental Oil Co.	C. H. Dalton No. 1	T.E.&L.Co. Surv., A-433, sec. 857, 330′ from E. and S. lines	I-1	1238	3035
Do.	Lane No. 1	T.&P.R.R.Co. Surv., A-349, Blk. 4, sec. 14	A-11		3098
Do.	Lane No. 2	T.&P.R.R.Co. Surv., A-1893, Blk. 4, sec. 14. NE. cor. SE. ¼	A-11	1101.3	3129
Do.	Lane No. 3	T.&P.R.R.Co. Surv., A-1893, Blk. 4, sec. 14, SE. cor. SE. ¼	A-11	1252	3255
Do.	Lane No. 4	T.&P.R.R.Co. Surv., A-349, Blk. 4, sec. 14, SE. cor. NE. ¼	A-11	1102	3129
Do.	Lane No. 5	T.&P.R.R.Co. Surv., A-349, Blk. 4, sec. 14, NW. cor. NE. ¼	A-11	1238	3225
Do.	Lane No. 6	T.&P.R.R.Co. Surv., A-1893, Blk. 4, sec. 14, SW. cor. SE. ¼	A-11	1236	3245
Do.	Lane No. 7	T.&P.R.R.Co. Surv., A-349, Blk. 4, sec. 14, NE. cor. NE. ¼	A-11	1102	3120
Do.	Lane No. 8	T.&P.R.R.Co. Surv., A-1893, Blk. 4, sec. 14, SE. cor. SW. ¼ (Stephens Co.)	A-11	1196	3233
Do.	Lane No. 9	T.&P.R.R.Co. Surv., A-349, Blk. 4, sec. 14, 330′ N. and E. of SW. cor. of E. ½ NE. ¼	A-11	1096.66	4255
Do.	Lane No. 10	T.&P.R.R.Co. Surv., A-349, Blk. 4, sec. 14 (Stephens Co.)	A-11	1083	3642
Upham Oil Co.	Belding No. 1	D. Strong Surv., A-399, NW. cor.	D-8	989	4236
Do.	Belding No. 2	B.B.B.&C. Surv., A-97, NW. cor.	D-8	1180	3764
Do.	Belding No. 4	B.B.B.&C. Surv., A-96, sec. 103, NE. cor.	D-8	1090	1904
Do.	Bleeker No. 1	T.&P.R.R.Co. Surv., A-942, Blk. A, sec. 50, SW. cor. NW. ¼	R-16	800	3740
Do.	Bradford No. 1	T.&P.R.R.Co. Surv., A-744, Blk. A, sec. 49, NE. cor. SE. ¼	R-16	771	3725
Do.	J. A. Chestnut No. 1	Geo. Green Surv., A-207, 1500′ from E. and N. lines	Q-14		4318
Do.	Ennis No. 1	T.&P.R.R.Co. Surv., A-744, Blk. A, sec. 49, SW. cor. NE. ¼	R-16	772.65	3840
Do.	J. Gilbert No. 1	Geo. Green Surv.	R-15	824	3752
Do.	D. A. Hess No. 6	D. Mahoney Surv., A-310, NE. cor. NW. ¼	Q-13	953	1064
Do.	Reasoner No. 1	T.&P.R.R.Co. Surv., A-741, Blk. A, sec. 49, NW. cor. SW. ¼	R-16	802	3750
Do.	C. von Hatzfield No. 3	D. Mahoney Surv., A-310, SW. cor. lse.	Q-13	1054 ?	1095
Do.	C. L. Walker No. 1	T.E.&L.Co. Surv., A-638, sec. 2541, SW. cor. NE. ¼	S-3	1170	2412
Do.	Watson No. 1	T.&P.R.R.Co. Surv., A-839, Blk. 3, sec. 25, SW. cor. SW. ¼	E-12	1072	3519
Do.	Watson No. 2	T.&P.R.R.Co. Surv., A-2009, Blk. 2, sec. 12, 900′ S., 400′ W. of NE. cor.	I-9	890	4190

Do.	Watson No. 4	T.&P.R.R.Co. Surv., A-839, Blk. 3, sec. 25, NE. cor. NE. ¼	E-12	992	3833
Do.	Wharton No. 1	Geo. Green Surv., A-207, 7 mi. S. of Mineral Wells	R-15	824	3665
Do.	Wharton No. 1	T.&P.R.R.Co. Surv., A-744, Blk. A, sec. 49, NE. cor. SE. ¼	R-16	774	3665
Walker et al.	C. E. Binnings No. 1	Strawn Townsite, Lot 3, center of Blk. 14	D-20	999	3017
F. L. Walker et al.	M. S. Loftin Est. No. 1	H. Bird Surv., A-26, SE. cor. W. ½	C-21	992	3231
F. L. Walker et al.	M. W. Smith No. 1	Burleson County School Lands, A-30, Blk. 3, sec. 82, S. ½, 996′ from E., 535′ from S. line	F-21	954	2984
Do.	F. L. Walker No. 1 (Strawn Coal Co.)	A. Ashworth Surv., A-1, 900′ from W., 300′ from N. line	E-19	989	3001
Werner et al.	Pennington No. 1	T.&P.R.R.Co. Surv., A-968, Blk. 1, sec. 4	K-8	1021	4260
Whiteside (Trans-continental)	A. B. Lane No. 1	T.&P.R.R.Co. Surv., A-750, Blk. 4, sec. 11, NE. cor. SE. ¼	A-10	1070	3750
Williams et al.	Allen No. 1	T.&P.R.R.Co. Surv., A-741, Blk. A, sec. 39, NE. cor. NE. ¼, ½ mi. SW. of Brazos River	R-16	808	3920
Worth & Coleman	Couger No. 1	A.B.&M. Surv. No. 5, A-13	A-7		3490
Yukon Oil & Gas Co.	Seaman No. 1	G.B.&C.N.G.R.R. Surv., A-1034, sec. 2, NW. cor. N. ½	C-7	1048.85	3968

Underground Water

POTABLE WATER[92]

Utilization.—Ground water is an important resource in the rural districts of Palo Pinto County. In some areas windmills dot the landscape and supply water for pastures, farm houses, and small gardens. In other areas where suitable underground water is absent or scarce, the farmers rely upon small reservoirs known as "tanks" made by excavating a water hole or damming a small valley. "Tanks" are unsatisfactory at best because they dry up in drought periods and silt up quickly in periods of heavy rainfall. Well water constitutes a much more satisfactory supply when it can be reached at moderate cost.

Occurrence.—Underground fresh water occurs in a number of sandstone layers that are penetrated at moderate depth. Most porous strata in Palo Pinto County below 700 or 800 feet carry brackish, salty, or mineralized water. Water that can be reached at depths of 50 to 400 feet is in many places good. The following sandstones constitute the most persistent and productive water-bearing horizons:

3. Turkey Creek sandstone of the Mineral Wells formation.
2. Brazos River sandstone of the Garner formation.
1. Sandstone beds in the upper part of the Millsap Lake formation.

Sandstone reservoirs in the Millsap Lake formation.—Two water sands occur near the top of the Millsap Lake formation and furnish water for wells in the southeastern part of the county. The deepest sand is encountered about 500 feet below the top of the Brazos River sand and yields good water in the southeastern corner of the county east of the town of Brazos and southeast of the Brazos River sandstone escarpment. The sand lies in the geologic section between the Brannon Bridge and Barton Creek limestones. It outcrops on Buck Creek in southwestern Parker County and is here designated the Buck Creek sandstone. The rock is coarse-grained, porous, highly permeable, about 25 feet thick, and appears to be a fairly persistent layer that carries water of good quality. Its occurrence

[92]*Literature*.—Gordon, C. H., Geology and underground water of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, pp. 1–88, 1913. Schoch, E. P., Chemical analysis of Texas rocks and minerals: Univ. Texas Bull. 1811, pp. 153-155, 224–225, 1918. Turner, S. F., Mineral-water supply of the Mineral Wells area, Texas: U. S. Geol. Survey Circ. 6, pp. 1-9 (mimeographed), 1934.

and thickness in a number of wells are presented in the following table:

Wells obtaining water from the Buck Creek sandstone.

Well	Location	Depth Feet
Cantrell No. 1	T.&P.R.R. Surv., 1 mi. N. of Santo	210
Chestnut No. 1 (Empire)	Geo. Green Surv., A-207, 2½ mi. N. of Brazos	525–550
Duese No. 1	D. Shipman Surv., Santo Townsite	106
Edmonson No. 2 (Jordon et al.)	Daniel Bourne Surv., A-45, NW. ¼	118–462
Edmonson No. 6 (Empire)	D. Bourne Surv., A-49, 1500′ from E., 500′ from S. line of tract	710–745
Edwards No. 1 (Lone Star Gas Co.)	James Dimpkin Surv., cen. NW. ¼	340–372
C. Hutzfield No. 3 (Upham Gas Co.)	D. Mahoney Surv., A-310, S. edge	425–450
S. A. Keown No. 7 (Lone Star Gas Co.)	Daniel Bourne Surv., A-32, E. of cen.	350–365
J. D. Oakes No. 3 (Lone Star Gas Co.)	D. Mahoney Surv., A-310, cen.	450–485
Rochelle No. 1 (O. R. Rochelle et al.)	James Dimpkin Surv., NW. cor. NE. ¼	340–355

The Buck Creek water sand furnishes the water supply for the town of Santo and vicinity. The water is very slightly mineralized by carbonate and sulphate salts, but otherwise it is of good quality. The following is a typical analysis of this water:

Analysis[9] *of water from the W. B. Marrs well, Santo.* (This sand lies about 100 feet below the Santo limestone.)

Constituents	Parts per million	Reaction values (per cent)
Sodium	419.0	42.0
Calcium	12.3	4.6
Magnesium	7.0	1.6
Chloride	257.0	18.5
Bicarbonate	650.0	27.5
Sulphate	73.6	3.9

The upper water-bearing sand of the Millsap Lake formation lies near the top of the formation and about 300 feet below the top of the Brazos River sandstone. It outcrops north of Dobbs Valley and is here named the Dobbs Valley sandstone. It supplies good water to deep wells northwest of the Brazos River sandstone escarpment in the Mineral Wells gas field area. Its position is shown in figure 8 and on Plate VI. It has not been reached in wells outside the gas field, and its extent and productivity are unknown.

[9] Analyzed by E. C. Sargent.

Brazos River sandstone reservoirs.—The Brazos River sandstone member consists of two layers of sandstone separated by a bed of impervious, hard, dark-blue clay. The upper layer is medium grained, loosely cemented, of non-marine origin, and about 50 feet thick, and in the vicinity of Mineral Wells it carries mineralized water. Along the outcrop east of Mineral Wells its water is fresh. The lower layer of sand is coarse grained and in places grades into conglomerate; it is well cemented, and in part, at least, it is of marine origin. On an average it is about 60 feet thick. This sand nearly everywhere carries water of good quality, and in most places its flow is inexhaustible, for wells pump continuously from 50 to 500 gallons per day. The positions of these two sands is shown in figure 8 and on Plate VI. The following tables furnish data on the wells producing from these sands.

Water wells producing from the lower layer of the Brazos River sandstone.

Well	Location	Depth of sand *Feet*	Remarks
Strawn Coal Co.	Abner Ashworth Surv.	366-500	Hole full
Chestnut No. 1 (Empire)	Geo. Green Surv., A-207, 2½ mi. N. of Brazos	210-250	Drilled deeper to gas
Oak Park Water Co.	T.P.&R.R.Co. Surv., Blk. A (E. of B.), sec. 31	196	Formerly city supply
W. J. Walker	T.&P.R.R. Surv., Blk. A (E. of B.), sec. 46	250	Domestic supply
C. H. McMasters	R. Starr Surv.	70	Domestic supply
C. Hatzfield No. 3	D. Mahoney Surv., A-310, S. edge	160–180	Drilled deeper for gas
S. A. Keown No. 7 (Lone Star)	D. Bourne Surv., A-32, E. of cen.	110–130	Do.
S. H. McMeen	0.3 of a mi. S. of Hubbard St. on highway to Inspiration Pt., Mineral Wells	322	Do.
J. D. Oakes No. 3 (Lone Star)	D. Mahoney Surv., A-310, cen.	205–225	Do.
Parmenter No. 1 (Consumers Gas)	D. Bourne Surv., A-32, SW. ¼ NW. ¼	110-175	Do.
Reliance Brick Co.	1 mi. E. of Oak and Hubbard streets, Mineral Wells	308	Do.
Rochelle No. 1 (O. R. Rochelle et al.)	James Dimpkin Surv., NW. cor. NE. ¼	130–165	Do.
Deep Well Water Co., Well No. 459	N. edge of town of Mineral Wells	383	City supply
Edmonson No. 2 (Jordon et al.)	Daniel Bourne Surv., A 15. NW. ¼	146–185	Drilled deeper for gas
Edwards No. 1 (Lone Star)	James Dimpkin Surv., cen. NW. ¼	140–160	Do.
W. C. Forbes No. 2 (Lone Star)	F. H. Gray Surv., A-206, NE. ¼ NW. ¼	130–146	Do.
Gill No. 1 (Empire)	D. Bourne Surv., A-32, S. edge	130-175	Do.

Wells producing fresh water from the upper layer of the Brazos River sandstone.

Well	Location	Depth of sand *Feet*	Remarks
Asia Wallace	Daniel Bourne Surv.	135	Domestic supply
Metz Bros.	R. Starr Surv.	70	Do.
A. J. Hubbard	Francis Gray Surv., sec. 4	140	Do.
W. S. Ford		200	Do.
Mrs. W. M. Glover	J. Dimpkin Surv.	160	Do.
Mineral Wells Country Club	T.&P.R.R. Surv., Blk. A (E. of B.), sec. 4	160	Public supply
Mattie Foster	D. Bourne Surv.	77	Domestic supply
Mrs. Harris	D. Bourne Surv.	48	Do.

Analyses of the waters from these two layers of the Brazos River sandstone are presented in the following tables:

Analyses of water from the lower layer of the Brazos River sandstone. (In parts per million.)

Well	Coörd.	Depth *Feet*	Fe	Ca	Mg	Na,K	HCO_3	SO_4	Cl	NO_3	Total solids
Reliance Brick Plant[94]	S-9	308	Tr.	20	18	117	309	88	116		728
Deep Well Water Co.[95]	R-8	383	Tr.				410	105	135	1.7	707
Oak Park Water Co.[96]	R-8	406						250	80		

Analyses of water from the upper layer of the Brazos River sandstone. (In parts per million.)

Well	Coörd.	Depth *Feet*	Fe	Ca	Mg	Na,K	HCO_3	SO_4	Cl	NO_3	Total solids
W. S. Ford[95]	T-10	200	.97	73	18	145	422	60	116	0	620
Metz Bros. No. 1[94]	T-11	54	0	119	30	43	232	119	142		685
Metz Bros. No. 2[94]	T-11	52	0	96	18	39	188	67	125		533
Mineral Wells Country Club[94]	T-9	160	0	25	13	139	332	63	58		630

Water, to be of good quality for domestic use, should have not over two parts per million of iron, not over 300 to 400 parts per million of chloride, nor over 500 parts per million of sulphate. Water somewhat more concentrated than the amounts mentioned can be used, though it is unsatisfactory. Eight parts or more per million of iron gives an objectionable color to the water, 800 parts or more per million of chloride gives a disagreeable salty taste, and 1000 parts or more per million of sulphate yields a taste of gypsum and has unpleasant effects. The waters from the Brazos River sandstone near its outcrop, as shown by the last four analyses above, are all excellent drinking waters.

---

[94]Analyzed by Virgil E. Barnes, Bur. Econ. Geol.

[95]Analyzed by M. D. Foster U. S. Geol Survey.

[96]Analyzed by S. F. Turner. U. S. Geol Survey.

Turkey Creek sandstone reservoir.—Wells drilled into the Turkey Creek sandstone at depths of 50 to 500 feet in the area bounded on the southeast by the Turkey Creek escarpment, on the northwest by a line drawn approximately five miles west of the Palo Pinto limestone escarpment. and on the east by the Palo Pinto-Parker county line, obtain good water wells. The sand has a porosity and permeability comparable to those qualities of the Brazos River sandstone, the water is of good quality, and the reservoir is one of the most persistent water-bearing strata in the county. A typical analysis of this water is as follows:

Analysis[97] *of water from Snoddy well on Highway No. 1, two miles west of Palo Pinto.* (From Turkey Creek sand 203 feet below surface.)

Constituents	Parts per million	Reaction values (per cent)
Sodium	132.5	33.8
Calcium	49.4	14.4
Magnesium	3.7	1.8
Chloride	334.0	5.3
Bicarbonate	410.0	39.4
Sulphate	44.4	5.4

Most of the many water wells drilled on the dip slope of the Palo Pinto limestone and northwest of the Palo Pinto outcrop, obtain water from this bed. In southern Palo Pinto County, north of a line drawn from Lone Camp southwest of the old Strawn oil field, both the Brazos River and Turkey Creek sandstones are thin and more calcareous, and consequently they do not carry good supplies of water. Therefore, the southwest corner, the western edge, and the northwest portions of the county have a much poorer supply of underground water than the other parts. "Tanks," small reservoirs, and springs have to be relied upon for a water supply. In the northwest corner of the county the Turkey Creek and Brazos River sandstones are too deep to yield fresh water, and shallower sands are dry or too heavily mineralized, so that ranch owners have to make use of creeks and springs. The following table furnishes data on wells drilled to the Turkey Creek sandstone reservoir:

[97]Analyzed by E. C. Sargent.

Wells drilled to the Turkey Creek sand, Mineral Wells formation.

Well	Location	Co-ord.	Depth	Remarks
Walker & Parks	T.&P.R.R. Surv., Blk. 2, sec. 35	H-12	180–197	- - - -
Belding	A.B.&M. Surv., sec. 3	F-8	730–770	2 bailers per hr.
Dalton	T.E.&L. Surv., sec. 1791	K-5	199–309	12 bailers per hr
Dalton	T.E.&L. Surv., sec. 1790, 800′ from S., 300′ from W. lines	J-5	280–320	2 bailers per hr.
E. F. Snoddy	M. V. Smith Surv., sec. 29	J-11	205	Abundance of water
Tkecz	T.&P.R.R. Surv., Blk. 1, sec. 45	L-13	205–240	Abundance of water

Springs.—Flowing springs are rare in Palo Pinto County and are not a reliable source of water supply. About a dozen springs were noted during the investigations in the county. These are described in the following paragraphs.

Pickwick spring (Coörd. F-5) is located one-quarter of a mile east of the town of Pickwick on the north side of the road. The water, which flows out of a gravel deposit at the contact with the Merriman limestone, is of good quality and does not diminish during ordinary droughts. The spring was probably one of the factors that led to the location of the town of Pickwick in this remote part of the county.

Frog Hollow spring (Coörd. H-1) is located at extreme north end of Frog Hollow Creek valley, on Allen & Ritchie ranch, in the extreme north edge of the county. The water seeps out of loose sandy soil from a ledge in the upper part of the Ranger limestone at the contact of an overlying porous jointed layer and an underlying impervious ledge. The water is of excellent quality and furnishes the supply for cattle and for drilling oil wells on the Allen & Ritchie ranch.

Turkey Creek spring (Coörd. O-8) is located about one mile above the junction of Turkey Creek with Brazos River, and five and one-half miles west of Mineral Wells. The water flows out of a sand in the bank of Turkey Creek at about the water-table level. It is of excellent quality and flows the year round but is not utilized except as a source of good drinking water by travelers and campers.

Palo Pinto spring (Coörd. H-11) is located two and one-half miles east of Palo Pinto on the north side of state highway No. 1 at a point where the highway is cut through the Palo Pinto limestone escarpment. The spring is intermittent and flows only during and following wet weather. It evidently originates from seepage water that finds its way into the porous upper layers of limestone.

Spring Gap spring (Coörd. F-15) is located near Spring Gap School in the eastern part of section 55, T. & P. Survey, Blk. 2, two miles south of Metcalf Gap. The spring has its origin in porous upper layers of Palo Pinto limestone near the head of a small branch. It is similar to Palo Pinto spring but has a somewhat more continuous flow of water.

Belding Spring (Coörd. F-9) is one-quarter of a mile east of the Belding ranch homestead. The spring occurs in the valley of a small branch. The water seeps out of sandy surface deposits at their contact with the impervious Merriman limestone. The Belding homestead, one of the pioneer houses in the county, was located near this spring because of its good supply of water, which ceases to flow only in times of extreme drought.

Dripping Spring (Coörd. D-9) lies two miles southwest of Belding ranch house along the upper course of Jewel Creek. The spring is similar to Belding spring. The water has its source from the surface of the impervious Merriman limestone.

Slemmons Spring (Coörd. D-13) is one-quarter of a mile northwest of Slemmons ranch house, and three miles west of Metcalf Gap store. The water seeps out of pervious beds in contact with impervious Merriman limestone.

Upper Ioni Creek Springs (Coörd. B-14). Several springs occur along the head waters of Ioni Creek and supply the stream with water, even during periods of ordinary drought. The source of the water is similar to that in the Belding spring and other springs that get their water from contact of Merriman limestone and overlying water-bearing beds.

Doubtless other small springs occur along the sides of the deeper valleys at contacts of pervious layers with impervious ledges. Possibly more of them could be found and developed as water supply for cattle. Wells equipped with good windmills are more dependable, and if located so that they will penetrate a water-bearing sand of known quality, they are sure to be more satisfactory, since most Palo Pinto County springs cease to flow during times of drought.

MINERAL WATER[98]

Occurrence.—Mineral waters occur in Palo Pinto County at Mineral Wells, at Oran, and in many wildcat tests drilled for oil, especially in the southern part of the county. The water at Mineral Wells has medicinal properties and has been developed very extensively. The mineralized waters occur at depths of 100 to 300 feet

[98]*Literature.*—Schoch, E. P., Chemical analysis of Texas rocks and minerals: Univ. Texas Bull. 1814, pp. 128-133, 153-155, 1918. Cummins, W. F., Report on the geology of northwestern Texas: Geol. Survey Texas Second Ann. Rept., p. 521, 1891. Turner, S. F., Mineral-water supply of the Mineral Wells area, Texas; U. S. Geol. Survey Circ. 6, pp. 1-9 (mimeographed), 1934.

in two, and possibly in three, different sands under the town of Mineral Wells. The mineralized water area extends from Lake Pinto east to the Peerless Water Company wells (three-fourths of a mile east of town) and from the Texas and Pacific Railroad north to Twenty-third Street, over an area of about three square miles (Pl. VI).

History.--The first water well in Mineral Wells was put down by Judge J. A. Lynch in 1878. According to Yeager,[99] Judge Lynch was en route west in 1877, when, on account of a severe attack of rheumatism, he was obliged to camp for a time on the side of East Mountain, now the site of Mineral Wells. He liked the spot so well that the next year he purchased eighty acres, erected a log dwelling, and engaged a man with a drilling machine to drill a well for water. The well was located just back of the present State National Bank Building, near the corner of Oak and Hubbard streets (Pl. VI). At a depth of 110 feet an abundant supply of water was encountered. The liquid tasted bitter, however, and was not regarded as suitable for drinking purposes. It was so far to any other supply of water, however, that during dry spells Judge Lynch was forced to use the mineral water. Soon thereafter, according to Yeager, he recovered entirely from his rheumatic affliction and became thoroughly convinced that the cure was due to the mineral water. The news of the cure spread, and many afflicted persons came to the well. A city of tents sprang up, cures were reported, and other wells were drilled. In 1881, Judge Lynch laid out the original townsite of Mineral Wells, and a village of health seekers sprang up. The original well was equipped with a well-head in the shape of a triangular box, having a wooden reel for the well rope, an elevated pulley, and a wooden bucket. In 1885, a small house was built over the well, having a porch or gallery on one side and an enclosed room with window and door on the other. The name "Crazy Well" was prominently inscribed on the roof.

---

[99]Yeager, B. A., Early history of the founding of Mineral Wells. The Daily Index, Mineral Wells p. 10, January 30, 1929.

The name "Crazy Well" is said[100] to have its origin in the effect of its waters upon a crazy woman. In 1884, Dr. C. F. Yeager, pioneer physician of Mineral Wells, had a patient who was suffering from mental disorders. She used to sit in the shade of the trees near one of the original wells and drink the water when it was brought to her. Children at school nearby pointed her out as "the crazy woman" and dubbed the well near which she sat daily the "crazy woman well." After some weeks the woman improved in health and departed. The well continued to be referred to, especially by the children, as the "crazy woman well" and then "crazy well." Soon the significance of the name was expanded to denote the waters from the well and later was applied to a drinking pavilion built about the well in 1895, and finally to the Crazy Hotel, erected in 1910. The hotel was destroyed by fire in 1924 and replaced in 1926 by the present Crazy Hotel and Pavilion, one of the leading resort hotels of the State.

The Crazy Water Company, a subsidiary of the Crazy Hotel Company, was organized in 1926. This company built a large dehydrating plant and bottling works and now employs more than sixty workers and a trained chemist. The capacity of the plant is about 25,000 gallons of water per day, which will make about 1600 pounds of crystals. The company in 1929 shipped about 1500 cases of one-half gallon bottles and about 1500 bottles of five-gallon carboys per month. At present (1933) it markets less water and does a larger business in crystals.

The Crazy Water Company was by no means the only concern developing this extensive mineral water industry. In the 90's Col. W. R. Austin drilled the Austin well located in the north edge of the town (Pl. VI). In 1900 W. T. Sims purchased an interest in the well, and after the death of Col. Austin in 1913 Mr. Sims took over the entire management.

In 1893, the following wells are reported to have been in operation:

---

[100]Yeager, Dr. Bob, Authentic version of origin of Crazy Water: The Daily Index, Mineral Wells, p. 12, January 30, 1929.

Well	Date	Map No.	Depth *Feet*	Type of well
Wells recorded by Cutter[101]—				
Austin	1890	15	165	Drilled
Crazy	1892	6	170	Dug
Gibson	1886	8	130	Dug
Lynch	1879	--	110	Partly dug
Palo Pinto	------	7	172	Drilled
Johnson	------	---	160	Drilled
Star	------	3	120	Dug
Lamar	------	80	------	------
Bitter	1883	----	------	------
East Mountain[102]	------	77	168	Dug
French	------	77	168	Dug
Central Hotel	------	79	------	------
Other wells not recorded by Cutter—				
Sangcura	------	11	157	Dug
Browns	------	81	128	Dug
Cicero Smith	------	82	160	Dug

The first mineral crystals were made, according to Richards,[103] in 1883 by Mr. Dynkle from water from the Bitter well at the old Piedmont Hotel. Mr. Austin made crystals from the Austin well in the early 90's, and they have been continuously manufactured to the present time.

In 1899, J. G. Ford started operations in the southeast part of town and became interested in manufacturing mineral crystals from the water. He constructed a vat, pumped the water into it, and concentrated it by evaporation over a wood fire. In this way be made the white crystals at the rate of about 15 pounds per day. A few years later Ford sold out to W. T. Loveless, who organized the Loveless Mineral Water Company. At present (1933) Mr. Loveless operates seven wells and uses all the water for making crystals.

The Famous Mineral Water Company has operated its wells for twenty-one years. Their first wells were drilled in 1912 on the west side of town near the present Lake Pinto (Pl. VI). At present

[101]Cutter, Charles, Cutter's Guide to Mineral Wells, the Great Health Resort. 1893.

[102]East Mountain and French wells are said to have been the same well.

[103]Richards, Frank, personal communication.

(1933) thirteen wells are operated by this company in the same area. Each well has had an initial production of 20 to 25 gallons of water in about one and one-half hours. The natural water is retailed at the Dameron Hotel: a concentrated water is marketed as Dismuke's Pronto-Lax, and the crystals as Dismuke's Famous Mineral Crystals.

The Carlsbad Water Company was another early company that helped to develop the sale of Mineral Wells water since 1903. This company has four wells near the center of town, and a drinking pavilion on the corner of Northwest First Avenue and Northwest Fourth Street. It markets Palo Pinto Mineral Water, Palo Pinto Concentrate, and Palo Pinto Crystals.

The Baker Hotel Water Company is a more recent organization for the large-scale production and marketing of mineral water. In 1929, the Baker Hotel Company erected a splendid new 250-room resort hotel and in connection with the hotel established a water company known as the Mineral Wells Water Company. Wells were drilled along the east side of Lake Pinto in the west edge of town, near the hotel on the south end of East Mountain, and in the east part of town (Pl. VI). The water is pumped from the wells to treating tanks where bacteria are killed and sediment removed. It is then piped to glass-lined storage tanks of 1500 gallons capacity, and from these storage tanks it runs by gravity to the hotel and to the bottling plant. The company has also a thoroughly modern dehydrating plant on the east edge of Lake Pinto, where the water is evaporated in Monel Metal pans for crystals. One pound of crystals is made from about 15 gallons of water. The company in 1929 handled 330 cases containing 12 half-gallon bottles of natural mineral water each month. In 1932, the Baker Hotel transferred its interest in the water company to D. A. Upham.

The concerns that are handling mineral water and crystals are shown in the following list:

Companies producing mineral water and crystals in the Mineral Wells area in 1933.

Company	Location	No. of wells	No. of evaporating units
Crazy Well Water Co. (east plant)	Sam Houston Ave., Pasadena Heights		36
Crazy Well Water Co. (west plant)	NW. Second Ave. and NW. Ninth St.	11	4
Famous Mineral Water Co. (Leon Dismuke)	East shore of Lake Pinto	——	——
Mineral Wells Water Co. (Bakerwell Products) (D. A. Upham)	East shore of Lake Pinto	50–60	
Mineral Valley Water Co. (Nature's Crystals) (R. S. Luke & Veda Weatherly)	NW. Second Ave. and NW. Twelfth St.	11	1
Crystone Co. (Frank E. Miller) (Formerly Texas Crystal Co.)	NW. Third Ave. and NW. Seventeenth St.	3[a]	4
Peerless Mineral Water and Crystal Co. (Ed. Owen)	Country Club road	4	2
Austin Well (W. T. Sims)	NW. Second Ave. and NW. Ninth St.	4	2
Loveless Mineral Water Co. (W. T. Loveless)	¼ mi. NE. of Pasadena Heights	6[b]	8
Richards Crystal Co. (Frank Richards)	NW. Second Ave. and NW. Eighth St.	4[c]	0
Hester, M. W.	NW. Second Ave. and NW. Ninth St.	8[d]	0
Bloodworth	Millsap road	2	1
R. T. Jones	NW. Third Ave. and NW. Tenth St.	6 ?[d]	0
Mineral Wells Crystal Producers (H. S. Cholson, L. D. Parks, C. V. Fletcher)	N. Oak Ave. and NW. Seventh St.	5	2
Buckhead Crystal Co. (Buckhead Crystals)	Buckhead Bath House, N. Oak. Ave. near Second St.	0	0
Mineral Crystal Water Co. (J. B. Thomas)	Star Bath House, N. Oak Ave. near NE. Third St.	14[e]	0
Ponce de Leon Crystal Co. (Gregg) (Sales Co.[f])		0	0
Dependable Crystal Co. (Charles Hatfield & Leo Reinhart)	N. Oak Ave. and NW. Ninth St.	2	1
Health Mineral Crystal Co. (A. C. Horn, Harry Burton, J. C. Joplin, T. B. Spencer)	West edge of Parker Co. on Millsap-Brazos road	4	2
Bloodworth Crystals Co. (J. D. Wallser)	Oran[b]	——	—
Garrison, Bob	Oran	——	—
Mineral Water Corp.[g] (Bendick, Scott Emerson, and C. B. Baughn)		?	?
Sunshine Crystal Co. (R. R. Bossier)	East edge Palo Pinto Co. on Millsap-Brazos road	2	3

[a]In addition water is purchased from Frank Richard's wells.
[b]Now closed down and partly demolished.
[c]Water is sold to Crystone plant.
[d]Water is sold to Famous plant.
[e]Sell crystals from Mineral Wells crystal producers.
[f]Purchases crystals from Oran.
[g]Buys crystals from D. A. Upham.

Geology.—The sands carrying the mineral waters are in the Mineral Wells and Garner formations of upper Strawn age. A composite section of the beds below the surface at Mineral Wells is given below and is shown graphically in the cross-section, Plate VI.

Generalized geologic section penetrated in wells drilled for water in the town of Mineral Wells.

	Depth *Feet*	Thickness *Feet*
Mineral Wells formation—		
East Mountain shale member—		
9. Shale, brown, soft	0–48	48
8. Shale, dark blue, soft	48–65	17
7. Shale, light blue, soft	65–120	65
6. Shale, gray, calcareous	120–121	1
5. Shale, light blue	121–165	44
4. Clay, yellowish gray	165–170	5
3. Hog Mountain sand lentil—		
b. Sand, gray, hard	170–172	2
a. Sand, light gray, medium grained, containing mineral water near Lake Pinto and in the town of Mineral Wells	172–205	33
2. Shale, dark blue and black, soft	205–274	69
Garner formation—		
Brazos River sandstone member—		
1. Sand, light gray, containing mineral water in the eastern part of Mineral Wells	274–304	30

The wells in the east side of town start at the surface on beds No. 4 to No. 6 of the above section and reach the mineral water at depths from 117 to 200 feet in the Brazos River sandstone (Pl. VI). The wells in the center and on the north side of the town produce from either the Hog Mountain or the Brazos River sand, depending on the depths of the wells. The wells west of town near Lake Pinto start on bed No. 10 and reach mineral water in the Hog Mountain sand at depths of about 175 feet (Pl. VI).

The Brazos River sandstone member in its outcrop comprises three divisions:

3. Ripple-marked, cross-bedded, coarse sand composed of alluvial and tan-colored deposits with layers and lentils of coarse conglomerate. This body is about 20 feet thick. Mineralized water.
2 Well-bedded shale about 10 feet in thickness.

1. Rather uniformly textured sandstone of finer grain than the upper sandstone and conglomerate body. A few marine fossils are present in these layers. Thickness about 25 feet. Fresh water.

The several complex layers of the Brazos River sandstone grade northwestward beneath the surface into much finer grained, more uniformly textured, and more evenly bedded quartz sands.

The grains in the upper sandstone division comprise 90 per cent quartz, 5 per cent chert, and 5 per cent dark ferro-magnesian minerals. The grains average 0.248 mm. in size and have the following size range measured with standard screens:

Screen analysis[104] *of upper division of Brazos River sandstone northwest of Millsap.*

Size in mm. On	Size in mm. Through	Weight in grams	Per cent
0.250	0.42	197.60	39.72
0.177	0.250	238.90	47.78
0.149	0.177	18.40	3.68
0.125	0.149	16.80	3.36
0.074	0.125	6.70	1.34
pan	0.074	20.20	4.04

Screen analysis[105] *of lower division of Brazos River sandstone northwest of Millsap.*

Size in mm. On	Size in mm. Through	Weight in grams	Per cent
0.250	0.42	26.20	5.24
0.177	0.250	120.70	24.14
0.149	0.177	67.70	13.54
0.125	0.149	154.10	30.82
0.074	0.125	77.80	15.56
pan	0.074	51.60	10.32

The outcropping Hog Mountain sand, which forms a distinct topographic bench and caps mesas south and southeast of Mineral Wells, is a medium-grained, impure quartz sand more or less cemented by calcite. Beneath the surface the sand is a medium- to fine-grained quartz sand about 20 feet in thickness. The thickness, however, varies considerably from well to well, and the sand appears to be less persistent than the Brazos River sand below.

[104] Analysis by T. H. Shelby, Jr.
[105] Analysis by T. H. Shelby, Jr.

The size range of the grains, measured with standard screens, is as follows:

Screen analysis[106] of Hog Mountain sand east of Mineral Wells.

Size in mm. On	Through	Weight in grams	Per cent
0.250	0.42	85.30	17.06
0.177	0.250	282.70	56.54
0.149	0.177	42.60	8.52
0.125	0.149	49.20	9.84
0.074	0.125	20.80	4.16
pan	0.074	18.40	3.63

These water sands, both in outcrop and in well sections, contain in places heavy impregnations of mineral water. During dry intervals the salts can be seen crystallizing out of the sand on exposed ledges at a number of places along the outcrop. The condition is not uniformly continuous, but rather more or less spotted, and it occurs where the mineral waters happen to be most concentrated in the sand. The same characteristics are observed in the subsurface waters. In places the sands contain strongly mineralized water, as in the Loveless and Crazy Water Company wells in the eastern part of Mineral Wells. A quarter of a mile away in the same sand the water contains much less mineral matter. Because of this irregular mineralization, it is never certain just what type of, or how concentrated, a mineral water will be obtained until the hole is finished and chemical tests are made of the water.

Chemical composition.--The chemical character of the waters of the Mineral Wells district is based on about forty chemical analyses. Twenty-three of these were made by Virgil E. Barnes, working as research fellow for the American Petroleum Institute in the laboratories of the Bureau of Economic Geology. The others were made by E. C. Sargent, chemist for the State Highway Department, and by various chemists working in the Division of Chemistry of the Bureau of Economic Geology, now the Bureau of Industrial Chemistry.[107] The results of the analyses can be discussed best by classifying them according to the sand from which they are derived, as follows:

---

[106]Analysis by T. H. Shelby, Jr.

[107]Schoch, E. P., Chemical analyses of Texas rocks and minerals: Univ. Texas Bull. 1814, pp. 224-225, 1918.

3. Hog Mountain water sand.
2. Upper water sand of Brazos River sandstone.
1. Lower water sand of Brazos River sandstone.

The stratigraphic occurrence of these waters and their relationship to surrounding sediments is shown in the section, Plate VI.

The Hog Mountain sandstone water is the shallowest of the mineral waters. It produces characteristically in the Baker and Famous wells located just east of Lake Pinto in the western part of the town of Mineral Wells (Pl. VI). The composition of the water is known from analyses presented in Table 18.

The analyses show that the waters are high in sodium, magnesium, and sulphates. It is probably the presence of the calcium, magnesium, and sulphate ions in the form of Glauber salt (hydrous sodium sulphate) and Epsom salt (hydrous magnesium sulphate) that give the therapeutic properties to these waters. The mineral salts are not present in so large quantities in the Hog Mountain sand as in some areas in the deeper water sands. For this reason the water from the Hog Mountain sand is not so desirable for making crystals as is that from the Brazos River sand. A comparison of the compositions of waters from the three sands is shown in figure 17.

The upper part of the Brazos River sandstone furnishes the water for the largest number of mineral-water wells. It is especially productive in the center and just east and north of the town (Pl. VI). At a distance of two to four miles east of Mineral Wells the water is shallower and is much less mineralized. West and northwest of the town the Brazos River sand is too deep and too thin to be developed economically. The mineralization of the water varies considerably from well to well, especially in wells far apart. The most concentrated water appears to be close to the town.

The chemical composition of the water from the upper part of the Brazos River sandstone has been determined from about thirty-five samples, as shown in Table 19.

TABLE 18.—*Analyses of waters from Hog Mountain sand.*

Chemical composition

(In milligrams per liter)

OWNER	MAP No.	LOCATION	Ca	Mg	Na	Cl	SO_4	HCO_3	SOLIDS	DEPTH *Feet*	CHEMIST
Bakerwell Co.	19	E. of Lake Pinto	66	39	1663	255	3087	454	5564	175	V. E. Barnes
Do.	19a	Do.	246	233	1016	182	2981	516	5174	175	Do.
Gibson	8	Center of town	—	—	—	—	—	—	4085	130	E. P. Schoch
Sangcura Co.	11	Do.	—	—	—	—	—		4804	151	Do.
Taylor	21	E. side of town	287	193	2266	1630	3742	301	8419	117	V. E. Barnes
City Park	20	W. edge of town	41	17	1194	339	1753	570	—	160	E. C. Sargent

Percentage-reaction values

OWNER	MAP No.	LOCATION	Ca	Mg	Na	Cl	SO_4	HCO_3
Bakerwell Co.	19	E. of Lake Pinto	2.09	2.03	45.88	4.57	40.74	4.69
Do.	19a	Do.	8.13	12.63	29.24	3.37	41.01	5.62
Taylor	21	E. side of town	5.5	6.1	39.3	17.9	30.3	1.9

Properties

OWNER	MAP No.	LOCATION	PRIMARY SALINITY	SECONDARY SALINITY	PRIMARY ALKALINITY	SECONDARY ALKALINITY
Bakerwell Co.	19	E. of Lake Pinto	90.62	0.0	1.14	8.24
Do.	19a	Do.	58.48	30.28	0.0	11.24

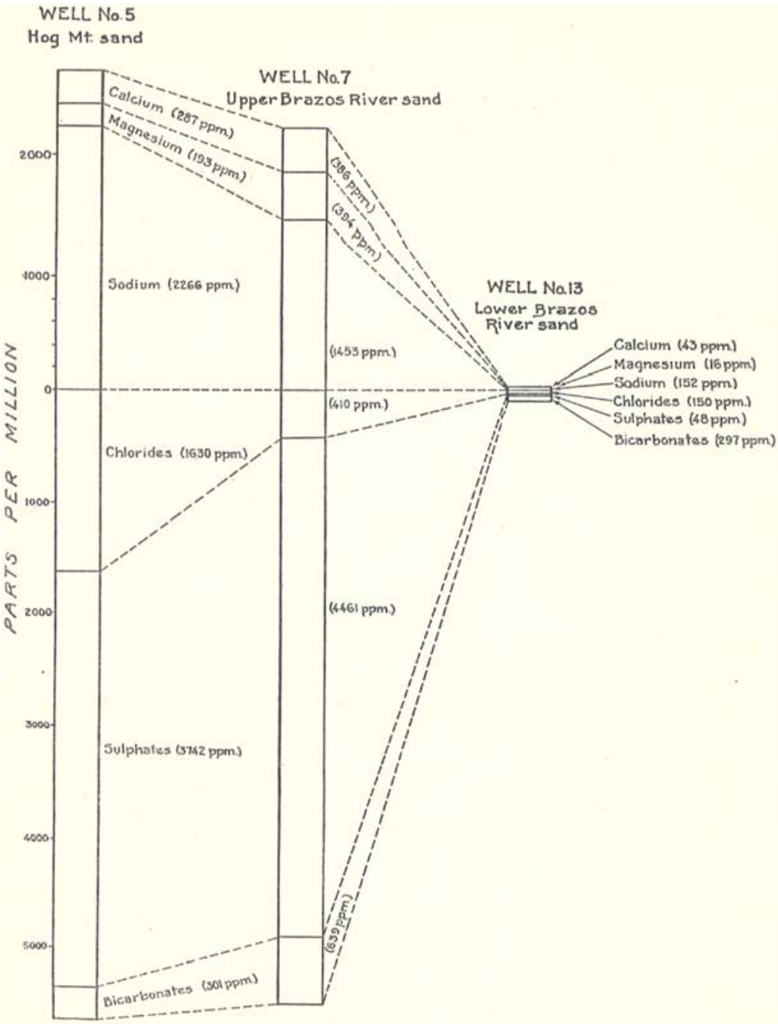


FIG. 17.—Graph showing the composition of mineral waters from the Hog Mountain sand and from the upper and lower water-bearing beds of the Brazos River sandstone. (Compiled by E. C. Sargent.)

The deep sand in the lower portion of the Brazos River sandstone member furnishes the least-mineralized water of the sands in the Mineral Wells district. It contains less than 200 parts of chlorine and less than 100 parts of sulphate per million, as compared with

TABLE 19.—*Analyses of waters from the upper part of the Brazos River sandstone.*

WELL	MAP No.	LOCATION	Ca	Mg	Na	Cl	SO_4	HCO_3	SOLIDS	DEPTH *Feet*	CHEMIST
			Chemical composition (In milligrams per liter)								
Loveless	22	E. side of town	202	89	2338	840	4306	357	8132	218	V. E. Barnes
Crazy Water Co.	23	Do.	386	394	1453	410	4461	639	7743	219	V. E. Barnes
Baker Water Co.	32	NW. 2nd Ave. between 12th and 13th Sts.	103	62	2041	997	3075	423	6701		V. E. Barnes
Crazy Water Co.	6	N. of Crazy Hotel	108	77	1836	434	3465	445	6365	170	V. E. Barnes
Do.	14	Old well at Crazy water crystals plant	270	256	868	271	2720	490	4850	218	V. E. Barnes
Do.	30	1 Blk. N. of Crazy water crystals plant	182	172	1074	128	2917	344	4817	----	V. E. Barnes
			Percentage-reaction values								
Loveless	22	E. side of town	4.5	3.1	42.6	9.9	37.9	2.5			
Crazy Water Co.	23	Do.	8.4	14.1	27.5	5.1	40.5	4.6			
Baker well	32	NW. 2nd Ave. between 12th and 13th Sts.	2.6	2.6	44.9	14.2	32.3	3.5			
Crazy Water Co.	6	N. of Crazy Hotel	2.9	3.4	43.6	6.7	39.4	4.0			
Do.	14	Old well at Crazy water crystals plant	9.7	14.5	26.1	5.2	39.0	5.5			
Do.	30	1 Blk. N. of Crazy water crystals plant	6.5	10.1	33.4	2.6	43.1	4.0			

over 300 parts of chlorine and more than 2000 parts of sulphate per million for water from the upper part of the Brazos River sandstone. It is a good drinking water and furnished a supply for the town of Mineral Wells until a modern water supply was obtained from a large lake constructed in Rock Creek valley in the eastern edge of Parker County. Analyses of water from the deep sand are offered in Table 20.

Method of production.—Water was produced in the early days from the mineral-water wells by buckets, windless bailers, pulleys, and various types of hand-operated pumps. The Austin well was pumped for many years by a blind horse that traveled in a circle turning a reel. At present most of the productive wells are pumped by short-stroke, ball-and-socket suction pumps with half-inch rods pulled by a 4- or 6-inch crank geared to a drive shaft of one-half horse power electric motor (fig. 18-A). The wells are cased to the top of the sand with 6⅝-inch casing, which in most wells is not cemented. A square or rectangular block of concrete is poured about the casing-head to form a foundation for the pumping equipment. Two-inch galvanized tubing perforated at the bottom is run to the bottom of the hole. Then a 6⅝-inch Axtell No. 3 flange head is attached to the tubing and screwed into the casing-head. To the top part of the flange a 2-inch galvanized nipple is attached with a stuffing box, polished rod, and pump connections. The electric motor, crank, and gears are mounted on the concrete block at the well head. Many of the wells drilled on town lots are spaced 20 feet apart and pumped in units of two or four wells. The pump cranks are attached directly to a horizontal drive shaft worked by a pulley by means of a band wheel powered by an electric motor. Most of the motors are operated by a time switch, so that wells pump thirty minutes and are off for an hour to allow the water to flow into the well from the sand. The water is pumped directly into galvanized-iron flow tanks of 50- to 100-barrel capacity, from where it flows by gravity or is pumped to the crystal plants. The water for drinking purposes goes into treating tanks where it is treated with chlorine to kill all bacteria. The water for the Baker Hotel is stored in glass-lined tanks in an especially constructed storage house. All water for the trade is transported and sold in glass bottles or glass carboys.

TABLE 20.—*Analyses of waters from the lower sand layer of the Brazos River sandstone.*

Chemical composition

(In milligrams per liter)

WELL	MAP No.	LOCATION	Ca	Mg	Na	Cl	SO_4	HCO_3	SOLIDS	DEPTH *Feet*	CHEMIST
Reliance Brick Co.	24	E. side of brick plant	20	18	177	116	88	309	728	308	V. E. Barnes
Crazy Water Co., deep well	83	Near center of town	43	16	152	150	48	297	706	400	V. E. Barnes
Country Club	25	2 mi. E. of town	25	13	139	58	63	332	630	160	V. E. Barnes
Gibson deep well	9	Near center of town	--	--		--	-		664	387	W. T. Reed
Webster farm		4½ mi. SE. of town	224	26	434	808	261	305	2077	80	V. E. Barnes
Metz Bros. camp		Highway No. 1, 4½ mi. SE. of town	119	30	43	142	119	232	685	54	V. E. Barnes
Do.		Do.	96	18	39	125	67	188	533	52	V. E. Barnes

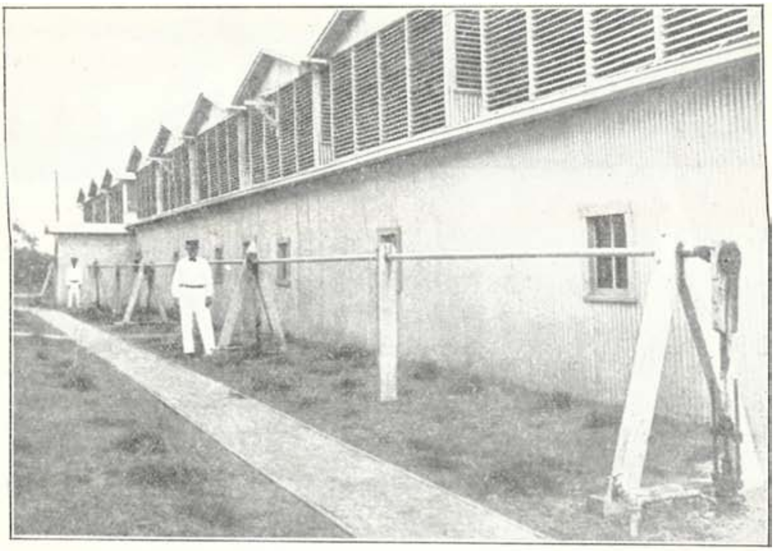
Percentage-reaction values

WELL	MAP No.	LOCATION	Ca	Mg	Na	Cl	SO_4	HCO_3
Reliance Brick Co.	24	E. side of brick plant	4.9	7.4	37.7	16.1	8.8	25.0
Crazy Water Co., deep plant	83	Near center of town	10.4	6.5	32.8	20.9	5.0	24.4
Country Club	25	2 mi. E. of town	7.2	6.6	36.5	9.6	7.8	32.4
Gibson deep well	9	Near center of town	17.1	3.2	28.9	34.8	8.3	7.7
Webster farm		4½ mi. SE. of town	28.6	12.1	9.2	19.4	12.1	18.3
Metz Bros. camp		Highway No. 1, 4½ mi. SE. of town	30.0	9.4	10.6	21.9	8.7	19.4

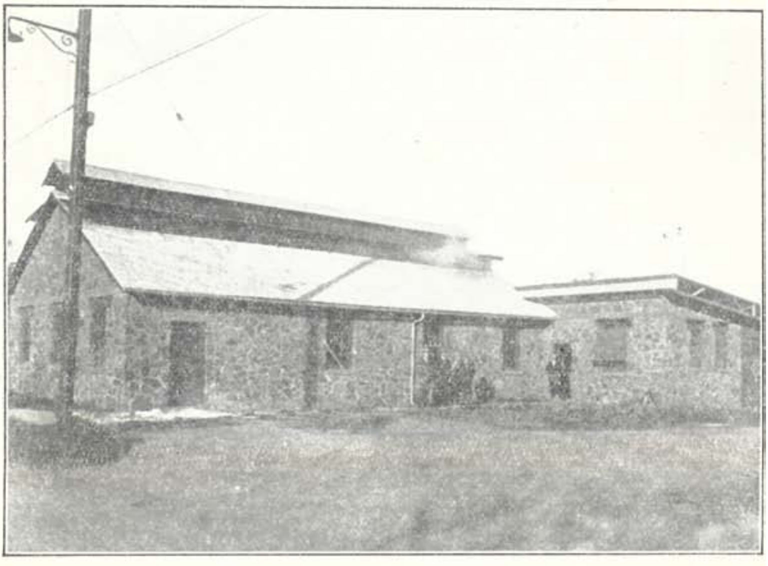
TABLE 21.—*Analyses*[a] *of mineral waters at Mineral Wells, in parts per million.*

WELL	ANALYSIS No.	DEPTH *Feet*	MAP No.	Ca	Mg	Na	Cl	SO_4	HCO_3	SOLIDS	CHEMIST
Austin well	2498	165	15	133.6	66.8	1549.2	354.2	2283.8	578.3	5653.7	W. T. Read, 1913
Gibson well	2499	130	8	333.8	372.5	1699.0	905.1	4166	592.5	8135.6	Do.
Indian well	2500	190	17	100.3	70.5	1611.5	340.8	3035.5	514.8	5865.9	Do.
Crazy well No. 2	2502	-	?	131.3	169.3	1050.7	639.8	1811.8	568.5	1891.8	Do.
Palo Pinto well	2503		13	103.0	97.5	1765.8	298.1	3162.4	524.6	6336.8	Do., 1915
O.K. or Sleepy Water, Lamar well	2504	120	36	61.4	60.02	175.75	140.6	311.0		1016.37	P. S. Tilson
Lamar well	2505	120	36	106.7	537.0	1588.95	375.0	4586	559.9	7666.05	F. B. Porter
Gibson well	2506	137	8	64.36	58.18	1379.1	243.8	2473.89	695.8	4955.49	J. R. Bailey
Do.	2508	137	8	107.2	29.69	1742.44	210.2	2948.09	--	5588.37	E. T. Dumble
Lamar white sulphur water	2511	112	36	207.3	223.0	1116.67	139.5	305.99		5340.51	T. S. Tilson
Gibson well	2513	137	8	223.3	163.0	1554.3	903.2	2687.3	648.5	6308.3	W. T. Read, 1912
Do.	2514	137	8	258.6	275.9	1243.1	494.4	3231.9	444.2	6027.9	J. R. Bailey, 1912
Do.	2515	137	8	88.6	60.5	1397.3	242.1	2494.7	691.7	5015.8	Do.
Carlsbad No. 1	2516	125	13	65.6	76.6	714.2	135.1	1348.9	550.0	2975.8	W. T. Read
Carlsbad No. 2	2517	125	13	69.7	74.6	645.0	127.6	1209.4	531.1	2745.7	Do.
Carlsbad No. 3	2518	150	?	172.4	155.6	1276.3	149.0	3197.8	370.9	5437.7	Do., 1912
Carlsbad No. 4	2519	170	?	125.8	101.2	1323.0	220.4	2792	449.3	5146.2	Do.
Crazy well	2521	170	?	153.8	167.5	643.6	490.2	1253.0	611.6	3502.1	W. T. Read
Do.	2522	170	?	129.6	169.6	1026.93	602.6	1810.0	570.0	4891.69	Do.
Do.	2523	170	?	148.6	154.0	1181.5	147.7	2857.19	462.1	5101.9	Do.
Do.	2524	170	?	81.46	63.98	1674.8	311.46	3206.5	434.99	5852.77	Do.
American well	2525	--	?	56.08	66.2	1212.5	191.6	2440.44	171.75	4660.17	(Company)

[a]Compiled from E. P. Schoch's paper in The University of Texas Bull. 1814, pp. 150-155, 224-225, 1918.



A



B

Fig. 18.—Views of mineral-water industry in Mineral Wells. A, Crazy water wells in Pasadena Heights, east side of the city. B, Crystone plant, in northwest part of the city. (Photographs by Young Studio, Mineral Wells.)

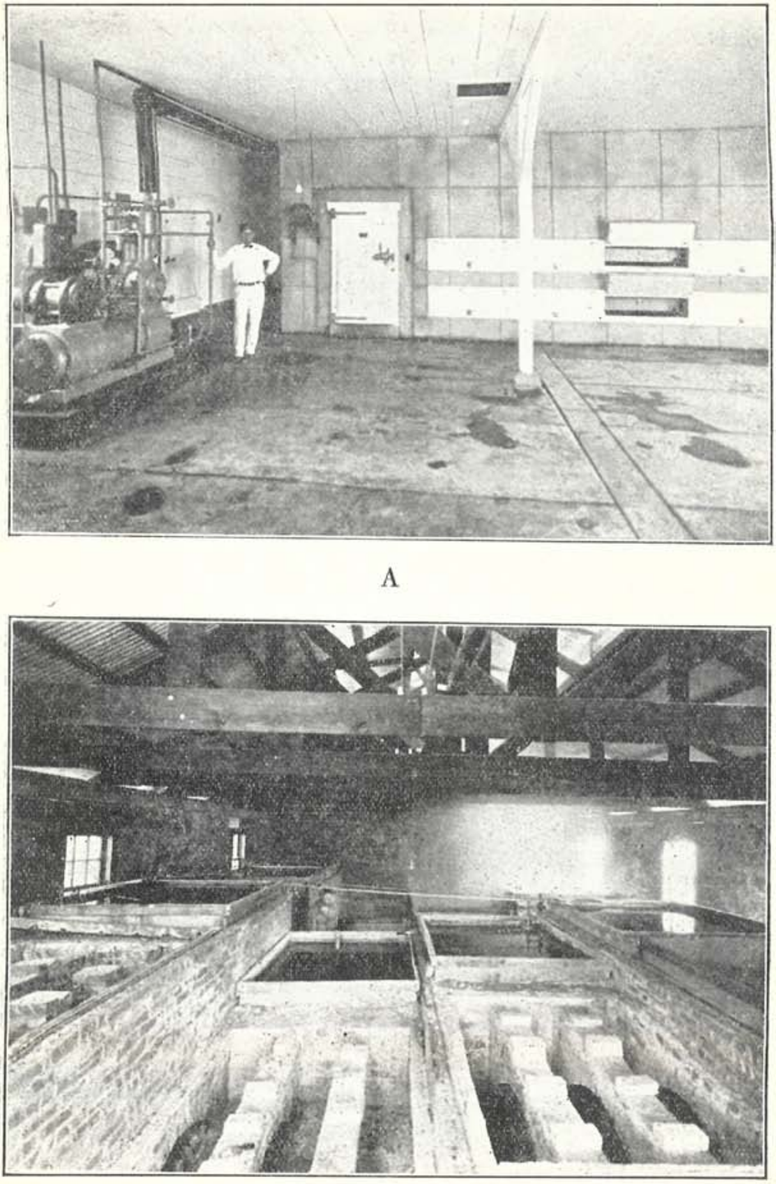
The manufacture of the mineral crystals from the water has become a leading industry. At least ten plants are in operation in or near the city. The water is evaporated in galvanized pans until it is reduced to a specific gravity of about 3.2. It is then removed and cooled in a refrigerator (fig. 19-A) at about 32° F. for about twelve hours or until crystals have formed. The mother liquor is then drained off and the crystals are dried by fans.

The evaporating pans are from 8 to 10 feet square and about 18 inches deep. These are set on fire-brick furnaces and arranged in batteries of three to the furnace. The battery is so arranged that No. 1 pan is above No. 2 and No. 2 is above No. 3, so that the water will flow by gravity from the first to the third during the process of evaporation (fig. 19-B). The flow of water into the tanks is controlled by flow valves. The furnaces are heated by natural gas except at the plants of the Crazy Water Co., where superheated steam pipes are used. The water boils strongly in pan No. 1, is kept at the boiling point in No. 2, and evaporates more slowly in No. 3 until the proper concentration is reached. The concentrate is drawn off from the last pan, filtered through a felt filter directly into a tank or pan in the refrigerating chamber, and is allowed to stand 24 hours at 32° F. The crystals are next drained and placed in a centrifuge, which removes the excess liquid. The crystals are then placed on cheesecloth stretched on a wooden frame where they are fanned by large electric fans or blowers for 24 hours or till they are dry. They are then packed in pound containers and sent to the shipping department.

The water wells have an initial production of 24 to 40 barrels per hour. but they decline rather rapidly to half this amount. The average old well produces from eight to nine barrels of water per hour,[108] or about 100 gallons per day. On the average, 15 gallons of water produce a pound of crystals. One well will make about 12 pounds of crystals per day. Two batteries of evaporating pans will take care of the water from six average old wells at a fuel cost of $130 per month and produce from 3500 to 4000 pounds of crystals,[109] and three men can operate the plant in 8-hour shifts. The cost of a two-battery unit varies from $1000 to $10,000, depending

[108]Personal communication, Mr. N. F. Sheppard, Aug., 1933

[109]Personal communication, W. T. Loveless, Aug., 1933



A

B

Fig. 19.—Views of: A, Refrigerating room for production of mineral crystals, Crazy Plant. B, Evaporating pans, Crystone Plant. (Photographs by Young Studio, Mineral Wells.)

upon the type of building, furnace, refrigerators, dryers, and other equipment. The cost of drilling in 1933 ranged from 60 to 80 cents per foot, and a well could be finished (cased and tubed) for about $250 to $300.

The efficiency of operations can be increased and cost of production lowered in a number of ways, as follows:

1. An accurate log of formations penetrated should be kept for each hole drilled.
2. Unless another water sand lies beneath the mineral-water sand, the hole should be drilled about 30 feet below the mineral-water layer and cased with old casing up to the bottom of the producing sand. Then the tubing should be run to the bottom of the hole and brass- or copper-perforated, or coarse, screen should be set from the bottom up to the top of the mineral-water sand. The pump should be set below the mineral-water sand, near the bottom of the hole.
3. The capacity of the pipe below the bottom of the water sand should be calculated. The production of water in each well should be carefully gauged by measuring the flow in the tank with a gauge stick and the pumping time adjusted so that the pumps operate as soon as the water has filled up in the pipe to the bottom of the mineral-water sand. The hydrostatic pressure in the Hog Mountain mineral-water sand is not over ten feet of water or 3.4 pounds per square inch. Therefore the flow into the casing stops as soon as water has filled up ten feet in the sand. A maximum flow is obtained if the head of water is kept below the mineral-water sand. The practise of pumping each well exactly 30 minutes, irrespective of its rate of flow, and of allowing each well to stand exactly 60 minutes without pumping is inefficient.
4. The wells should not be drilled closer than 200 feet apart. The practice of drilling 20 to 40 feet apart causes interference between wells and too rapid a depletion of the sand production.
5. The rate of evaporation, and hence the efficiency of the furnace, can be increased by gently sucking the steam away from the hot liquid with an inexpensive separator. The rate of evaporation can in this way be increased as much as 20 per cent.
6. The practise of firing directly on to the bottom of the pans shortens their period of usefulness. Two companies heat by steam coils. Steam heat requires more fuel consumption but allows more even temperature control and assures a longer life to pans. A disadvantage of steam coils is their tendency to become coated with lime carbonate from the water and to lose their

heating efficiency quickly. The carbonate has to be removed from the tubes after each run. One company uses Monel Metal instead of galvanized iron for the evaporating pans.

7. The crystals could be more efficiently dried on oscillating or rotating copper screens so constructed that they would drop the crystals gently and slowly from one screen to the next thus exposing all surfaces to the action of the air blast as the screen is moved.

Origin.—The mineral water in the sands at Mineral Wells is probably not connate water left in the sand at the time of deposition, like so many oil-field waters. In part, at least, the sands are land laid, as evidenced by the stream ripple marks and the plant remains. The sands were spread out on an almost flat-lying coastal plain, and in places were assorted by winds. Scattered over the sandy plain were small ponds and playa lakes or marshes that in drying up left deposits of sulphates, chlorides, and carbonates, so that small areas rich in salts are scattered over or in the sand. Later the sand and lake deposits were buried deeply beneath thick layers of clay. The overlying clay, and in places the sand, were impregnated with sulphates and to a less extent by chlorides left by evaporation of the water in the small playas and ponds of the ancient coastal plain.

Ground water that enters the sand bed at the outcrop has slowly migrated down dip and has probably replaced much of the original water in the sand. In migrating through the sand and in standing in the sand the water has dissolved the soluble salts. In those places where the salts are most concentrated, the water has dissolved most. The salts are not necessarily in the sand only. Some salts may be in the clay in contact with the sand, so that they are slowly absorbed or dissolved by the water that drains the sand deposit. The highly mineralized water is of restricted occurrence; furthermore, in the same water sand the distribution of the mineral water is far from uniform. This is clearly shown by the table of water analyses and by the diagrams, figure 20. These diagrams present graphically the concentration of sulphates and chlorides in water from the upper Brazos River sand in wells arranged along an east-west line across the sand layer.

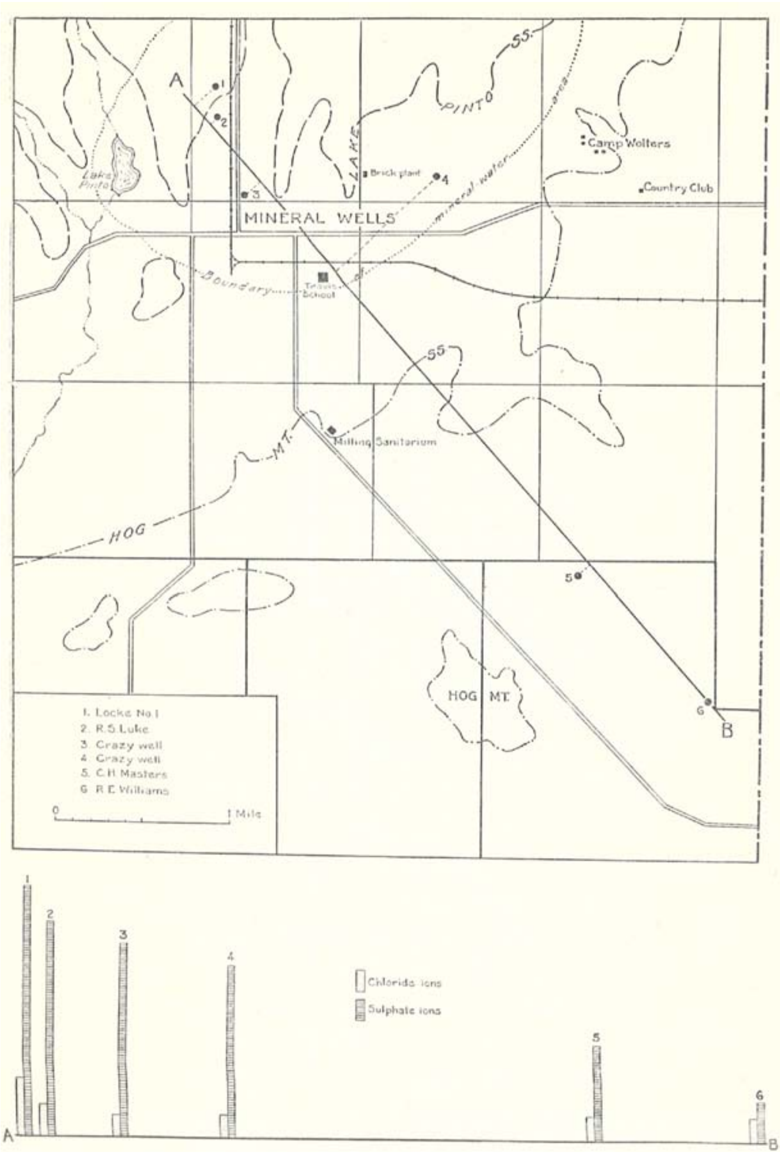


FIG. 20.—Graphic presentation of the concentration of sulphates and chlorides in waters from wells arranged along line A-B and along the dip of the Brazos River sand. (Adapted from map in U. S. Geol. Survey Cir. 6, 1934.)

Future supply of mineral water.—If the water seeps into the sand body at the surface, migrates down dip to the wells, and absorbs and dissolves soluble mineral matter as it travels or after it comes to rest, theoretically the supply of mineral water should last indefinitely, unless it is removed faster than new water enters. Unfortunately, the movement of ground water is very slow. The rate of movement depends upon the permeability of the sand and the hydrostatic head of the water. For conditions like those at Mineral Wells, where both permeability and water head are comparatively low, water probably does not seep faster into a six-inch hole of an old well than 5 barrels per day per foot of water sand penetrated. If wells are pumped faster than this, they will pump dry. Also, since the water movement is slow, since there is very little movement from one part of the reservoir to another, and since the mineral matter is concentrated in certain spots, rapid and continuous removal of water over an extended period weakens and exhausts the supply of mineral water just as oil and gas are exhausted in an oil pool.

The supply of underground water can be calculated by two methods—(1) porosity method, and (2) production-decline method. The porosity method consists of determining experimentally the percentage of porosity of a small core or in several cores of the sand, of calculating the volume of the water-bearing sand body from an estimation of the average thickness and geographic extent, and by multiplying the percentage by the volume. This is not accurate, because the porosity and thickness of the sand body vary and the water removed is continuously replaced by other water, some of which may be mineralized. The production-decline method consists of measuring the daily decline in mineral content per barrel of water calculating the percentage decline each month or each six months, and from this estimating the date when operation of the well will no longer be remunerative.

The rate of decline in mineral content depends upon the permeability of the sand and the rate of removal of the water. In the old part of the field, where the wells are drilled close together, the initial production is about 10 barrels per hour, but in a few weeks it declines to 4 or 5 barrels per hour and produces at this rate for two or three years, when it has to be cleaned out or worked over. In some parts of the field the mineral content of the water decreases as pumping continues. This is particularly true of the edges of the producing field. It is due to the replacement of the mineral waters by less mineralized water that has migrated into the well from adjacent areas. The water may move laterally from less mineralized areas in the same sand. Under such conditions the change is gradual, and no abrupt change in the amount of water pumped daily or in the hydrostatic head of the water in the well takes place. The water may migrate vertically from a shallower or a deeper sand, which has been penetrated in drilling and was not properly cemented off. Under such conditions the change is more likely to be abrupt, and the hydrostatic head of water in the hole rises. The fresh-water sands in general have a greater permeability and higher hydrostatic pressure than sands carrying mineral water.

If the production of a well increases, and the percentage of mineral matter decreases abruptly, a cement plug should be set in the bottom to shut off the bottom water. If the well continues to produce fresh water after cementing, it is probable that the mineral supply is exhausted, and nothing can be done.

So far, about one square mile of mineral-bearing water has been developed in the Mineral Wells area from the upper water sand of the Brazos River member. The mineral-water-bearing sand averages about 10 feet in thickness and has an average porosity of 20 per cent. About one-half of its water is recoverable before it becomes too dilute from incoming water to produce crystals. Ten feet of saturated sand covering one square mile and having a porosity of 20 per cent under the above conditions yields 1280 acre-feet of water equal to 10,000,000 barrels from the upper sand of the Brazos River member. The Hog Mountain sand probably has an equal amount, but the water is somewhat less mineralized and the mineral content of the water appears to decline somewhat more rapidly.

As the production declines, the mineral supply can be replaced by opening up new producing areas. There are two good possibilities for new mineral-water development, as follows: (1) along the strike of the water sand to the northeast and southwest of Mineral Wells where the mineral-water sand can be reached at about the same depth as in Mineral Wells, (2) in deeper sands in the Millsap Lake formation below the Goen limestone in the area along the Palo

Pinto-Parker county line southeast of Mineral Wells. Already this lower sand has been developed by shallow wells three miles west of Millsap in Parker County, and two mineral crystals plants are now in operation in Parker County.

COAL[110]

OCCURRENCE

Coal occurs in at least four zones in the geologic section in Palo Pinto County, as follows:

4. Dalton coal, near the middle of the Graford formation on Dalton ranch southwest of Graford. This deposit has not been developed.
3. Abbott coal, in the Brazos River sandstone on the F. H. Abbott farm southeast of Mineral Wells. It has been prospected but not developed.
2. Thurber coal, at the base of the Garner formation at Thurber, Strawn, Coalville, and Rock Creek. It has been mined extensively in the past, but at present only one mine is in operation.
1. Sunday Creek coal, near the top of the Millsap Lake formation, along Sunday Creek, south and southeast of Santo.

DALTON COAL

The Dalton coal bed outcrops along the Merriman limestone escarpment on Dalton Ranch west and southwest of the town of Dalton at a point about 150 to 160 feet below the top of the escarpment. The layer has been traced only from outcrops in headwaters

[110]*Literature.*—Phillips, W. B., The coal, lignite and asphalt rocks of Texas: Western Soc. Eng. Jour., vol. 9, pp. 571–592, 1904. Phillips, W. B., Worrell, S. H., and Phillips, D. M., The composition of Texas coals and lignites and the use of producer gas in Texas: Univ. Texas Bull. 189 (Sci. ser. 19), pp. 5–36, 1911. Phillips, W. B., and Worrell, S. H., The fuels used in Texas: Univ. Texas Bull. 307, pp. 9–55, 1913. Phillips, W. B., The Texas coal industry: Eng. Min. Jour., vol. 91, p. 1067, 1911. Schoch, E. P., Chemical analyses of Texas rocks and minerals: Univ. Texas Bull. 1814, pp. 75–95, 1918. Cummins, W. F., The southern border of the central coal field: Texas Geol. Survey First Ann. Rept., pp. 143–182, 1890; Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., pp. 436–441, 519–534, 1891. Ashburner, C. A., Brazos coal field, Texas: Trans. Am. Inst. Min. Met. Eng., vol. 9, pp. 459–506, 1881; Eng. Min. Jour., vol. 32, pp. 72–73, 89–90, 1881. Taff, J. A., The southwestern coal field: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 3, pp. 402–409, 1902. Wentzel, R. H., The coal fields of Texas: Ohio Min. Jour., vol. 19, pp. 98–103, 1890; (Abst.) Eng. Min. Jour., vol. 50, pp. 211–216, 1890. Fuller, Myron L., Relation of oil to carbon ratios of Pennsylvanian coals in north Texas: Econ. Geol., vol. 14, pp. 536–542, 1919. Bement, A., Illinois coals: Ill. State Geol. Survey Bull. 56, pp. 1–112, 1929. Moore, Elwood S., Coal: John Wiley & Sons, pp. 1–462, New York, 1922. Cady, G. H., Coal resources of District I (Longwall), Illinois: Ill. State Geol. Survey Bull. 10, pp. 1–149, 1915. Zern, E. N., Coal Miner's Pocketbook: McGraw-Hill Book Co., New York, pp. 1–1273, 1928.

of small branches of Valley Creek one mile southwest of Dalton, southward and westward along the escarpment to the northwest corner of the S. P. R .R. Co. Survey, section 1, A-419, a distance of less than four miles (Pl. II). The outcrop, however, is everywhere covered by talus from the Merriman limestone cliffs, except in a few places where the detritus is removed by branch streams. It is probable that the coal extends much farther, since it is well developed at each end of its outcrop. The best exposure is 210 feet long in a small branch just northeast of the northwest corner of the D. B. Brooks Survey, A-46 (Pl. II). The coal is black, soft, much weathered, and in the outcrop it is breaking down into thin, fissile fragments that show abundant impressions and fragments of stems and roots of coal plants, and some ferruginous coal balls. In one locality a complete stump of an ancient tree was exposed in the coal. The thickness of the coal at its northernmost exposure is 9 feet 8 inches. It rests directly upon an uneven surface of hard, impure, gritty, fossiliferous limestone and is overlain by soft, thin-bedded, marine shale. A section of the outcrop measured in the headwaters of a small branch one mile southwest of Dalton and about 800 feet northeast of the northwest corner of the D. B. Brooks Survey is as follows:

Section of the Graford formation measured one mile southwest of Dalton.

	Thickness *Feet*
4. Shale, light gray, fine grained, silty, made up of paper-thin layers, and containing thin seams of limonite and fragments of small coal plant leaves. The upper part is covered by talus	10
3. Coal, black, thin bedded, brittle, weathering into small black fragments showing impressions of coal plants	9¾
2. Limestone, dark, brownish gray, thin bedded except in its upper 2 inches, containing great quantities of small crinoid fragments, and in its upper layer flat, water-worn pebbles of limestone	1½
1. Shale and marl, gray, soft, containing large numbers of limonite concretions. The lower part is covered by talus	20

The coal is the thickest bed in Palo Pinto County and, as far as can be judged from the poor, and deeply weathered outcrop, is of good quality. It has never been mined or explored with drill holes, so far as known. Mining will be difficult. It is exposed along so steep a slope that stripping will be impossible. It can be removed by drifts into the seam. The soft shale above, however, will probably furnish a very poor roof, and timbering will be expensive and difficult. The hard limestone underneath the coal will make undercutting difficult and expensive. It is probable, however, that if in the future fuel becomes sufficiently scarce, so that a demand for this remarkably thick deposit develops, a way to mine it successfully will be developed.

ABBOTT COAL

A coal seam of limited extent and of unknown quality occurs in the Brazos River sandstone along the upper part of the escarpment above the conglomerate layers five miles southeast of Mineral Wells. This has been referred to as the Abbott coal, because it outcrops in the Abbott pasture. The coal is black, soft, much weathered, impure, and poorly exposed. It has been prospected by drill holes. One drift has been run near the center of the south half of the Mahoney Survey, five miles southeast of Mineral Wells. The geologic section at the drift is as follows:

Section measured at the coal drift five miles southeast of Mineral Wells.

	Thickness *Feet*
5. Sandstone, dark brownish gray, interbedded with thin layers of gray clay	45½
4. Coal, black, soft, impure	2⅕
3. Sandstone, reddish and brownish gray, cross bedded and of medium hardness, covered in most places by talus	16±
2. Shale, gray, calcareous	10±
1. Conglomerate, brownish gray, exposed along creek bank	20±

The coal was prospected between 1890 and 1900 at the time of the mining operations in the Rock Creek district of Parker County. At present (1933) the timbers are rotting away, the dump is nearly covered by vegetation, and it is impossible to examine the face of the coal. It is evident that mining operations were unsuccessful. The seam appears not to be so good as the Thurber or Dalton coal beds. The coal occurs between loose and more or less unconsolidated sandstone beds, so that mining operations are difficult, and it is doubtful whether the seam has much commercial value.

THURBER COAL

Extent.—The Thurber coal is of considerable economic importance and is the only one that has been developed commercially. Its outcrop in most places is obscured by talus and slope wash from the sandstone ledges of the Garner formation, which occur along the steep hillsides above the coal bed. It has been traced by means of shallow wells, drill holes, and a few exposures from Thurber northward to Mingus, thence northeastward along the northwest side of Palo Pinto Creek to the southern edge of the Johnson Ranch, from where it swings southward and passes west of Coalville to the E. P. Cowan Survey, one-half mile north of the Texas and Pacific Railway. From this survey the coal outcrop continues northeastward as far as Palo Pinto Creek on the Wm. Logan Survey. It has not been traced definitely northeast of this point. It has been recorded, however, in wells drilled near Lone Camp, and a thin streak of coal at the same stratigraphic position as the Thurber coal has been observed on the Mineral Wells-Millsap road five miles southeast of Mineral Wells. The coal outcrops along Rock Creek and Dry Creek in Parker County east of Mineral Wells. One of the best exposures of this coal in Palo Pinto County is on the south line of the John Bird Survey, one mile south of the Johnson ranch-house. Beneath the surface the coal has been traced in wells and drill records down dip to the northwest for a distance of eight or ten miles, where it pinches out. The extent of the coal beneath the surface, as recorded in wells, is given in Table 22.

History of development.—Coal was first mined extensively in the Brazos valley area on Rock Creek in Parker County about two miles east of the Palo Pinto-Parker county line. Cummins[111] records the following operations in 1890:

Coal in the west edge of Parker County.

Mine	Location	Thickness *Inches*	Date abandoned
Carson & Lewis[112]	NW. cor. sec. 359	18–26	About 1888
Lake[113]	SW. 1/4 sec. 359	18–26	1890
Johnson shaft	NE. 1/4 sec. 374		
Helms shaft	NW. 1/4 sec. 374		
Brown's mine	Center E. line sec. 7		

[111]Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., pp. 519-521, 1891.

[112]The coal was hauled to Weatherford in wagons and burned in the Carson and Lewis flour mills.

[113]The coal was hauled to Millsap and sold to the Texas and Pacific Railway to burn in their locomotives.

TABLE 22.—*Subsurface records of the Thurber coal in Palo Pinto County.*

Company	Well	Survey	Surface elevation *Feet*	Depth of coal *Feet*	Elevation of coal *Feet above sea level*
Britton et al.	Strawn Coal Co. No. 2	A. Ashworth	993	136	557
Britton & Ritchie	Strawn Coal Co. No. 1	A. Ashworth; 2.5 mi. NE. of Strawn	990.3	369	621.3
Do.	Strawn Coal Co. No. 4	A. Ashworth	1016	380–383	636
Do.	Strawn Coal Co. No. 3	A. Ashworth	1016	281–284	735
Do.	Strawn Coal Co. No. 6	A. Ashworth	992	305–307	687
Cousins & Wickens	Herbin No. 1	A. Ashworth	987	280	707
W. K. Gordon et al.	J. K. Williams No. 1	A. Ashworth	980	280–285	700
Palo Pinto Oil & Gas Co.	Strawn Coal Co.	A. Ashworth	-	280–282	696
Hoffman & Page	L. P. Strawn	H. Bird	-	405	
Palo Pinto Oil & Gas Co.	E. S. Britton No. 1	H. Bird Surv.	996	305	691
T. & P. Coal & Oil Co.	R. E. Colvard	H. Bird	998	375	326
Do.	T. & P. Coal & Oil Co. No. 1 Fee	H. Bird	-	365–375	--
F. L. Walker	M. S. Loftine Est. No. 1	H. Bird	992	365	627
Gordon & Britton	Johnson No. 1	John Bird, 10 mi. NE. of Strawn	--	238	764
R. H. Montgomery et al.	R. A. Crocker	J. Bird	--	80–81	813
J. G. Hamill	Howard No. 1	Jus. Dimpkins	--	91–93	--
T. & P. Coal & Oil Co.	Dyches C-31	Wm. Dyches	1095	475	620
Do.	Dyches C-32	Thos. Court	1082	460	622
Do.	Dyches-C-34	Wm. Dyches	1110	490	620
Do.	Fee No. C-33	Thos. Court	1082	480	602
Do.	Fee No. C-37	Wm. Dyches	1152	492–495	660
Rinear (owner)	Rinear Well No. 1	Howard Farm		93–95	
Rogers & Barber	Smart	Lone Camp district?	--	250	----
Do.	Smart	Lone Camp district	--	250–255[1]	----
Britton & Gordon	Strawn Coal Co. No. 2	I. Ryan	1031	400–405	631
Do.	Strawn Coal Co. No. 3	I. Ryan	1021	405–410	616
Burton & McKee Oil Corp.	Strawn Coal Co.	I. Ryan	1020	420	---
Burton & McKee & Gordon & Britton	Strawn Coal Co. No. 5	I. Ryan	1029	418–422	602
Gordon et al.	Newman No. 1	Sidney & Phillips	---	--	552
Britton & McKee	Strawn Merchandise Co	Strawn Townsite, Blk. 4	1003	410–412	592
Burton & McKee Oil Corp.	Vernon et al. No. 1	Strawn Townsite, lot 6, Blk. 16	997	392	605
Do.	Vernon et al.	Strawn Townsite, Blk. 16	997	392–395	605
Burton & McKee & Palo Pinto Oil & Gas Co.	Smith	Strawn Townsite, Blk. 2, lot 4, Woodlawn Add.	1012	418–420	594

R. F. Comcans & B. H. Pollard	J. E. Lucas et al. No. 1	Strawn Townsite, lot 23, Woodlawn Add.	--	395–400	----
C. F. Gibson	C. W. Watson et al.	Strawn Townsite, Woodlawn Add.	992	398–400	--
W. N. Gibson	R. E. Grounds	Strawn Townsite, James Add.	1012	430	582
J. B. Gordon et al.	Waston Bros.	Strawn Townsite, Woodlawn Add.	1004	380–382	624
Hoffman & Page	J. B. Hash	Strawn Townsite, NE. corner	994	375–377	619
Lucus & Gibson	Pollard No. 1	Strawn Townsite, Woodlawn Add.		398–400	---
Palo Pinto Oil & Gas Co.	C. E. Allen	Strawn Townsite, Blk. 20	997	382	614
Do.	C. Crooker	Strawn Townsite, Woodlawn Add.	985	382–385	603
Peters	W. L. Stephens	Strawn Townsite, Blk. 17	997	375–380	622
T. & P. Coal & Oil Co.	R. E. Colvard	Strawn Townsite, lot 33, Woodlawn Add.	998	377	621
Do.	Texas & Pacific Ry. Co.	Strawn Townsite, Blk. 16	998	360	638
F. L. Walker	C. E. Binnings No. 1	Strawn Townsite, Blk. 14, lot 3	999	390–392	609
Little Caddo Syndicate	Laura Massie No. 2	Texas & Pacific Ry. Co., Sec. 32, Blk. 3		500–505	?
Owen et al.	Watson	T.&P.Ry., Sec. 8, Blk. 2	919	490–500	429
Tom Owen, for Thompson, 1915	Watson No. 1	T.&P.Ry., SE. ¼ Sec. 8	919	905	14
T. & P. Coal & Oil Co.	S. R. Bogess No. 1	T.&P.Ry., Sec. 4B. Blk. 4	--	483	----
Do.	Mary E. Robinson	T.&P.Ry., Sec. 74, Blk. 11	-	905	---
	Smart Well (water)	Town of Lone Camp	---	--	680
	Walls No. 4	Townsend, Walls farm, Lone Camp area	--	765–768 ?	----

[a]Coal and slate.

Coal in northern Erath and southern Palo Pinto counties.

Company	Location	Thickness *Inches*	Date opened
Texas & Pacific	Pedro Herrera Survey near Thurber	28-30	
Newcastle	1½ mi. SE. of Texas and Pacific mine	28-30	About 1893
Gordon	3 mi. NE. of Gordon		About 1888

The first mining operations of importance in Palo Pinto County appear to have been undertaken by W. W. Johnson, who explored the country and opened up workings three miles northeast of Gordon and around Coalville early in the 80's. The mines supplied fuel for the newly constructed Texas and Pacific Railway. In 1885, the Texas and Pacific Railway organized a coal company to supply their own fuel and purchased land from Johnson. In 1886, this company opened a shaft at Thurber at a depth of 78 feet and began mining the coal on a larger basis. In 1895, they opened their No. 1 mine near Strawn. Altogether, the Texas and Pacific Coal Company sank eleven shafts between 1894 and 1920. In 1920, when the railway changed from coal to oil for fuel, all operations of their coal mines were suspended. All mining equipment in mine No. 11 was hauled into mine No. 10 and left until 1934, when the company decided to abandon operations permanently and to salvage the equipment.

The Mt. Marion Coal Company was organized about 1895 and just south of the town of Strawn sank its No. 1 shaft to a depth of 415 feet. In 1900 this company was sold to the Strawn Coal Company, which has operated continuously until the present year, and has sunk four shafts, as follows:

Coal mines of the Strawn Coal Company near Strawn.

Mine	Location	Depth *Feet*	Thickness *Inches*
No. 1	South of Lyra	330	30
No. 2	North edge of Lyra	400	32
No. 3	½ mile north of Lyra	365	30
No. 4	1¼ miles northwest of Lyra	485	26-36

During the summer of 1933 only one coal mine, the Strawn Coal Company's No. 4 (fig. 21), was in operation, and it was running only about one day a week. The company during winter months employs on the average 80 miners and can produce a maximum of 580 tons per day. The production is limited, however, to the amount of coal that can be disposed of. During the depression years the demand has been small.

Geology.—The workable coal is in a single bed about 30 inches thick and lies at the base of the Garner formation from 140 to 210 feet below the base of the Brazos River sandstone. The stratigraphic position of the coal and the character of the adjacent beds is shown in the following section:

Section of Garner formation measured in the vicinity of Thurber.

	Thickness *Feet*
8. Brazos River sandstone and conglomerate	50
7. Shale, gray sandy	40
6. Sandstone, buff brown, hard, calcareous, forming a cliff	10
5. Shale, gray, sandy, grading downward into less sandy, thinly-laminated, dark bluish-gray shale	30
4. Limestone, or very calcareous siltstone, sandy, fossiliferous, containing on its surfaces large Spirifers, many crinoid fragments, *Allerisma*, fucoidal markings	½
3. Shale, dark bluish gray, laminated, containing a few concretions 6″ to 14″ in diameter. This is the clay from which the brick is made at Thurber	65
2. Coal, black, soft, fragile	1–3
1. Sandy shale, grading in places into sandstone	40

The coal is 218 feet below the top of the Brazos River sandstone in the Newman well north of Lone Camp. In the Smart well in the town of Lone Camp, it is 248 feet below the top of the Brazos River sandstone, and in an outcrop near Gordon it is 195 feet. A hard, dense shale overlies the coal seam in most places. It does not cave badly and forms a fairly good roof for the mines. In the Strawn Coal Company mines east of Strawn a layer of hard marine siltstone, from 6 to 8 inches thick, lies on top of the coal, and they are removed together. In the outcrop of coal on the north side of the outlier east of Thurber. the coal lies directly on a sandstone lentil containing coal plants. In most places, however, the coal lies on a dense blue clay, containing in places plant remains.

The coal in Strawn Coal Company's mine No. 4 at Strawn has a thickness of from 26 to 36 inches with an average of 32 inches. It rests on dark bluish-gray, dense fire-clay and is overlain by a thin band of calcareous, sandy siltstone containing fossils. The coal is divided into an upper and lower layer by a 1-inch band of shale 19 inches above its base. The lower part is hardest and yields the best grade of coal.

Composition.—The coal is bituminous, having a fuel ratio of 1.79 per cent. The percentage of ash and sulphur are high, ranging from 1 to 3 per cent by weight. The coal can be coked successfully but contains too much sulphur and ash to be used for metallurgical operations. The analyses in Table 23 show its chemical composition.

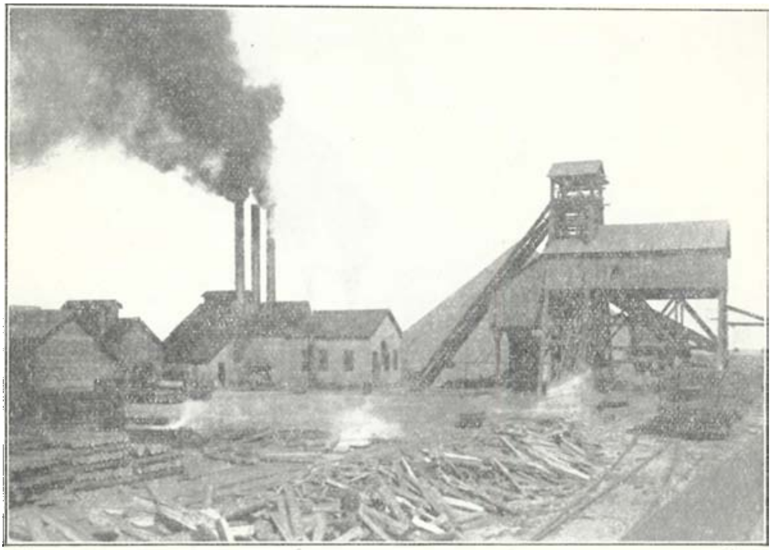


FIG. 21.—View of Strawn Coal Comnpay's Mine No. 4, northeast of Strawn. (Photograph furnished by Judge Ritchie, Mineral Wells.)

Method of mining.—The advancing long-wall method of mining is practiced in all mines in the Strawn and Thurber districts. A shaft 8 by 16 feet in size, large enough to hold two 8 x 8-foot elevators, is sunk to the coal. Four drifts are run laterally on opposite sides of the shaft for distances of 50 feet, then the coal is removed along the face of an advancing circular wall (fig. 22). In this way an area of solid coal 100 feet square is left around the shaft through which the entries run, and all the coal outside the circle

TABLE 23.—*Analyses*[114] *of Thurber coal.*

Owner	Location	Moisture Per cent	Volatile Matter Per cent	Fixed Carbon Per cent	Ash Per cent	Sulphur Per cent	B.T.U.
T. & P. Coal Co.	Thurber, Erath Co.	.88	31.57	56.81	8.93	1.47	-----
Do.	Mine No. 7, Erath Co.	5.36	33.82	45.47	20.81	2.16	12099
Do.	Mine No. 8, Erath Co.	5.46	37.72	52.01	10.27	1.71	13755
Do.	Mine No. 9, Erath Co.	5.83	35.26	45.83	18.91	2.77	12157
Do.	Mine No. 10, Erath	1.31	37.22	46.56	16.22	3.14	12817
Strawn Coal Co.	Strawn Coal Co. Mine	1.06	39.70	50.65	9.65	2.91	13563
Do.	Do.	1.00	33.11	43.80	23.09	2.40	12005
Texas Coal & Fuel Co.	Mine No. 1, Rock Cr., Parker Co.	8.12	32.24	49.90	17.86	1.70	12533
Do.	Mine No. 2, Rock Cr., Parker Co.	5.95	35.18	47.67	17.19	2.13	12175

is removed. Working space is increased by removing some of the overlying strata with hand picks, and the coal is undercut also in the fire-clay below the coal. The undercuttings from the clay and the shale, taken down in extending the entries, are used to build up the back wall behind the coal face to prevent too much settling. The roof in the galleries is timbered to prevent caving. In this way, as the wall is cut forward, the open space in the rear, adjacent to the entries, is filled with tailings taken out with the coal. Temporary props are removed and the roof allowed to settle on the refuse or "gob." In this way an open space is maintained all along the face of the coal and is connected with the shaft by propped entries. As the drifts are advanced, air shafts 6 by 8 feet in size are put down to allow proper air circulation throughout the workings. Some of the air shafts are provided with winding stairways to furnish safety exits during accident or fire. A plan of Strawn Coal Company's mine No. 4 is shown in figure 22. About 400 acres of coal are removed around each shaft, and then a new shaft is sunk. The slate roofs stand up well and less timbering is required than in most mines.

In 1933 about 80 miners, receiving $1.75 per day, were employed by the Strawn Coal Company. The cost of mining was about $3.00 per ton. $2.00 for digging and $1.00 for loading and transporting to the railroad. The cost of sinking the shaft 8 by 16 feet was about $10.00 per foot. The coal was hauled by mules to the shaft and lifted to the surface in cages driven by motors. The mine was dry.

[114]Phillips, W. B., and Worrell, S. H., The fuels used in Texas: Univ. Texas Bull. 307, pp. 14, 21, 50, and 28, 1913. Schoch, E. P., Chemical analyses of Texas rocks and minerals: Univ. Texas Bull. 1814, p. 196, 1918.

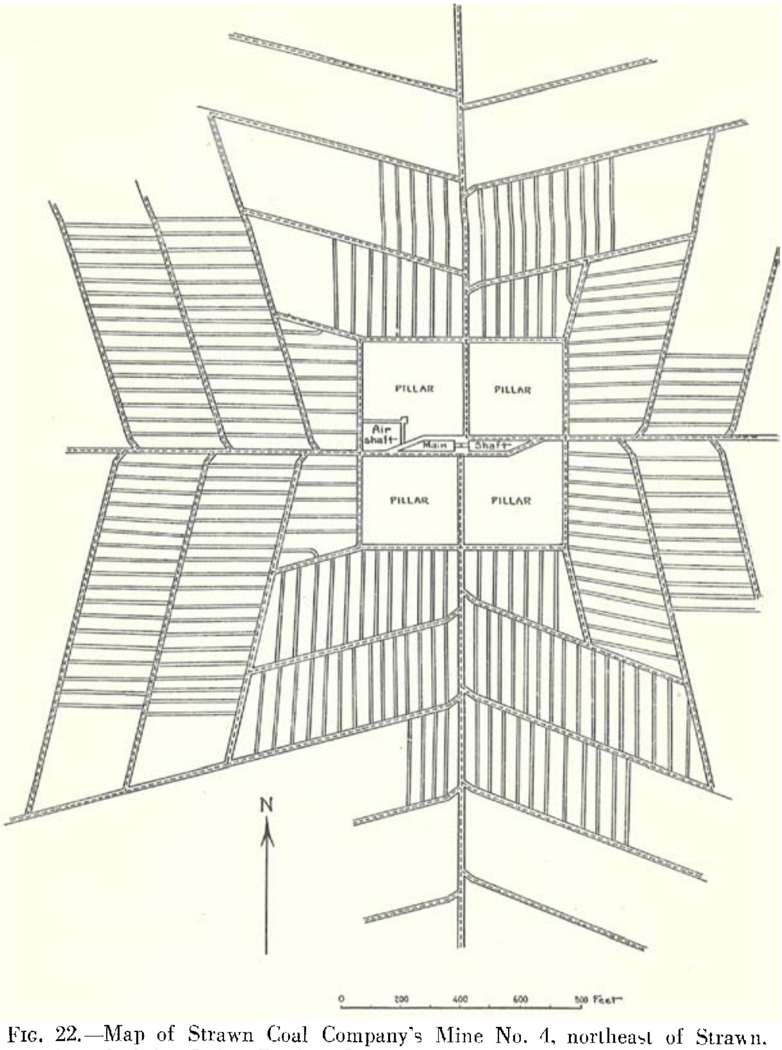


FIG. 22.—Map of Strawn Coal Company's Mine No. 4, northeast of Strawn. Map furnished by Judge Ritchie, Mineral Wells.)

The Texas and Pacific Coal Company mines at Thurber were shut down during 1933 and are now abandoned. The mining methods, however, were similar to those used at Strawn except that electric motors instead of mules were used to haul the coal, and the elevators in the shafts were driven by electric motors. Some of the mines have run into water, and pumps have had to be installed.

Future reserves.—It is estimated that about 5600 acres of coal lands have been mined, worked over, or discarded. Probably about 40,000 acres[115] of reserves of commercially productive coal lands in the Strawn coal basin remain to be developed at some future time, when coal as a fuel is in demand. These 40,000 acres of 28-inch coal amount to 4,065,600,000 cubic feet, or over 50 million tons of coal.

SUNDAY CREEK COAL

The lowest coal seam in Palo Pinto County is the Sunday Creek coal bed, which lies 65 feet below the upper Santo limestone in the Millsap Lake formation. It outcrops in the southeastern corner of the county south of the Texas and Pacific Railway along branches of Sunday Creek. It is well exposed at the following localities:

1. North side of a small sandstone-capped knob on the south side of an east-west road (tap road to Gold Ranch) that joins the Santo-Lipan road 2.7 miles south of Santo and 0.8 of a mile east of that highway.
2. East of Santo-Lipan road, one-fourth mile east of Southwestern Bell Telephone Co. repeater station, which is on the Santo-Lipan road.
3. West side of Sunday Creek, 1½ miles due west of Southwestern Bell Telephone Co. repeater station.
4. South branch of Sunday Creek, 2.2 miles east-southeast of Judd.

The coal is brownish black, fibrous, brittle, and impure. The seam is 18 to 22 inches thick, fairly persistent, and in some places it is well exposed and easy to examine. One of the best exposures is the first locality described in the above list.

Section measured along an east-west road about three miles south-southeast of Santo and 0.8 of a mile east of the Santo-Lipan highway.

	Thickness *Feet*
5. Sandstone, brownish gray, coarse grained, cross bedded	5
4. Shale, gray, sandy, unfossiliferous	25
3. Coal, black, soft, thinly laminated	1.7
2. Shale, yellowish gray, thin bedded, much laminated into paper-thin layers, containing, especially in its lower part, numerous marine fossils	20
1. Sandstone, coarse grained, conglomeratic, cross bedded, poorly exposed	10

[115]Estimate of Mr E. S. Britton, Strawn Coal Company.

The coal has never been developed or utilized commercially except by a few farmers for blacksmith's forges. The bed appears to be of about the same quality as the Thurber coal but is somewhat thinner. It is exposed at several places along low creek banks, and it is likely that some outcrops can be stripped and mined cheaply. It will probably be in little demand in the immediate future, because of the large amount of oil in sight, which furnishes a cheaper fuel easier to utilize. If some method could be developed to remove the sulphur from coal cheaply, the Texas coal would find a market for cooking purposes. On the whole, it does not appear that Texas coals will be utilized much during the present generation. They constitute, however, an important reserve for the future, when petroleum and natural gas will have become depleted.

Brick and Tile Clays

Locations of clay pits.—Ceramic products are manufactured from clays at Mineral Wells, at Bennetts in Parker County just east of the county line, and at Thurber in Erath County just south of the county line. The clays at Mineral Wells come from the East Mountain shale of the Mineral Wells formation; at Thurber they come from the Mingus shale of the Garner formation; and at Bennetts they come from the Millsap Lake formation. Tile, common brick, and paving brick are manufactured at Mineral Wells: paving and building brick at Bennetts; and road paving brick at Thurber.

History of operations.—The first brick plant in this district was built at Thurber in the 80's by Green & Hunter. It operated under this firm name until 1900, when it was taken over by the Thurber Brick Company, a subsidiary of the Texas & Pacific Coal and Oil Company. The first plant in Palo Pinto County consisted of a single small kiln set up at the south end of East Mountain, just north of East Hubbard Street and west of the cemetery in Mineral Wells. Brick was manufactured in an old-fashioned dry press on a small scale for use in Mineral Wells during 1906 and 1907. The plant was abandoned in 1908. The next plant in this district was built at Thurber by the Texas & Pacific Coal and Oil Company about 1900 and operated until 1929. In this plant the paving bricks were manufactured for laying the brick pavement on Highway No. 1 in Palo Pinto and Eastland counties, and for paving streets in Fort

Worth and other cities. In May, 1921, a brick company financed by local and Kansas City capital was organized with Mr. A. Eaton as president, and a thoroughly modern brick plant was erected on the east side of East Mountain, about one mile east of the center of Mineral Wells. The plant was operated practically continuously from 1921 to 1929. When the general depression of 1930 slackened business, the whole equipment was sold out to the Reliance Clay Products Company of Dallas, and Mr. Eaton resigned from active management. The brick plant is one of the largest and most modern in Texas. It consists of 21 beehive-shaped kilns, 3 steam shovels for stripping, 2 complete grinding and brick-making machines, 2 complete dryers, and one 24-track and one 26-track oven. The capacity of the plant is about 10,000 tons of brick per month. Production has ranged from 5,000 to 10,000 tons per month during a ten-year period, as follows:

Production of brick at plant of Reliance Brick Company.

Year	Average monthly production *Tons*
1921	5,000
1922	5,000
1923	5,000
1924	7,000
1925	7,000
1926	7,000
1927	7,000
1928	10,000
1929	10,000
1930	10,000

About 1925 the third brick plant was constructed at Bennetts, Parker County, near the Palo Pinto-Parker county line by Acme Brick Company.

In 1931, Mr. Eaton organized the Mineral Wells Clay Products Company opened up an excellent clay deposit three miles east of Mineral Wells on the south side of the Mineral Wells-Garner road, and built another thoroughly modern plant for manufacture of brick and tile. The new plant consists of gas-fired kilns having a capacity of 1,600,000 bricks per month and is equipped with steam shovels, roller-bearing conveyors, and two, double-unit, brick-making machines. The plant is designed for manufacturing hollow builder's tile, face brick, chemical brick, red quarry floor tile, and paving brick.

Descriptions of clay pits.—The clay deposit utilized by the Reliance Clay Products Company covers 208 acres along the east bluff of East Mountain at Mineral Wells beneath the Lake Pinto sandstone. The deposit consists of an upper and a lower bed separated by a layer of one-foot fossiliferous limestone. The lower member, averaging 24 feet in thickness, is dark grey, in places almost black, thinly laminated, soft, fossiliferous clay that contains near its top carbonaceous material, thin incrustations of sulphur, and gypsum crystals. The upper member, averaging 68 feet in thickness, is darker and almost black, compact near its base but grading upward into a softer, lighter colored shale, which becomes silty at the top. The lower shale is used especially for paving and face brick, the upper shale for common brick and hollow tile. The upper shale is somewhat finer grained, more silty, and more difficult to dry. The clay burns to dark reds, maroons, and tan colors.

The clay deposit at the plant of the Mineral Wells Clay Products Company is made available by a pit 800 feet long and 25 feet deep excavated on the northwest side of the plant. The deposit consists of a dark-gray to black, siliceous, non-calcareous, laminated shale, containing a few small ironstone nodules and a few small fragile marine fossils. The clay is overlain by two to three feet of soil and gravel, which is removed by scrapers at low cost. The shale underlies the whole floor of a broad valley in the vicinity of the plant. It appears to be of fairly uniform grade and to extend over several hundred acres of available space. Shrinkage tests on samples of shale taken from the bottom of the pit are as follows:

Shrinkage tests[116] *on a sample of shale from the pit of the Mineral Wells Clay Products Co., east of Mineral Wells.* (Sample made into bars 6″ x 1′ x 1′ with an auger machine.)

Bar No.	Temperature *Fahrenheit*	Total Shrinkage *Per cent*	Dry Shrinkage *Per cent*	Firing Shrinkage *Per cent*
2	1400	5.5	6.0	0.5
4	1600	6.5	5.0	0.5
7	1650	6.5	6.0	0.5
10	1700	8.0	6.0	2.0
13	1800	10.0	6.0	4.0
16	1850	10.0	6.0	4.0
19	1900	11.5	5.5	6.0
22	1950	12.5	5.5	7.0
25	1975	13.0	6.0	7.0
34	2000	13.0	6.0	7.0

[116]Tests made by Harrop Ceramic Service Co., Columbus, Ohio.

These figures show that the shrinkage increases regularly with increasing temperature, a change that is normal. The shale was completely vitrified at 1900 degrees and did not overfire at 2000 degrees, showing that it has a long vitrification range and is therefore a good grade of shale for face brick, tile, or paving brick.

The upper material in the Texas and Pacific clay pit at Thurber consists of gray, silty, siliceous, non-calcareous shale, which is almost black when freshly exposed. This grades downward into a 30-foot bed of less silty, darker colored, laminated, bluish-grey clay, which is separated by a thin bed of fossiliferous calcareous siltstone from a lower bed of dark-gray to blue, laminated brick clay that contains a few calcareous concretions from six inches to fourteen inches in diameter and has a total exposure of 20 to 25 feet. The chemical composition of this shale is given in the following table:

Analysis[117] of brick clays at Thurber, Erath Co., one mile south of the Palo Pinto county line.

Constituents	Sample No. 1 *Per cent*	Sample No. 2 *Per cent*
Silica	64.52	63.07
Alumina	17.72	19.43
Ferric oxide	4.46	4.75
Lime	0.27	1.32
Magnesia	1.58	0.50
Soda	1.24	----
Potash	2.71	----
Titanic acid	1.30	1.17
Water	5.44	6.90
SO_3	----	0.15
Air shrinkage	8.0	7.7
Fire shrinkage	5.0	5.6

The shale is overlain by a coarse-grained, massive, 15-foot sandstone. As the shale slope is cut back into the hillside, the sandstone slumps down, and its removal becomes necessary. A few years ago, in order to avoid the cost of removing the overburden, the Texas and Pacific Coal Company opened up a second pit along an escarpment one-half mile northeast of their plant. The clay in the new pit is similar to that in the old, but the available deposit is much larger. A cut 1200 feet long and 75 feet high has made available one million cubic yards of good quality, siliceous, brick

[117]Ries, Heinrich, The clays of Texas: Univ. Texas Bull. 102, p. 218, 1908.

clay. The clay has to be hauled in tram cars from the pit upgrade to the brick plant.

Undeveloped clay deposits.—A shale or clay, to make good brick and tile, must have low shrinkage and a fairly long vitrification range, must burn to a good color, and must furnish a product of good tensile strength. The deposit must not have much overburden nor contain harmful ingredients that need to be removed. It must be located near a railway and where cheap fuel is available. The clays of the Strawn group, especially the East Mountain and Mingus shales, satisfy these qualifications best. They are more siliceous, less sandy, less contaminated with ironstones, and have less shrinkage than most shales from the Canyon group of formations. The outcrops of the East Mountain and Mingus shales in Palo Pinto County are shown on the geologic map, Plate II.

Favorable sites for pits occur in the East Mountain shale outcrop along the Mineral Wells branch of the Texas and Pacific Railroad, south and east of Mineral Wells in the east edge of the county, and northeast of Lyra within reach of the branch line running to the Strawn Coal Company's No. 4 mine. Other good localities are to be found in Mingus shale outcrops along the main line of the same railroad in the vicinity of Mingus, Gordon, and Santo.

An abundant supply of natural gas is available in southern and eastern Palo Pinto County. The clay deposits are almost inexhaustible and are cheaply mined. The county is within easy reach, by short railway hauls, of Dallas and Fort Worth. Undoubtedly these clays will be extensively developed, as the commercial industries of north Texas are expanded and demands for buildings increase.

BUILDING STONE[118]

Utilization of stone.—Palo Pinto County is one of the leading counties of Texas in quantity, variety, and availability of building stone. Sandstone blocks and slabs are quarried in the eastern and southeastern parts. Limestone outcrops through the central and

[118]*Literature.*—Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., pp. 521–525, 1891. Merrill, G. P., Stones for building and decoration: 3d edition, pp. 1–112. 1903. Miller, Benjamin LeRoy, Limestones of Pennsylvania: Penn. Geol. Survey Bull. M–20, pp. 1–279, 1931. Stone, R. W., Building stones of Pennsylvania: *Penn.* Geol. Survey Bull. M–15, pp. 1–308, 1932. Woolf, D. O., The results of physical tests on road-building rock: U. S. Dept. Agric. Pub. 76, pp. 1–148. Washington, 1930.

western parts in inexhaustible quantity. The terraces along the winding course of Brazos River are built up out of sand and gravel that furnish a rich supply for road building and concrete manufacture.

The early settlers in north Texas appreciated the value of native stones for buildings more than have their descendants, at least until recent times. The dignified courthouse at Palo Pinto, completed in 1886, was built of a fine-grained sandstone quarried southeast of town. Several of the early buildings in that town and in Mineral Wells were fashioned out of the same rock. Later quarries were opened up in the southern part of the county along the Texas and Pacific Railroad, and sandstone blocks were hauled to Fort Worth and Dallas for building stores and houses, for paving sidewalks, and for use in building business houses in Brazos. One of the first large hotels in Dallas, the Grand Windsor Hotel, was completed in the 80's out of this rock. With the introduction of more brick, concrete, and steel into construction, the stone quarries were abandoned and forgotten, and very little quarrying was done until the building of the state highways about 1920 brought a demand for crushed rock for road material. In 1920 and 1921 four limestone quarries were opened, crushers installed, and large quantities of crushed rock produced and used to grade Highway No. 1 and Highway No. 66. In the last five years architects and builders have again realized the value of Palo Pinto field stone on account of its durability, beauty, and heat resistance. Recently many houses, walls, and terraces have been constructed out of the beautiful, reddish-brown sandstone blocks and lichen-covered boulders. Notable among these recent structures are the terraces around the high school grounds at Mineral Wells, the patio walls of the beautiful Baker Hotel at Mineral Wells, the Boy Scout Camp northeast of Palo Pinto, the home of Benton Holmes at Mineral Wells, the Crystone Crystal Plant building at Mineral Wells, the Baker Mineral Crystals Plant near Lake Pinto, and the community house at Lake Mineral Wells. These and others are examples of the beauty and utility of native stones for permanent building purposes. Rock buildings are more beautiful, more durable, more fireproof, and much cooler to live in and to work in than are uninsulated wooden or concrete structures.

Characteristics of building stones.—The utilization of native stones for different purposes depends upon the following properties which determine the character of the stone: color, texture, structure, hardness, strength, and resistance to weathering agencies. The color depends upon the chemical composition of the minerals in the rock. The color of pure quartz (SiO_2), the principal mineral in sandstone, is white, as is also the color of pure calcite ($CaCO_3$), the principal mineral in limestone. Sandstone and limestone, however, are rarely pure but are contaminated by numerous impurities, the commonest of which are iron minerals of various sorts. The iron gives green, buff, tan, and brown or red shades, depending upon its chemical composition and state of oxidation. Carbonaceous matter in the rock may color it gray, dark gray-blue, or black. The color of a rock at the surface is different from that of the same rock at depth. Sandstone may be dark gray or greenish gray at depth and weather on the surface to buff and brown or red. The most pleasing colors are the mottled effects in which buffs or browns are tinged with dark red or green tints. The brown and reddish-brown and tan colors of some of the sandstones of the Strawn formation give pleasing effects, and the gray, tan, and brownish-red slabs make beautiful floors for porches and terraces.

The texture of the rock is determined by the size, arrangement, and cementation of its constituent grains or crystals. Some limestones have so fine a texture that individual particles cannot be distinguished with an ordinary lens; sandstones range in texture from exceedingly fine, almost indistinguishable, grains to very coarse sand grains and run to small pebbles like those in the Brazos River and Turkey Creek beds, in which the grains are so large that the rock is known as a conglomerate. Evenly textured, fine-grained rocks that have even lamination and even bedding make the best blocks and flags for building terraces and buildings in which flat, even surfaces are desired.

The strength of a rock depends upon the mineral composition and cement that hold the grains together. Solidly cemented quartz in the form of quartzite is strongest. Well-cemented sandstones are next strongest, and limestones and loosely cemented sand are weakest. The crushing strength of rocks is measured by determining the pressure in pounds per square inch required to break a one-inch or two-inch cube of the rock. The crushing strength of Palo Pinto County rocks varies from 5,000 to 33,000 pounds per square inch, as follows:

Material	Crushing strength *Lbs. per sq. in.*
Limestone	12,875–25,579
Sandstone	19.050–33,077
Chert conglomerate	33,515–33,718

The hardness of a rock depends upon the hardness of its individual mineral particles and upon the amount and toughness of its cementing material. Limestone, for example, made up mostly of calcite, has a hardness of 3; quartzite, made up of quartz, has a hardness of 7; whereas a diamond has a hardness of 10. Hardness is a more important quality in choosing paving and flag stones for walks and terraces than it is for ordinary building stone. Soft friable sandstones wear out rapidly and are more porous and more easily effected by weathering agencies. Hardness of a rock can be determined best by the Deval test.[119] This test consists of breaking by hand approximately 50 pieces of rock in shapes as nearly cubical as possible, and in sizes weighing approximately 5,000 grams (1.02 oz.) each. The samples are then placed in a large iron cylinder mounted with its axis at an angle of 30° and rotated rapidly for 10,000 revolutions. The chunks are in this way thrown against each other and against the sides of the cylinder violently and are perceptibly worn. All the detrius is then removed completely from the cylinder and screened through a No. 12 standard screen. The amount passing is expressed in percentage of initial weight.

$$\text{Hardness} = W_1/W \times 100$$
W = original weight
W_1 = Weight passing No. 12 screen

The hardness of limestone determined in this way is about 14, hard calcareous sandstone is about 16, and soft, poorly cemented sandstone is much less.

The structure of a rock depends largely upon the arrangement of the grains or crystals of which it is composed and upon the amount of pressure and temperature to which the rock has been subjected

---

[119] Woolf, D. O. The results of physical tests on road-building rock: U. S. Dept. Agric. Misc. Publ. 76, pp. 1–118, Washington, 1930.

since its deposition. Sandstones may be thinly bedded and loosely cemented along bedding lines so that they split easily to produce thin slabs. Limestones may be jointed and composed of so much pure calcite that they break easily along cleavage lines to form more or less square, smooth-surfaced blocks. Quartzites rarely break evenly but part along conchoidal fractures, leaving rough, uneven surfaces. The structure, lamination and texture of a rock are important factors in the selection of building stone.

Building stone in Palo Pinto County.—The sandstone and limestone ledges of the Garner and Millsap Lake formation in the southeastern corner of the county furnish good building stone. Some of the strata are very evenly bedded, of uniform thickness, sufficiently hard, yet quarry easily into blocks that require but little facing, and they have good color.

Quarries have been opened in the past mainly near the railways as follows:

Sandstone—

1. Near Brazos River in the vicinity of Brazos.
2. Near Brazos River one mile west of Bennetts, Parker County.
3. Along Grindstone Creek near the southeastern corner of the county.
4. Two miles northeast of Gordon on east side of Barton Creek.
5. Along the Millsap-Brazos highway south of Goen Cemetery.
6. Along the Santo-Patillo road south of Santo.
7. Along Rock Creek east of Mineral Wells in the western edge of Parker County.
8. Below the Brazos River conglomerate escarpment southeast of Mineral Wells.

Limestone—

1. One mile east of Santo on the south side of Texas & Pacific Railway.
2. Other equally good sites are available that are somewhat farther from the railroad but within reach of good roads for truck haulage.

Building stone from these localities may be divided into four groups:

1. Sandstone flags.
2. Sandstone blocks.
3. Sandstone boulders.
4. Limestone blocks.

The flags find a use for paving walks, floors of buildings, porches and terraces, and may be used as a veneer for facing sides of buildings. When used in this way, they are laid with bedding planes vertical. The sandstone and limestone blocks are used for walls, foundations, chimneys, fireplaces, and other purposes, and are best laid with bedding planes horizontal and with end faces overlapped like brick or concrete blocks. Examples of this type of rock construction are to be seen in the Palo Pinto and Jack county courthouses.

Most boulders are natural, weathered field stones, picked up on the surface and laid with a minimum of facing so as to preserve the original shape and colors. For some purposes lichen-covered boulders are selected and laid with the lichen attached. Some of the most pleasing effects have been attained in this way at a minimum of cost. A good example of this type of construction is to be seen in the walls of the new home built by D. C. Witherspoon on northwest Fourth Street, west of the Crazy Mineral Water Plant.

The Mineral Wells formation has three sandstone members and one limestone member that furnish building material as follows:

1. Fine-grained, evenly bedded sandstone just beneath Palo Pinto limestone.
2. Turkey Creek sandstone.
3. Lake Pinto sandstone.
4. Village Bend limestone.
5. Hog Mountain sandstone.

Numbers 2. 3, and 5 are poorly bedded, unevenly textured, and of uneven hardness. The rock, however, weathers to subangular boulders of good color that are much used for ornamental walls and terraces. Member No. 1 is evenly grained, breaks with a smooth face, and is a good building stone much used by the earlier builders of Palo Pinto. The Palo Pinto courthouse is built out of this rock quarried at Round Top Mountain, located in the southeast corner of section 35, about one-half mile southeast of town.

The limestone ledges of the Palo Pinto, Graford, Brad, and Caddo Creek formations are unevenly bedded, impure, and break in many places into small, rough-surfaced chips, so that most of the ledges cannot be quarried into building blocks. They find their chief use for road material in the construction of highways and for cement grout for concrete. The rock is quarried by blasting into fragments, which are crushed and screened to proper size. Quarries and rock crushers for manufacture of road material have been located at the following places:

1. South side of Mineral Wells, Weatherford, and Northwestern Railroad, 3 miles northwest of Salesville; Palo Pinto limestone. (Coörd. S-3.)
2. North side of Highway No. 1, about 2½ miles east of Palo Pinto, Texas and Pacific Railroad Survey Blk. 1, northwest corner section 26; Palo Pinto limestone. (Coörd. M-11.)
3. West side of Highway 1-B, about a mile by road southeast of Brad, Texas and Pacific Railroad Co. Blk. 3, southeast corner section 27; Merriman limestone. (Coörd. D-12.)
4. West side of Highway 1-A, about 4 miles by road north of Strawn on Crouch's Ranch, Texas and Pacific Railroad Survey Blk. 3, section 87; Palo Pinto limestone. (Coörd. D-18.)
5. East side of Highway 66, about 2 miles north of Hughes, Texan Emigration and Land Co. Survey, section 2541; Palo Pinto limestone. (Coörd. T-3.)

All these quarries, except No. 1, were established to supply road material for construction of main highways, but they were abandoned as soon as highway work was completed. Quarry No. 1 was opened by the Mineral Wells Crushed Stone Company but is now abandoned.

Sand and Gravel

Occurrence.—Sand and gravel deposits lie along the terraces of Brazos River; along the valleys of a few of the largest creeks in the county, especially Palo Pinto Creek and Keechi Creek; and along the outcrops of the Brazos River sandstone and conglomerate, the Lake Pinto sandstone, and the Turkey Creek sandstone and conglomerate. The deposits are fairly widely distributed throughout the county but are most available along the course of the Brazos and in the southwestern part of the county, where the sandstone and conglomerate ledges outcrops.

Description of pits.—Gravel pits have been opened at the following sites:

Pitman pit (Coörd. P-11).—This pit lies five miles southwest of Mineral Wells. The gravel is in a terrace of Brazos River, 20 feet above the present water level. The available material covers an area of about one acre. The deposit consists of 15 feet of gravel overlain by 5 feet of sand and silt. The pebbles are of fairly uniform size, ranging from one-eighth of an inch to cobbles three or four inches in diameter. By far the largest proportion is less than one inch in diameter.

Highway No. 1 pits (Coörd. P-10).—Two gravel pits have been opened up along Highway No. 1 on the west side of Brazos River, 5 miles by road west of Mineral Wells. The easternmost pit is in the middle terrace one-eighth of a mile west of the bridge. The next one to the west is in the upper terrace one-quarter of a mile west of the bridge. The deposit is from 5 to 10 feet thick, of good quality, and very accessible for highway purposes. A rough analysis of the material in the upper terrace shows 80 per cent of the large pebbles to be chert or quartz, 13 per cent or less to be limestone, and 5 per cent or less sandstone. The following analysis of the gravel from the easternmost pit shows proportions in sizes of material:

Mechanical analysis[120] *of gravel from pit in the middle terrace one-eighth of a mile west of Brazos River, Highway No. 1, Palo Pinto County.*

Size in inches Through	On	Weight in grams	Per cent
2½	2	--------	--------
2	1½	307.0	16.30
1½	1¼	85.0	4.51
1¼	1	106.0	5.62
1	¾	95.0	5.04
¾	½	140.0	7.43
½	⅜	108.0	5.73
⅜	¼	170.0	9.02
¼	.0787	320.0	16.98
.0787	.0331	138.0	7.32
.0331	.0232	50.0	2.66
.0232	.0165	28.0	1.48
.0165	.0117	68.0	3.64
.0117	.0098	26.0	1.38
.0098	.0070	54.0	2.38
.0070	.0059	13.0	0.69
.0059	.0029	72.0	3.82
.0029	pan	110.0	5.84
--------	loss	6.0	--------

Harrington pit (Coörd. P-10).—This pit is located on a lower terrace of Brazos River, four miles southwest of Minerals Wells. It is 800 feet long and 400 feet wide in a gravel bed that extends to the river. A size analysis shows that 98 per cent of the pebbles are between one-eighth and one-half of an inch in diameter, and these lie in a matrix of coarse, clean quartz sand. A mineral analysis

[120]Analysis made by E. C. Sargent.

shows that 6 per cent of the pebbles are hard sandstone, 11 per cent are limestone, and 83 per cent are chert and quartz. A cut near the center of the pit shows 10 feet of sand and gravel overlain by 7 feet of overburden consisting of soil and silt. The pit is accessible to trucks at all times except following heavy rains. Sifted gravel sells for 25 cents per cubic yard at the pit and 75 cents per cubic yard in Palo Pinto or in Mineral Wells

Strawn gravel pit (Coörd. D-21).—This pit lies one mile east of Strawn on the south side of the Strawn-Mingus highway and is located on a terrace of South Palo Pinto Creek. A small pit 100 feet wide and 150 feet long has been opened for road gravel. The deposit consists of good, fairly coarse gravel covering an area 800 feet by 1000 feet or more. The gravel is from 8 to 10 feet thick And has practically no overburden. A size analysis of the gravel is as follows:

Mechanical analysis[121] *of gravel from a pit 1.2 miles east of Strawn on south side of Mingus road.*

Size in inches Through	On	Weight in grams	Per cent
2½	2	95.0	2.16
2	1½	660.0	14.67
1½	1¼	550.0	12.22
1¼	1	465.0	10.33
1	¾	515.0	11.45
¾	½	437.0	9.72
½	⅜	205.0	4.56
⅜	¼	212.0	4.72
¼	.0787	373.0	8.29
.0787	.0331	309.0	6.87
.0331	.0232	106.0	2.36
.0232	.0165	124.0	2.76
.0165	.0117	206.0	4.58
.0117	.0098	95.0	2.16
.0098	.0070	88.0	1.95
.0070	.0059	10.0	.22
.0059	.0029	20.0	.44
.0029	pan	25.0	.56

Palo Pinto pit (Coörd. K-8).—This pit lies five miles north of Palo Pinto on the Palo Pinto-Graford road. It was developed by the State Highway Department to gravel the road leading north out of Palo Pinto. It is a good 5-foot deposit of medium-coarse gravel covering an area about one-quarter of a mile square and has no overburden. Much more gravel can be excavated along this terrace, which is especially favorably located for furnishing road material and concrete grout for the central portion of the county. The following analysis is typical:

[121]Analysis made by E. C. Sargent.

Mechanical analysis[122] *of gravel from a pit in the upper terrace of Brazos River 1.5 miles south of Brazos River bridge, on east side of Palo Pinto-Graford road.*

Size in inches Through	On	Weight in grams	Per cent
2½	2	-------	-------
2	1½	-------	-------
1½	1¼	43.0	2.52
1¼	1	15.0	0.88
1	¾	107.0	6.26
¾	½	128.0	7.48
½	⅜	106.0	6.20
⅜	¼	90.0	5.25
¼	.0787	439.0	25.75
.0787	.0331	266.0	15.58
.0331	.0232	145.0	8.48
.0232	.0165	109.0	6.38
.0165	.0117	74.0	4.33
.0117	.0098	26.0	1.52
.0098	.0070	38.0	2.22
.0070	.0059	11.0	0.64
.0059	.0029	38.0	2.22
.0029	pan	72.0	4.22
-----	loss	3.0	0.17

Geology of the gravel deposits.—The gravel deposits in Palo Pinto County belong to two classes of deposits:

1. Pleistocene terrace deposits.
2. Altered Pennsylvanian conglomerate deposits.

The terrace deposits are flood deposits spread out on the flood plains of the rivers during epochs of extremely heavy rainfall in the Pleistocene period. The gravel appears to have come from two chief sources:

1. Outcropping rock formations of Pennsylvanian age in the stream valleys contributed from about 15 to 20 per cent.
2. Unconsolidated basal Trinity gravel of Lower Cretaceous age contributed from about 80 to 85 per cent.

The Pennsylvanian rocks contributed the limestone and sandstone pebbles and to a minor extent chert pebbles from the conglomerate beds. The Trinity gravel contributed the quartz and chert pebbles and probably much of the sand matrix. Three terraces are discernible along the Brazos valley:

[122]Analyzed by E. C. Sargent.

3. Upper or upland terrace about 210 feet above the valley bottom. This contains a larger proportion of coarse gravel than the lower terraces. This deposit is early Pleistocene, or possibly pre-Pleistocene in age. It carries no fossils. In many places this terrace is the source of good gravel beds made up of a high percentage of quartz and chert.
2. Middle or intermediate terrace about 90 feet above the river in some places, to about 120 feet above the river in others. This late Pleistocene deposit of sand and gravel has yielded in a few places bones of Pleistocene mammals.
1. Lower terrace about 50 feet above the valley bottom. This is probably of post-Pleistocene age. In most places this material consists of a large proportion of sand, but it may contain pockets or lentils of good gravel.

Altered Pennsylvanian conglomerate deposits occur along the outcrop of the Brazos River sandstone, the Lake Pinto sandstone, and the Turkey Creek sandstone. The pebbles weather out of the hard conglomerate ledges and accumulate as gravel deposits some places along the base of the rock escarpment. In other places the rock is solidly cemented and breaks off in blocks and chunks which are extremely hard and cannot be broken down into individual pebbles. A deposit of the hard facies is to be seen on top of the escarpment on highway No. 1, three miles southeast of Mineral Wells. Softer, less consolidated layers occur near the town of Garner in western Parker County. In places where the rock is not too hard to be crushed economically, it yields a very good road material that wears much better than that produced by crushing and screening the Palo Pinto limestone.

Undeveloped gravel deposits.—The gravel deposits of the county have not been developed to the extent which the amount, quality, and accessibility of the beds warrant. Gravel for building the half-million-dollar dam at Lake Mineral Wells was hauled all the way from east of Fort Worth, when equally good material could have been procured within a few miles of the dam. Gravel beds of sufficient size and extent to produce a good supply of gravel have been noted at many places along the terraces of Brazos River and larger creeks of the county. A little prospecting along the flat terraces within a mile or two of the river will reveal workable deposits of gravel. The terraces along Palo Pinto Creek also contain much gravel, and thick deposits have likewise been noted along the valley of Keechi Creek. The outcrop of the Brazos River conglomerate in the eastern part of the county, especially in that portion extending from Inspiration Point to Garner in Parker County, contains much excellent chert gravel which in places weathers out to form sizable deposits of gravel.

CEDAR OIL

Cedar oil is manufactured from cedar wood in a plant erected at Graford in 1933. The red cedar (*Juniperus pinchoti* Sudworth) grows in thick stands along the limestone ridges of the Canyon formation. It is especially abundant along the outcrop of the Palo Pinto limestone. The trees average 8 to 12 inches in diameter, and are from 20 to 30 feet tall. They have been cut and used for fence posts since the invention of barbed wire. Many carloads of posts are shipped out of the county each year. In 1932, Mr. W. G. Richardson started experimental work on the manufacture of cedar oil from red cedar wood, and in 1933 he built and began operating a small plant at Graford. The cedar logs are dried, then ground to a fine wood dust. The dust is placed in retorts and distilled with steam. Two and one-half cords of wood yield from 8 to 12 gallons of oil. The oil is further refined and sold at about $2.25 per gallon. The cedar wood costs on the average $3.25 per cord. The Graford plant when completed will have a capacity of 50 to 100 gallons of oil per day; the plant is now running about 20 gallons daily. Cedar oil is used for paints, varnishes, polish, dust cloths, and in numerous other ways.

The cedar oil project promises to be a small but interesting new resource for Palo Pinto County.

WATER-POWER RESOURCES[123]

Availability of dam sites.—No county in all Texas has better water-power resources than Palo-Pinto. The State Board of Water Engineers has estimated that dams built along Brazos River will be

[123]*Literature.*—Bryan, Kirk, Silting of reservoirs: Studies by Engineers, National Research Council. Researches in Sedimentation in 1925–26, (mimeographed) pp. 88–94, 1926; Geology of reservoir and dam sites: U. S. Geol. Survey Water-Supply Paper 597, pp 1–38, 1929 Davis, A. P., Why some irrigation canals and reservoirs leak: Eng. News-Record, vol 8, pp. 663–665, 1918. Fuller, M.L., Dam and embankment failures in 1912, discussion of the types of structures and causes of destruction Eng News-Record, vol. 67, pp. 426–428, 1913. Justin, J. D, The

capable of impounding at least two million acre-feet of water within the limits of the county. This huge supply of water is capable of generating enough electric power to supply all Texas and adjoining states and of irrigating thousands of acres along the middle course of the river. Such a project is comparable in size and in potentialities to the Tennessee Valley Authority Project at Muscle Shoals, and when carried out it will constitute another guarantee of the future greatness of Texas' industrial empire.

Brazos River, receiving an annual run-off between 600,000 and 3,180,000 or more acre-feet of water per year, flows for more than one hundred miles in a very winding course through a narrow, steep-sided valley, which in places takes on the aspect of a canyon. Along this length of water course there are a large number of localities where successful dams could easily be built. All these localities have been investigated recently by the State Board of Water Engineers in coöperation with the United States Geological Survey, and several sites have been chosen that are especially satisfactory for impounding large reservoirs.

A good dam site should have the following requisites:[121]

1. A tight basin of ample size.
2. A narrow outlet suitable for constructing a dam economically.
3. Space for building a safe spillway.
4. Available materials for making concrete.
5. A basin that will not fill too rapidly with mud and silt.
6. Ample supply of water to fill the reservoir.
7. Market for water for irrigation or water power to assure returns on the investment.

---

design of earth dams: Amer. Soc. Civil Eng. vol. 87, pp. 1–61, 1924. Lapworth, Herbert, The geology of dam trenches: Trans. Inst. of Water Engineers (London), vol. 16, pp. 25–31, 1911. Lee, W. T., Water resources of the Rio Grande Valley in New Mexico and their development: U. S. Geol. Survey Water-Supply Paper 188, pp. 25–30, 1907. Lippincott, J. B., Storage of water on King's River, California: U. S. Geol. Survey Water-Supply Paper 58, 1902. Mead, D. W., Report on the damn and water-power development at Austin, Texas: pp. 1–205, Privately printed, Madison, Wis., 1917. Meinzer, O. E., Renick, B. Coleman, and Bryan, Kirk, Geology of No. 3 reservoir site of the Carlsbad irrigation project, New Mexico, with respect to water-tightness: U. S. Geol. Survey Water-Supply Paper 580, pp. 1–39, 1927. Patton, L. T., Geology and the location of dams in west Texas: Econ. Geol., vol. 19, pp. 756–761, 1924. Ransome, F. L., Geology of the St. Francis dam-site: Econ. Geol., vol. 23, pp. 553–563, 1928. Stearns, H. T., Porosity of reservoir prevents water storage, Malad reservoir, Idaho: Eng. News-Record, vol. 96, p. 561, Apr. 8, 1926.

[121]Lippincott, J. B., Storage of Water on King's River, California: U. S. Geol. Survey Water Supply Paper 58, p. 25, 1902.

These requirements, except the last, are easily fulfilled in most Palo Pinto County dam sites. The formations are dense, compact shale containing lentils of fine, water-filled, consolidated sandstone and overlain by limestone which at most sites occurs above the level of the spillway. The average width of the valley at the sites is less than 1400 feet. The rock ledges below the valley rims will make excellent foundations for spillways. Rock suitable for crushing, gravel, and sand are abundant at all the sites. Most of the sites are easily accessible to roads for haulage of materials. The rate of silting of Brazos River in Palo Pinto County is estimated to be not over 100 acre-feet per year. The amount will settle out largely in the upper dams, so that if a series of dams is constructed, silting up of the lower dams will be decidedly less. The yearly run-off of water available for the river is estimated by the Board of Water Engineers to be nearly two million acre-feet per year on the average.

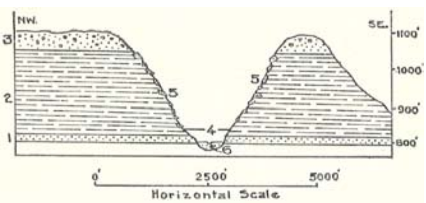


Fig. 23.—Profile and generalized geologic cross-section of Brazos River valley at the dam site southwest of Inspiration Point. 1, Poorly bedded, hard sandstone; 2, shale, in places covered by talus from above; 3, hard Brazos River conglomerate standing in resistant ledges; 4, spillway elevation; 5, talus; 6, alluvium.

The sites selected by the Board of Water Engineers are described in the following paragraphs.

Inspiration Point dam site.—This site is located eight miles south of Mineral Wells and about one and one-half miles north-northeast of Brazos, which lies on the main line of the Texas and Pacific Railway. The site is up the river from Inspiration Point in a direction about one and one-half miles west-southwest of the Point (Pl. II). Brazos River at the dam site cuts through the Brazos River sandstone and makes a narrow and steep-sided valley about 600 feet wide at the bottom and about 1500 feet wide at the 830-foot elevation (above sea level). which is the proposed elevation of the spillway. This narrow, steep-sided valley offers one of the best dam sites in the entire course of the river.

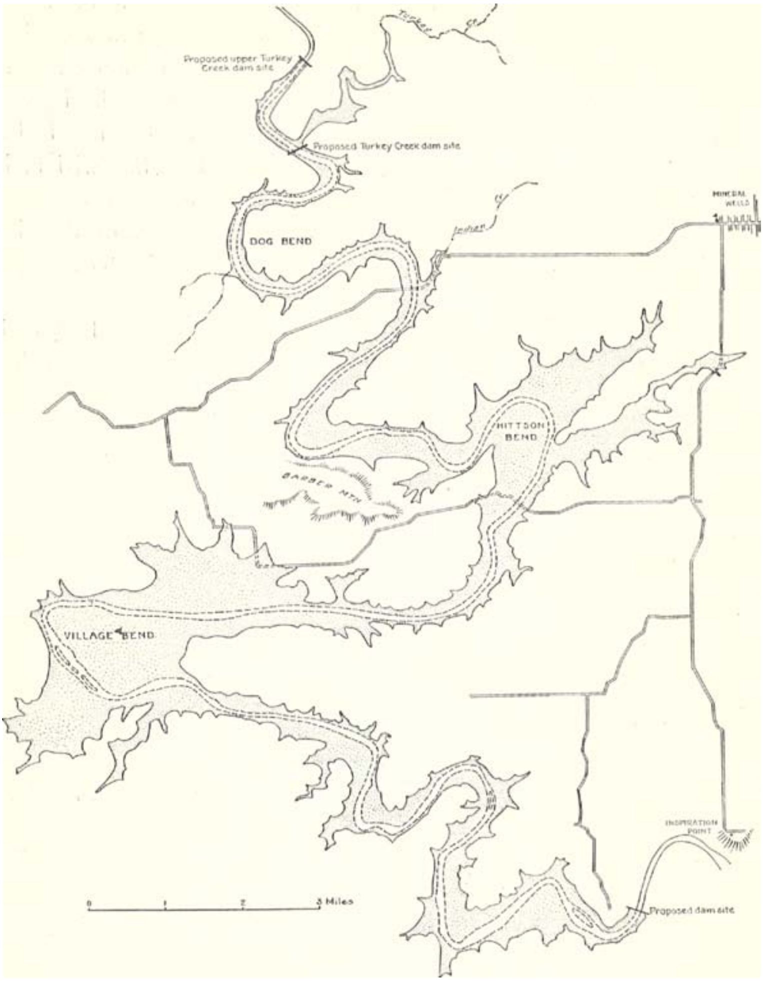


Fig. 24.—Lake to be formed by the proposed dam near Inspiration Point.

Much of the section near the valley bottom is covered by talus and slope wash from the escarpment. Core drilling will be necessary before an accurate section of the strata can be recorded. It is safe to say, however, that the section contains no unduly porous layers or pronounced fractures or other features unfavorable for dam construction. The sand and silt in the river bottom is probably not over 20 feet thick. The conglomerate comprising the Brazos River sandstone member will furnish a plentiful supply of material for concrete construction. A profile across the Brazos valley at this damsite is shown in figure 23.

This dam, if built with its spillway at the 830-foot elevation, will have a storage of about 300,000 acre-feet of water and will produce a lake 35 miles long measured along the winding course of the valley (fig. 24). A dam of this size should be capable of generating 11,000 kilowatts of electricity,[125] will supply abundant water for irrigating the rich soil of the Brazos flood plain below the dam, and will add to the attractiveness of the county's pleasure resorts.

Turkey Creek dam site.—This dam site is located on Brazos River just below the mouth of Turkey Creek, two and one-quarter miles north-northwest of the State Highway bridge and five miles west of Mineral Wells (Pl. II). The valley at this point is constricted, because the river is cutting through resistant Turkey Creek sandstone

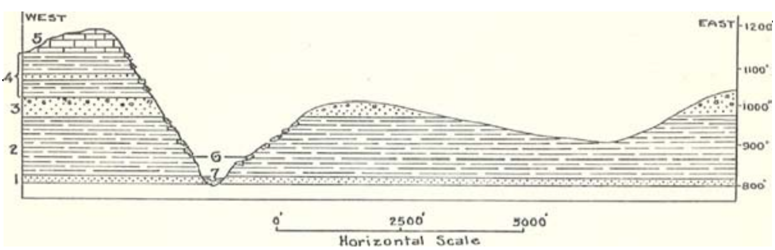


Fig. 25.—Profile and generalized geologic section across Brazos River valley at the dam site near the mouth of Turkey Creek. 1, Lake Pinto sandstone, not exposed but lies 15 feet or more below the bed of the river; 2, Salesville shale containing at its base a thin limestone; 3, Turkey Creek limestone; 4, Keechi Creek shale containing thin layers of limestone; 5, Palo Pinto limestone; 6, spillway elevation (860′); 7, Brazos River low-water level (810′).

and is undercutting on the west the high escarpment of the Palo Pinto limestone. The valley at this site is about 1500 feet wide at the 860-foot (above sea level) elevation, which is the elevation chosen for the spillway, and is 600 feet wide at the water level. A profile of the valley at this dam site is shown in figure 25.

The geologic section at this site consists of shale, with a little sandy shale, and one thin bed of limestone at the base. The top of the west bluff (fig. 28) is capped by a thick ledge of Palo Pinto

[125] Swift, A., Brazos River conservation and reclamation district: Report made for the State Board of Water Engineers, Dec., 1933.

limestone. The valley sides are covered by talus from the bluffs above, and in the lower part of the slopes by alluvium, so that an exact and detailed description of the strata can not be made until trenching or core drilling has been undertaken. It is safe to say, however, that the section contains no porous or loose sand layers unfavorable in any way to dam construction and that the sand in the river bottom is not over 20 feet thick.

A dam constructed at this site will be approximately 1500 feet long at the top, 50 feet high, and will form a lake 39 miles long measured along the course of the river. It will impound more than 40,000 acre-feet of water and be capable of developing 10,000 kilowatts of electricity.[126]

Upper Turkey Creek dam site.—Another excellent location for a dam exists 1.2 miles by river above the mouth of Turkey Creek. The width of the valley at the water level is 700 feet and only 900 feet at the spillway elevation, so that this dam site is shorter than that at the mouth of Turkey Creek.

The geologic section at this location is similar to that described for the Turkey Creek dam site and is quite favorable for dam construction. This site, however, is not so accessible, and road construction to the site will be much more expensive and haulage of materials farther. The capacity of the reservoir back of this site will be only slightly less than that of the Turkey Creek reservoir.

Little Keechi dam site.—This site is located on Brazos River just above the mouth of Little Keechi Creek, one and one-quarter miles below the Palo Pinto-Graford road bridge, seven miles north of Palo Pinto (Pl. II). The river at this locality cuts a narrow valley about 1200 feet wide through the Palo Pinto limestone escarpment. Beneath the limestone near the bottom of the valley, shale, sandy shale, and fine-grained, hard, calcareous sandstone outcrop. The sand and silt fill in the bottom of the river is estimated to be about 20 feet. A section of the strata exposed along the side of the valley at this site is as follows:

---

[126]Streiff, *op. cit.*

Section measured at Little Keechi dam site, one and one-quarter miles below the Palo Pinto-Graford road bridge, measured from the top of the bluff on the south side of Brazos River to low-water level.

	Thickness *Feet*
8. Gravel	2
7. Limestone, grey, thin, unevenly bedded, weathering to platy chips	4
6. Limestone, grey, hard, massive, medium bedded, weathers into large blocks	11.7
5. Marl, bluish grey, soft	10
4. Limestone, unexposed	5.5
3. Limestone, light grey, hard, massive, breaks along joints into large impervious blocks	42
2. Limestone, grey, thinly bedded, breaks along wavy uneven bedding planes	10
1. Sand, silt and clay at water's edge covering base of limestone	?
Total thickness measured	85.2 +

The north side of the river at this locality is a rock terrace covered by an unknown thickness of river sand and silt, which will have to be trenched, in order to build the dam on bed rock.

This dam site, because of the narrowness of the valley above the site, consequent small storage capacity, and possible necessity of grouting much of the limestone walls in order to make the rock definitely impervious, appears to be the least favorable Palo Pinto County site so far suggested. A 45-foot dam, with a spillway at an elevation of 875 feet, will flood an area of 2100 acres, impound 30,000 acre-feet of water, and produce a lake 19 miles long.

Possum Kingdom dam site.—This site is located in Possum Kingdom Bend of Brazos River, 10½ miles northwest of Palo Pinto and 10 miles due north of State Highway No. 1 and about 30 miles from the nearest railroad at Strawn, is not accessible by any present county or state highway. It can be reached, however, by a ranch road that leads north from Brad across Belding Ranch, or by a ranch road south from Pickwick and across Weldon Ranch.

The River at Possum Kingdom Bend has cut a canyon only 900 feet wide through the massive Merriman limestone, the underlying shales, and the thin limestone members of the Graford formation, thus offering an ideal dam site. The valley here is so narrow and

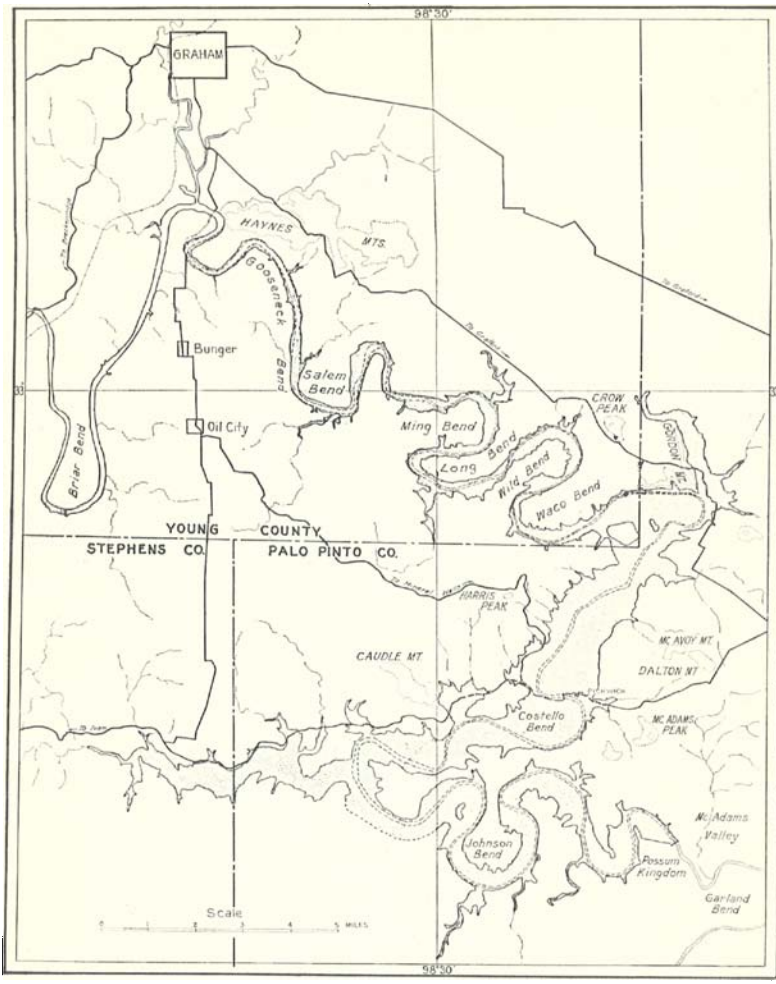


FIG. 26.—Lake to be formed by the proposed dam on Possum Kingdom Bend of Brazos River.

the walls so steep, that, in proportion to the amount of water impounded (fig. 26) less concrete will be needed than at any other point selected by engineers in the county. A cross-section of the valley at this site is shown in figure 27.

It is proposed to build the spillway at the 1000-foot elevation. This will require a dam 125 feet high and about 1000 feet long at the top. The reservoir as planned will be 60 miles long, will cover a total area of 21,300 acres of land, will impound water enough to reach back into Young County almost to the city of Graham, and will have a storage capacity of 757,000 acre-feet of water.[127] This is the largest reservoir so far proposed in Texas. Such a dam will be capable of generating 13,000 kilowatts of electricity and will insure a power supply sufficient for any future need of north Texas.

A generalized geologic section measured at the dam site in Possum Kingdom Bend is as follows:

Geologic section at the dam site on Brazos River at Possum Kingdom Bend, measured from top of bluff on north side of river to low-water level.

	Thickness *Feet*
5. Limestone, light gray, nearly white on weathered surface; much jointed near escarpment edge; contains numerous chert nodules	24
4. Limestone, gray, divided by bedding planes into beds from 6 to 12 inches thick	18
3. Limestone, gray, massive, hard; forms prominent protruding ledge	10
2. Limestone, yellowish gray, prominently bedded, compact granular, breaking with rounded surfaces, bottom covered by talus	52
1. Talus slope, broken angular chunks of limestone of all sizes, more or less covered by red silt and alluvium; sloping down to river at maximum angle of 37 degrees	175
	279

The total thickness of the limestone is known to be at least 125 feet and in places even 150 feet. It is compact, hard, massive, and less pervious than most limestones. Below the limestone the section consists, from the top downward, of 15 to 20 feet of sandy shale, 15 to 30 feet of medium-grained, gray, calcareous sandstone, and 100 feet of fine-grained, compact, thin-bedded, calcareous shale containing a few layers of limestone. The section on the south side of the river is similar, except that the talus slope is higher and less steep, and less limestone is exposed. A cross-section of Brazos valley at this dam site is shown in figure 27.

[127]Streiff, *op. cit.*

The dam site is ideal except for its inaccessibility. It will be necessary to build a road north from Brad a distance of 10 miles. The northern two miles of such a road must descend over steep limestone ledges and will require much blasting to obtain a suitable grade.

The strata in the bottom of the canyon are unexposed and need to be explored by core drilling. From a knowledge of this part of the geologic section exposed in other areas, it is inferred that no fractured or unduly porous rocks will be encountered. Gravel for making concrete can be manufactured by crushing the hard ledges of Merriman limestone or by locating gravel pits along the Brazos River terraces.

All factors considered, Possum Kingdom Bend appears to be one of the best dam sites in Texas.[128] The short length of dam required, the large amount of water impounded, the comparatively low price of land to be submerged (since no towns, oil fields, or industrial improvements will be effected), and the proximity of the location to the cities of Abilene, Wichita Falls, Mineral Wells, Fort Worth, and Dallas make this and the other sites in Palo Pinto County stand out as notable projects certain to play an important part in the industrial history of Texas in the near future.

---

[128] Other examples of water-power development in central and north-central Texas are:

1. Hamilton Dam on Llano River, Llano County. Length, 7000 feet; maximum height, 137 feet; capacity, 1,000,000 acre-feet; estimated cost, $5,500,000. Construction suspended for two years. About one-quarter complete. This year (1934) the U.S. Public Works Commission has appropriated $1,500,000 for the completion of this project, and it is estimated that Insull interests have already spent about $3,000,000.
2. Bridgeport Dam on West Fork of Trinity River, 4 miles west of Bridgeport., Wise County. Height, 110 feet; capacity, 290 000 acre-feet.
3. Eagle Mountain Dam on West Fork of Trinity River, about 20 miles northwest of Fort Worth, Tarrant County. Height, 60 feet; capacity, 210,000 acre-feet.
4. Lake Dallas on Elm Creek, east of Denton, Denton County. Height of dam, 65 feet; capacity, 211,000 acre-feet.
5. Lake Worth Dam on Trinity River, Tarrant County. Original capacity, 47,177 acre-feet.
6. Brownwood Dam on Pecan Bayou, Brown County. Maximum height, 80 feet; capacity, 110,000 acre-feet.
7. Cisco Dam, northwest of Cisco, Eastland County. Length, 1190 feet; maximum height, 133.5 feet; capacity, 45 000 acre-feet.
8. Lake Kemp Dam on Wichita River, Baylor County. Maximum height, 100 feet; capacity, 550 000 to 610,800 acre-feet.
9. Mineral Wells Dam on Rock Creek, Parker County. Maximum height, 68 feet; capacity, 7300 acre-feet.

Feasibility of dam construction.—The planned economy projected by the federal government calls for conservation of the country's water resources and the prevention of disastrous floods. The State Board of Water Engineers, in furthering these projects of dam construction, has investigated the entire Brazos River drainage basin and has selected a number of reservoir sites with the view to recommending the construction of a series of dams to impound water during times of heavy rainfall, to provide means of irrigation of rich lowlands during drought periods, and at the same time to generate cheap electric power. Three of the best locations for dams along the course of the Brazos are those in Palo Pinto County described above.

Two objections against the project of dam construction have been raised by citizens. First, the excessive cost of construction is out of proportion to the probable returns from sale of electricity. This

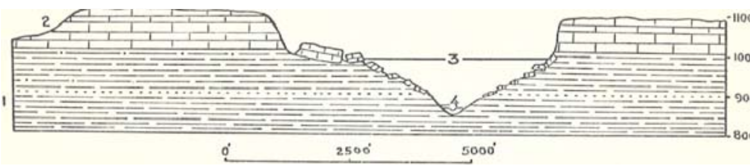


FIG. 27.—Profile and generalized geologic section across Brazos River at the dam site on Possum Kingdom Bend. 1, Wolf Mountain shale; 2, Merriman limestone; 3, spillway elevation at 1000 feet; 4, low-water level at 875 feet.

objection, however, is met largely by recognizing the prevention of the annual loss of millions of dollars in crops by floods that sweep over rich alluvial soil of the valley bottoms and of the lowlands along the lower course of the river. Second, the rapid silting up of reservoirs may soon seriously reduce the storage capacity. This question of silting is important and has received the earnest attention[129] of the Board of Water Engineers. Studies of the rate of silting by measurements and observations made by Hawley,[130] Tay-

10 Austin Dam on Colorado River, Travis County, to be located 3 miles above Austin. Length, 1091 feet; height, 66 feet; original capacity 49 300 acre-feet.

11 Medina reservoir on Medina River in Bandera and Medina counties, to be located 35 miles north of San Antonio. Height, 164 feet; capacity 254 000 acre-feet.

[129] Faris, Orville A., The silt load of Texas streams: U. S. Dept. Agric. Tech. Bull. 382. pp. 1 71, 1933.

[130] Hawley, J. B., Siltation of Austin and Lake Worth in Texas: Eng. News-Record, vol. 91, p. 811, 1923.

lor,[131] Hemphill,[132] Nagle,[133] and Faris have brought out the following data regarding the rate of silting:

Rate of silting in some reservoirs in Texas.

Reservoir	Size	Period	Amount of silting	Annual rate of silting
	Acre-feet		*Acre-feet*	*Acre-feet*
Old Cisco	55	1889–1910	4.9	0.23
Old Austin	49,300	1893–1900	23.559	3,365
New Austin	?	1913–1922	26,663	2,963
Lake Worth	47,177	11 years	10,890	990

The amount of silt carried in the river water varies with the amount of flow. It is greatest during periods of flood and least during periods of low water, as shown by the graph,[134] figure 31. Silt comes from two sources:

1. Scour and erosion of the stream channel by the waters of the main stream, a process that will be active as long as the water does not have a full load of silt.
2. Soil erosion, slope wash, and channel scour by all the tributaries that feed the main stream.

The proportion of silt from these two sources in Brazos River has not been ascertained. The first source, however, is larger than is generally supposed, as indicated by the large proportion of red bottom silt in the flood water and by the short duration of run-off through the tributaries, usually a matter of a few hours, whereas high water in the main channel may last for many days or weeks.

The load of silt in the main channel of a river is greatly reduced by dam construction, since reservoirs retard the rate of flow and prevent bottom scour in those parts of the streams occupied by lakes. The upper reservoir in a series is most affected by silting from the valley above the dam. Reservoirs below derive their silt largely from surface run-off and tributary streams. Silt in tributary

[131]Taylor, T. U., The Austin Dam: Univ. Texas Bull. 164, pp. 1–85, 1910; Silting of the lake at Austin, Texas: Univ. Texas Bull 2139, pp. 1–23, 1921; Silting of reservoirs: Univ. Texas Bull. 3025, pp. 1–170, 1930

[132]Hemphill, R. G., Silting and life of southwestern reservoirs: Amer. Soc. Civ. Eng. Proc., vol. 56, pp. 967–979, 1930

[133]Nagle, J. C., Progress report on silting measurements: U. S. Dept. Agric. Off. Exper. Sta. Bull. 133, pp. 196–217, 1903; Bull. 119, pp. 365–392, 1902; Bull. 104, pp. 293-324, 1902.

[134]Faris, *op. cit.*, p. 17.

streams can be reduced by planting vegetation in areas of rapid erosion, by terracing the slopes, and by constructing dams at advantageous sites along the principal branches. The latter method is most effective.

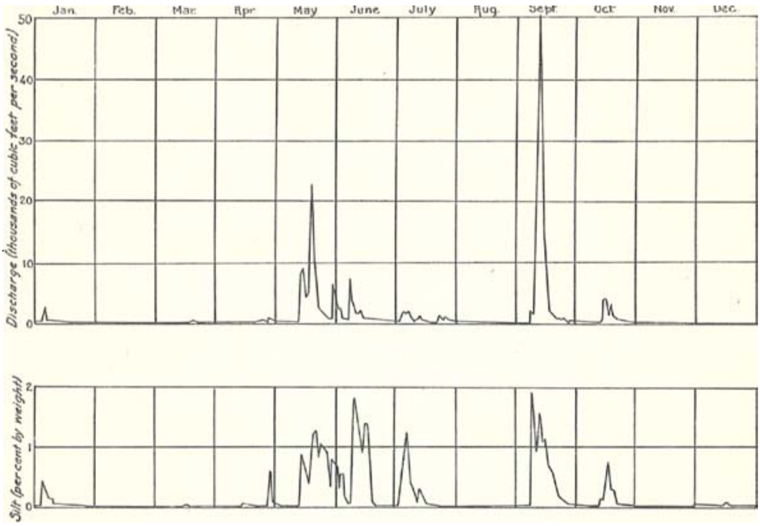


FIG. 28.—Graph showing discharge in second-feet and percentage of silt by weight, Brazos River, Mineral Wells, 1929. (After O. A. Faris.)

If the project of constructing a series of dams at intervals along the upper course of the Brazos is carried out, and if some practical plan to retard silting by the largest branch streams is worked out, the project of Brazos River water conservation and utilization will be of great and lasting benefit to the people of central Texas. If the project is restricted to a single reservoir, and particularly if a plan to curb silting is not undertaken in connection with reservoir construction, silting up, with decided reduction of water storage capacity, will take place in a comparatively short time.

SCENIC RESOURCES

Palo Pinto County is rich in spots of natural scenic beauty. Each year increasing numbers of tourists visit Mineral Wells and Palo Pinto to spend their vacations. Many come because of the mineral water; but fully as many others are attracted by the beauty of the lakes, cliffs, canyons, gorges, and caves carved by Nature's processes out of the massive limestone and conglomerate escarpments.

Many of the most beautiful spots are readily accessible in a few minutes' drive or walk from the resort hotels. Others, more remote, less well known, and uncontaminated with man-made roads and buildings, are even more beautiful and more worth the effort to explore them. A thrill awaits the enterprising traveler who searches out and discovers some of the many unexplored canyons, grottos, and emerald green pools of water for himself; and more pleasure will come when he introduces them to his nature-loving friends. The best-known and most-admired scenic spots are described briefly in the following paragraphs.

Inspiration Point.—(Co-ord. R-14.) Eight miles south of Mineral Wells. Follow the road leading due south from Mineral Wells High School (Southwest Fifth Ave.). Inspiration Point is a perpendicular cliff capped by Brazos River conglomerate. It rises 300 feet above the Brazos valley and offers an unexcelled view of the river flowing in its deeply intrenched, meandering course (Pl. I).

East Mountain.—(Co-ord. S-9.) East side of the city of Mineral Wells. Ascend the slope by Northeast Second Avenue, which leads directly north from Baker Hotel. The "mountain" is a mesa capped by the Lake Pinto sandstone and rises 140 feet above the city. This vantage point offers an aeroplane view of Mineral Wells and of the rolling farm lands to the east. Mineral Wells Country Club, Camp Wolters, and the Country Club Lake are visible in the foreground.

West Mountain.—(Co-ord. R-9). West side of the city of Mineral Wells. Ascend Tenth Street to the top of the mesa. The mountain is capped by Lake Pinto sandstone, a rock that furnishes a natural fortress for the National Guard Cavalry Camp maintained by the State on the summit. The top of the mountain is an upland park of oak trees, cacti, and buff, brown, and red ledges, and rock piles. The city of Mineral Wells holds one's gaze on the east, and beautiful little Lake Pinto rests in a green, tree-covered valley on the west.

Lake Pinto.—(Co-ord. R-9.) One-half mile west of Mineral Wells. Go north on the road branching off from Highway No. 1 on the east side of Grande Courts Tourist Camp. A beautiful little lake lies between steep boulder- and tree-covered valley walls cut out of West Mountain. The lake is privately owned by Baker Hotel Company. Boats are for rent, and fishing privileges are permitted at a reasonable price. In the summer the lake is famous for its beautiful lotus blossoms.

Lake Mineral Wells.—Four miles east of Mineral Wells on the western edge of Parker County. Go east on Hubbard Street past Camp Wolters and the Mineral Wells Country Club. A beautiful lake three and one-half miles long and three-quarters of a mile wide, with oak-covered rocky shores is situated in the valley of Rock Creek. The lake is owned by the City of Mineral Wells. Boats are for rent at the dam, and fishing is allowed.

Barber Mountain.—(Co-ord. O-11.) Six miles east of Palo Pinto. Go out Highway No. 1 and turn south at the filling station 4.1 miles west of Brazos River bridge; continue south and east about five miles. The mountain, a jagged promontory capped by Lake Pinto sandstone, rises 200 feet above Brazos River valley. Its top is a stiff climb on a hot day; but, once reached, it affords an excellent view of the valley and surrounding country.

Kyle Mountain.—(Co-ord. J-9.) Four miles north of Palo Pinto. Take the Palo Pinto-Graford road and at a point 3.9 miles by road south of Brazos River bridge turn west toward the Boy Scout camp. The mountain is capped by a remnant of Merriman limestone, which stands nearly 200 feet above the surrounding lowlands and lies three and one-half miles from the main outcrop of the Merriman limestone. The summit affords an excellent view of all of the central part of Palo Pinto County with its rugged topography, many escarpments, winding stream courses, and cedar forests. To the west are Fortune Bend, Crawford Bend, Chick Bend, and Dalton Bend, intrenched meanders of the Brazos River. Schoolhouse Mountain and McKenzie Mountain lie across the river, to the northwest; and Antelope Mountain and Crawford Mountain are situated to the southwest.

Scout Camp.—(Co-ord. J-9.) Go north from Palo Pinto on the Graford road, turn west along road about four miles north of Palo Pinto at the sign marked "Scout Camp." The camp is on a terrace overlooking the east side of Chick Bend of Brazos River. The lodge and club houses are in a grove of beautiful red cedar. The buildings are constructed of natural Palo Pinto County rocks. Specimens of petrified wood and fossiliferous rock make attractive fireplaces. The troops have a small museum of fossils, arrow heads, and natural curiosities.

McAdams Peak.—(Co-ord. F-5.) This prominence, located two miles southeast of Pickwick, furnishes another wonderful view. The Brazos in its curving course flows both to the north and to the south, and the most rugged escarpments in the county are on all sides. The bends in the river are truly remarkable. In traversing a straight line distance of 35 miles from northwest to southeast, the river actually flows over a course more than 130 miles long. The explanation of this tortuous course, which adds much to the charm of the scenery, is found in the geologic history of the county. At the end of the Lower Cretaceous period, north-central Texas land arose above sea level, and the sea coast was established along a line drawn approximately from Fort Worth to Waco. As a result of this uplift of land above the sea, Brazos River had its beginning. The newly emerged land was flat and featureless. The coastal plain streams meandered broadly over the gently inclined plain. As the land slowly rose and the sea retreated, the surface strata were slowly cut away. The river cut deeper, but continued to flow in its winding course. Finally, the soft Cretaceous rocks were cut through and the river found its channel, intrenching older Pennsylvanian rocks beneath. As some of the Pennsylvanian strata are extremely resistant, the river was deflected by hard ledges and cut deepest on the down-dip side of its valley. It thus shifted its course down dip toward the northwest and undercut the hardest ledges. These intrenching and shifting processes have contributed to the picturesque scenery in its winding valley and steep cliffs.

Brazos River Bluffs on Weldon Ranch.—(Co-ord. F-6.) This beauty spot lies two and three-quarters miles southeast of Pickwick. Take the Weldon ranch road from Pickwick, go to Weldon ranch house and turn nearly due south along a dim pasture road one-half mile to the bluffs on the north side of Possum Kingdom Bend. This bluff is one of the most picturesque of the limestone bluffs undercut by the Brazos. It is a sheer cliff of massive Merriman limestone rising 200 feet above the river, which at this point flows northward in a broad bend until it is deflected eastward and then turns south again. The top of the bluff offers a fine view of the sweeping curves of the river flanked by precipitous white limestone cliffs fringed with cedar and *Opuntia* along their tops and braced at their base by a short, steep talus slope covered by dark-green oak trees. It is this locality that the State Board of Water Engineers has chosen as the site for one of the largest dams on the Brazos. It is to be hoped that this man-made reservoir, if constructed, will form a beautiful curving lake that will add to the natural beauty of this imposing landscape.

Metcalf Gap.—(Co-ord. C-12 and D-12.) Sixteen miles west of Palo Pinto along Highway 1B. Metcalf Gap, site of the pioneer trails west from Fort Worth and Weatherford, is a picturesque deep valley with precipitous walls and shady trees. The canyon has been cut through the massive Merriman limestone, and great blocks of that rock border the roadway which follows the winding valley of the headwaters of a branch of Ioni Creek and ascends more than 200 feet in two miles along a very picturesque course. Ioni Creek is fed by numerous springs, and pools of clear water are to be found along its course even in the driest periods.

Johnson Ranch.—(Co-ord. J-18.) Located eleven miles south of Palo Pinto and two miles east of the Palo Pinto-Gordon road. The homestead of the Johnson family, pioneers in southern Palo Pinto County and early developers of the coal mines which have played such an important part in the industrial history of the county, is on the Johnson ranch. The house is situated in a beautiful grove of trees on a terrace on the west side of Palo Pinto Creek. In the grove is a park containing a large herd of deer. One mile west of the homestead, on a rocky prominence nestling in a dense growth of oak, is a mausoleum built out of native sandstone boulders picked up on the nearby ridge. It constitutes a fitting monument to this enterprising family.

Falls of Palo Pinto Creek.—(Co-ord. O-18.) One and three-quarters miles northeast of Santo. Take the Santo-Brazos road and turn off at the first left fork and drive to Warren farm. The waters of the creek fall over a massive ledge of white, and greatly jointed limestone, which forms a natural dam in the downward course of the stream. Above the falls there is a broad pool of water that furnishes a much-appreciated swimming pool and a good fishing locality.

CONCLUSIONS

Palo Pinto County is indeed fortunate in the diversity and quantity of its resources, in its vast stores of coal, petroleum, natural gas, and water power, and in its beautiful scenery. It is our hope that this review of the more important features will serve to acquaint others with the county's natural wealth and to awaken a conscientious desire to develop it further. The economical utilization of natural resources is the best guarantee of future security and of permanent prosperity. Palo Pinto County can contribute bountifully to this end.

BIBLIOGRAPHY

Adams, H. H., Geological structure of Eastland and Stephens counties, Texas: Bull. Am. Assoc. Petrol. Geol., vol. 4, pp. 159–167, 1920.

Cheney, M. G., History of the Carboniferous sediments of the Mid-Continent oil field: Bull. Am. Assoc. Petrol. Geol., vol. 13, pp. 557–559, 1929.

———, Stratigraphic and structural studies in north-central Texas: Univ. Texas Bull. 2913, 29 pp., 1929.

Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., pp. 521–534, 1891.

Dobbin, E., Geology of the Wiles area, Ranger district, Texas: U. S. Geol. Survey Bull. 736, pp. 55–69, 1922.

Donoghue, David, Note of the Ranger sand, Eastland County, Texas: Bull. Am. Assoc. Petrol. Geol., vol. 11, p. 635, 1927.

Esgen, W. K., Relation of accumulation of petroleum to structure in Stephens County, Texas: Structure of Typical American Oil Fields, vol. 2, pp. 470–479, 1929.

Goldman, M. I., Lithologic subsurface correlation in the "Bend Series" of north-central Texas: U. S. Geol. Survey Prof. Paper 129, pp. 1–22, 1921.

Hornberger, Joseph, Jr., The Mineral Wells gas field: Report submitted to the Department of Petroleum Engineering Library, The University of Texas, 1931.

Kennedy, William, Report on Palo Pinto and Stephens counties: Private report submitted to the Lone Star Gas Company (typewritten), 110 pp., Nov., 1916.

Matteson, W. G., A review of the development in the new central Texas oil fields during 1918: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 173–175, 1919.

Miser, H. D., Llanoria the Paleozoic land area in Louisiana and eastern Texas: Am. Jour. Sci., ser. 5, vol. 2, pp. 61–89, 1921.

Moore, R. C., and Plummer, F. B., Pennsylvanian stratigraphy of north-central Texas: Jour. Geol., vol. 30, pp. 18–42, 1922.

National Oil Scouts Association of America, Yearbooks: p. 275, 1931; p. 202, 1932; p. 100, 1933.

Pepperburg, L. J., Structural features in Palo Pinto County, Texas: Western Engineering, vol. 6, No. 6, pp. 252–254, Dec., 1915.

Phillips, W. B., Texas petroleum: Univ. Texas Bull. 5 (Mineral Survey series, Bull. 1), p. 30, 1900.

Plummer, F. B., Preliminary paper on the stratigraphy of the Pennsylvanian formations of north-central Texas: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 132–150, 1919.

———, Pennsylvanian sedimentation in Texas: Ill. State Geol. Survey Bull. 60, pp. 259–269, 1931.

———, and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. Texas Bull. 2132, pp. 1–237, 1921.

Pratt, W. E., Geologic structure and producing area in north Texas petroleum fields: Bull. Am. Assoc. Petrol. Geol., vol. 3, pp. 44–70, 1919.

Reeves, Frank, Geology of the Ranger oil field, Texas: U. S. Geol. Survey Bull. 736, pp. 11–170, 1922.

Schoch, E. P., Chemical analyses of Texas rocks and minerals: Univ. Texas Bull. 1814, pp. 153–155, 224–225, 1918.

Scott, Gayle, and Armstrong, J. M., The geology of Wise County, Texas: Univ. Texas Bull. 3224, pp. 1–77, 1932.

——— ———, The geology of Parker County, Texas: MS. submitted to Bureau of Economic Geology, The University of Texas, 1933.

Sellards, E. H., On the underground position of the Ellenburger formation in north-central Texas: Univ. Texas Bull. 1849, pp. 1–32, 1918.

———, The pre-Paleozoic and Paleozoic systems in Texas: Univ. Texas Bull. 3232, pt. 1, pp. 55–144, 1933.

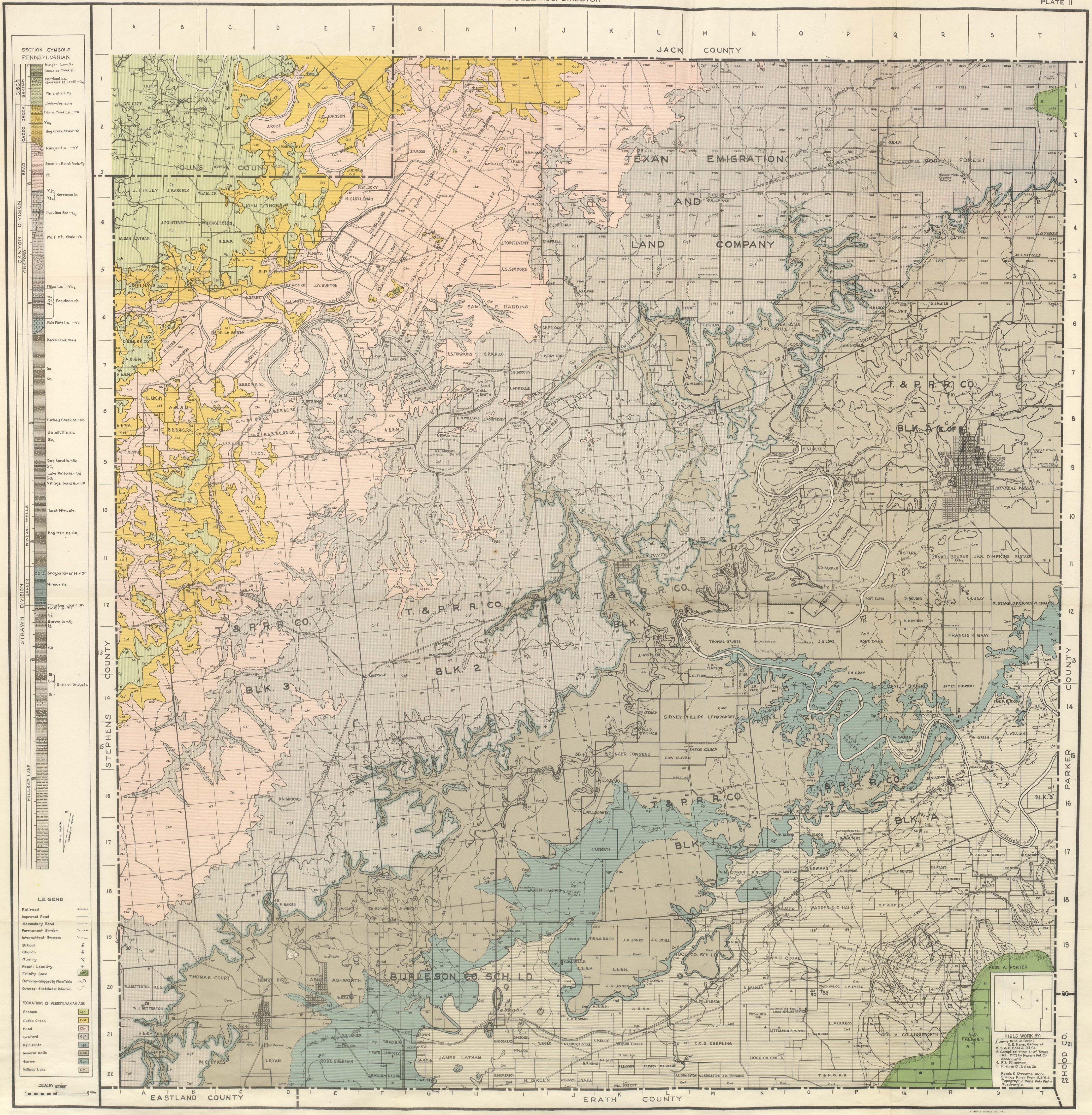
Shaw, E. W., Gas in the area north and west of Fort Worth: U. S. Geol. Survey Bull. 629, pp. 42–54, 1916.

Turner, S. F., Mineral-water supply of the Mineral Wells area, Texas: U. S. Geol. Survey Circ. 6, pp. 1–9 (mimeographed), 1934.

Udden, J. A., and Waite, V. V., Some microscopic characteristics of the Bend and Ellenburger limestone: Univ. Texas Bull. 2703, 8 pp., 1927.

Wegemann, C. H., reconnaissance in Palo Pinto County, Texas, with special reference to oil and gas: U. S. Geol. Survey Bull. 621, pp. 51–59, 1915.

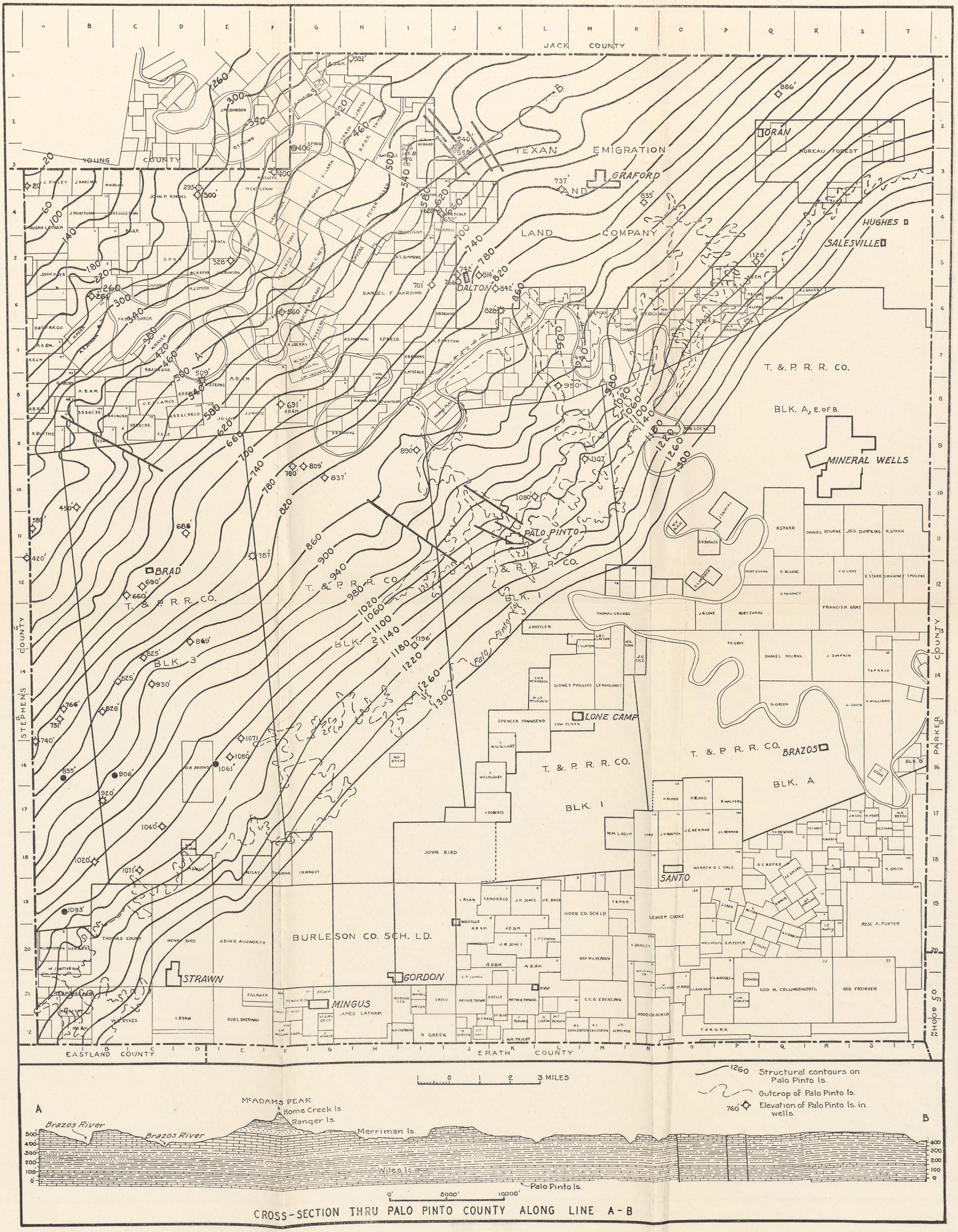
INDEX



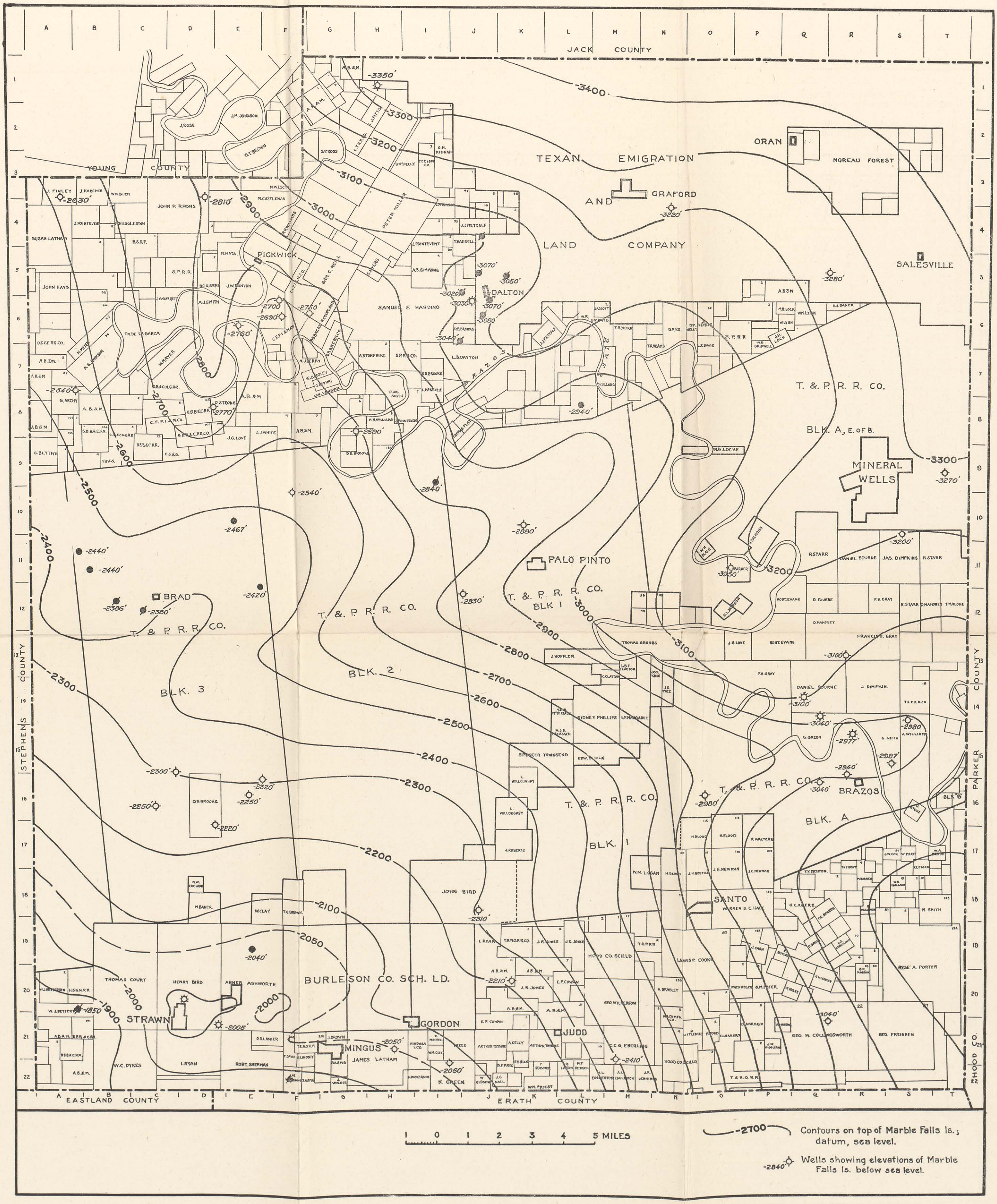
GEOLOGIC MAP OF PALO PINTO COUNTY, TEXAS

BY

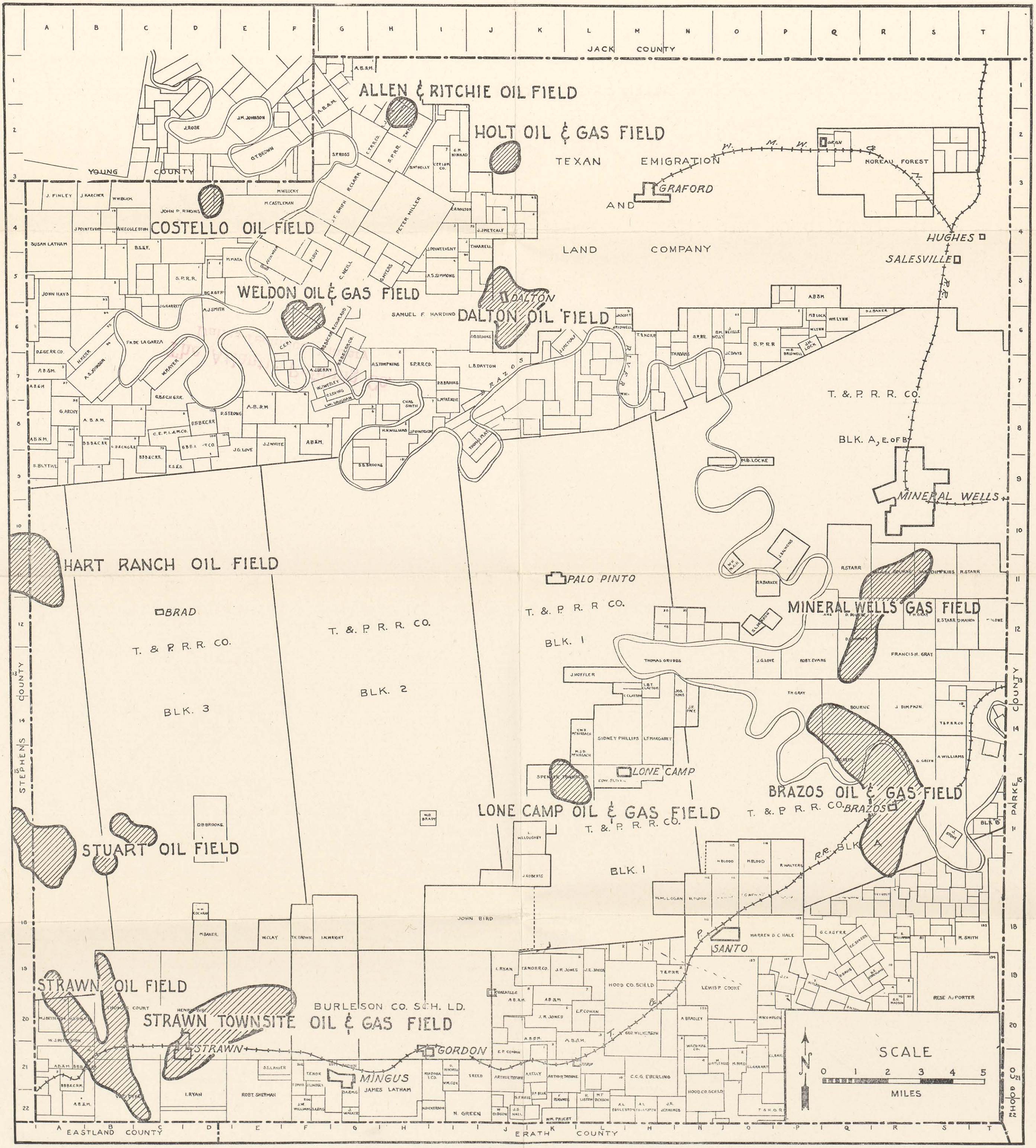
F. B. PLUMMER AND JOSEPH HORNBERGER, JR.



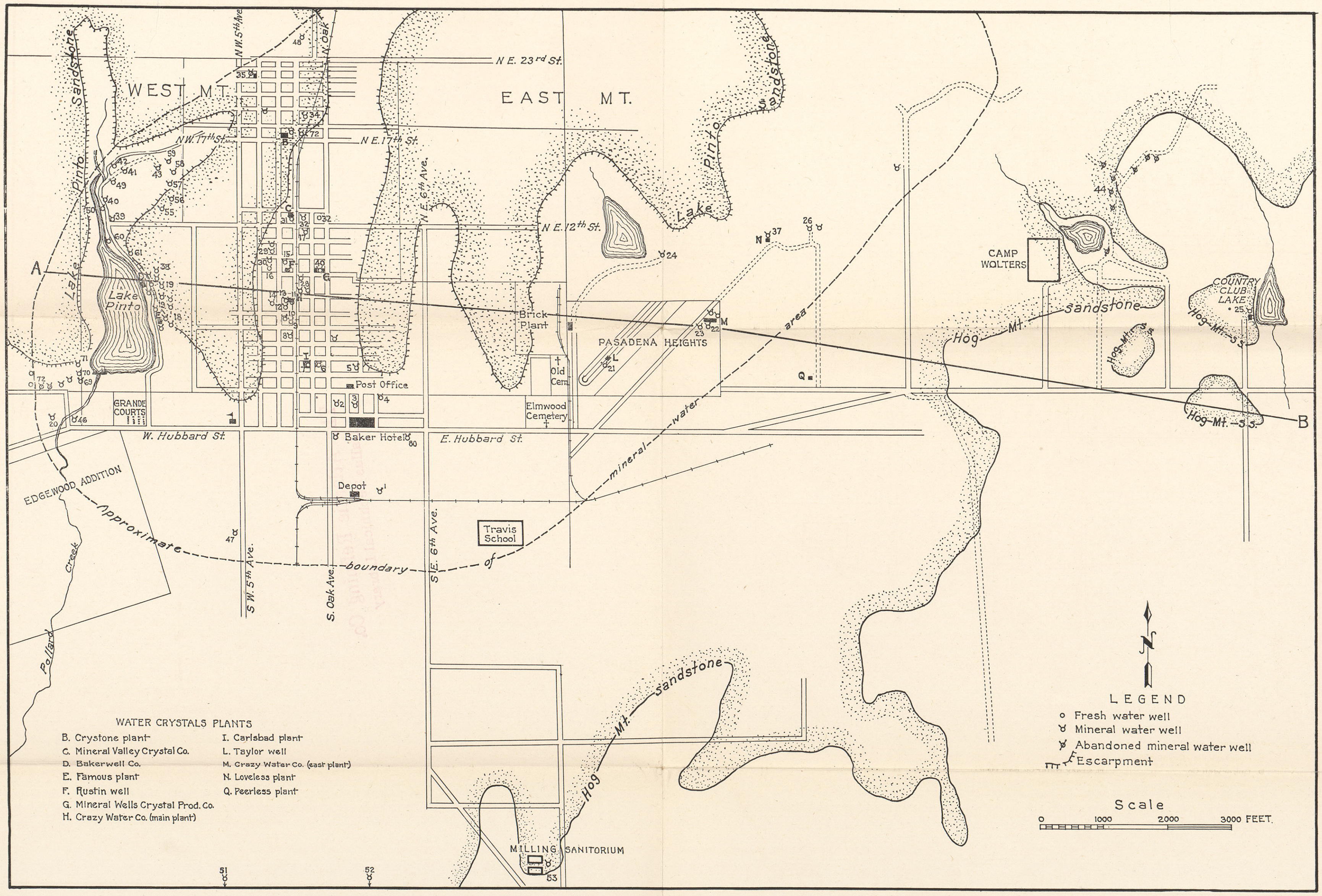
SURFACE STRUCTURE OF PALO PINTO COUNTY.

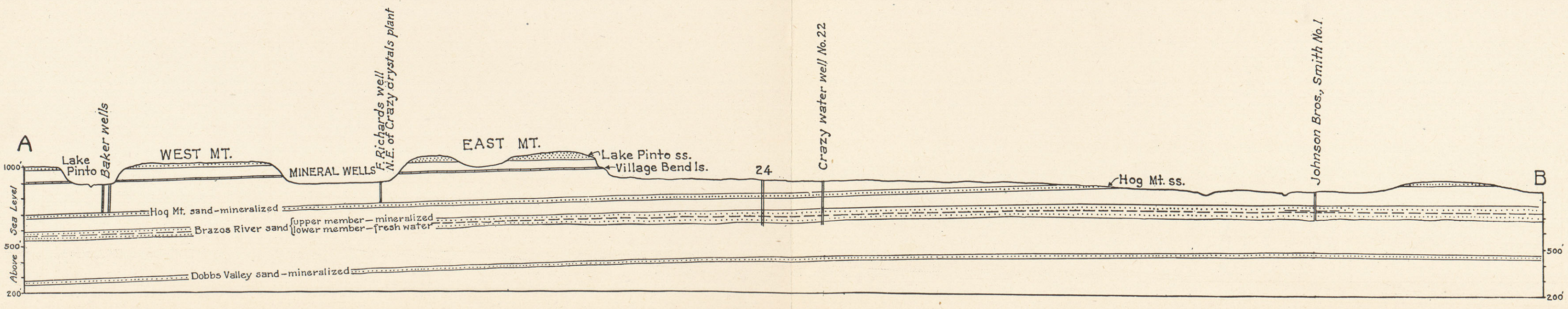


MAP SHOWING CONTOURS ON TOP OF MARBLE FALLS LIMESTONE IN PALO PINTO COUNTY.



OIL AND GAS FIELDS IN PALO PINTO COUNTY.

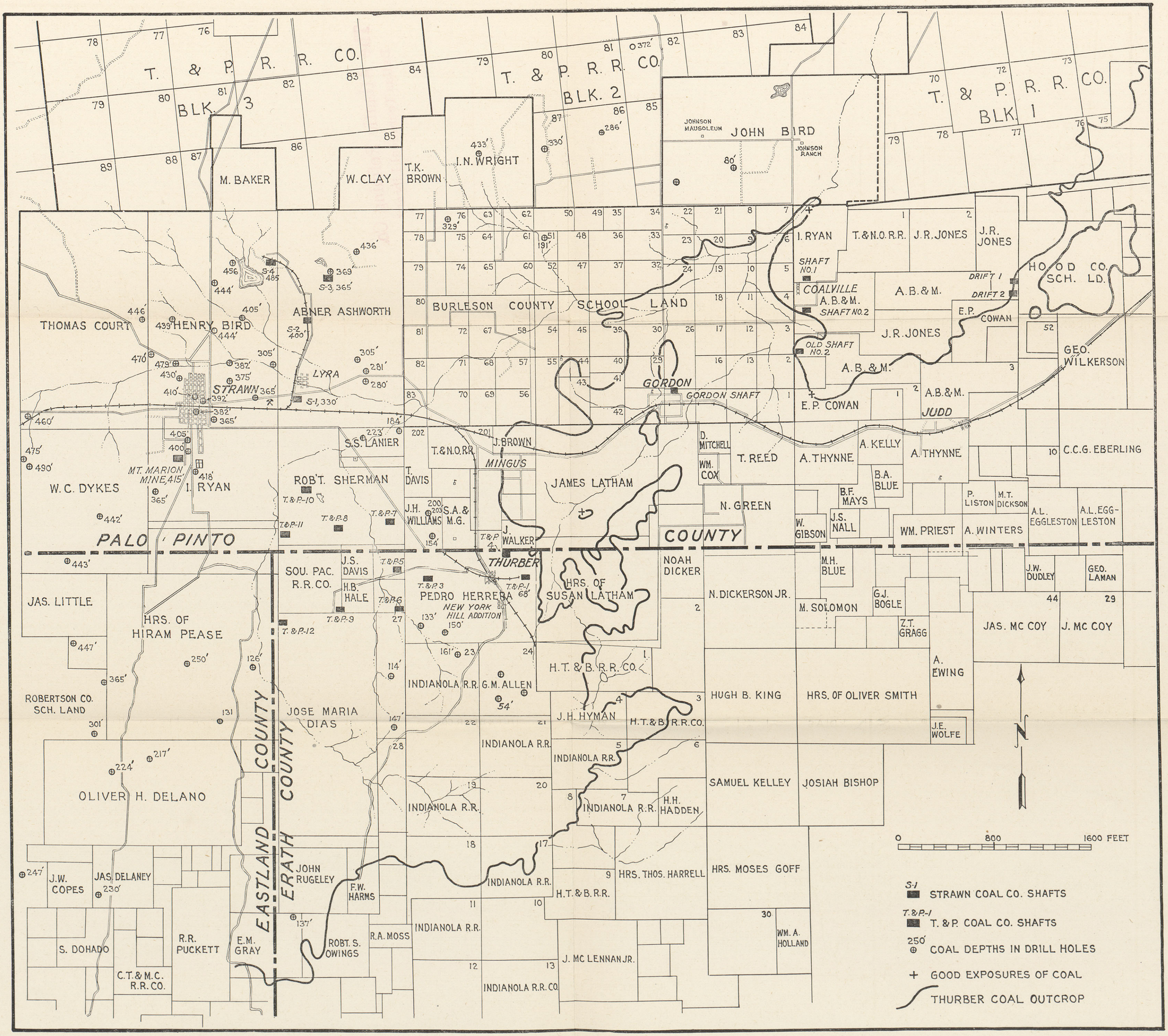




		Depth
1.	Sims well[a] (38 years old)	90–106
2.	Davis wells	----
3.	Star wells	----
4.	Baker Hotel wells (7)	162
5.	Crazy Hotel wells (7), Group 5	147–177
6.	Crazy No. 1 (original well)	170
7.	Carlsbad wells (2)	125
8.	Gibson "Little Well"	137–151
9.	Gibson "Big Well"	387
10.	Gibson well	----
11.	Sangcura wells (3)	137–151
12.	Lynch discovery well	110
13.	Palo Pinto well	125
14.	Crazy Well Water Co. wells	218
15.	Austin[a] well	165
16.	Crazy Well Water Co. wells (15), Group 6	167–190
17.	Indian wells	167–190
18.	Famous wells	175–200
19.	Baker wells	178
20.	City park well[a]	----
21.	Taylor well	117
22.	Loveless wells (3)	88–218
23.	Crazy Well Water Co. wells[a]	195–219
24.	Brick plant well (fresh water at 308′), mineral water at	140
25.	Country Club well	----
26.	Peerless wells (6)	----
27.	R. S. Luke wells (12)	200
28.	Hester well	----
29.	R. T. Jones well	----
30.	Crazy Well Water Co. No. 4	----
31.	Mineral Valley Water Co. wells	----
32.	Baker wells (2)	----
33.	Crystone wells	----
34.	Mineral Valley Water Co. wells	----
35.	Dalton well	230
36.	Lamar wells (3)	120
37.	Dependable Crystal Co. wells	----
38.	Bartlett well	280
39.	Upham[b] No. 19	----
40.	Upham No. 20	----
41.	Upham No. 21	----
42.	Upham No. 22	----
43.	Upham No. 29	----
44.	Upham wells (8)	----
45.	Upham No. 45	----
46.	Oscar Bish[a] well	154
47.	S. H. McMeen well	322
48.	Deep Well Water Co.	383
49.	W. S. Ford well	200
50.	Upham No. 50	214
51.	Mattie Foster well[a]	77
52.	Barris well[a]	48
53.	Milling well[a]	----
54.	Upham No. 54	----
55.	Upham No. 55	----
56.	Upham No. 56	----
57.	Upham No. 57	----
58.	Upham No. 58	----
59.	Upham No. 59	----
60.	Upham No. 50	----
61.	Upham No. 61	----
62.	Upham No. 62	----
68.	Upham No. 68	----
69.	Upham No. 69	----
70.	Upham No. 70	----
71.	Upham No. 71	----
72.	Coffin wells (3)	----
73.	Upham No. 28	201
76.	Johnson well	----
77.	Old French well (near locality No. 5)	168
78.	Old Barber well (near locality No. 72)	----
79.	Old Central Hotel well (near locality No. 5)	----
80.	Bitter well	----
81.	Brown's well	----
82.	Cicero Smith well	----
83.	Crazy deep well	400
84.	Lamar deep well	400

[a]Water analysis available.
[b]Formerly Bakerwell Company.

MINERAL-WATER AREA IN THE VICINITY OF MINERAL WELLS.



STRAWN COAL FIELD.