GEOLOGY OF THE PONTOTOC AREA, MASON, LLANO, AND SAN SABA COUNTIES, TEXAS

A Thesis

By

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Chairman of Committee

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FRONTISPIECE

The Llano basin. View to the south from road cut on top of escarpment north of Pontotoc. Lower Cap Mountain Limestone Member forms the sides of the road cut. The Hickory Sandstone Member crops out between the escarpment and Pontotoc. The hills in the background are formed by Precambrian gneiss and granite.

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ABSTRACT

The Pontotoc area is situated on the northern flank of the Llano uplift and includes portions of Mason, Llano and San Saba counties. The area is characterized by a steep, east-west trending escarpment north of Pontotoc, and by low to moderately high hills in the northeast and southeast parts.

Precambrian, Upper Cambrian, Lower Cretaceous, and Quaternary rocks are exposed in the Pontotoc area. The Precambrian rocks consist predominantly of a gneiss-schist unit which has been intruded by masses of fine-grained granite and by aplite dikes. The Upper Cambrian Riley and Wilberns formations consist of sandstone, limestone, and shale members. Cretaceous rocks are exposed in three outliers north of Pontotoc and consist of three units, which are in ascending order: a basal conglomerate-sandstone unit, a siltstone unit, and a limestone unit. These units were not mapped separately due to the gradational contacts between the units and to the thick soil cover. The Cretaceous rocks unconformably overlie the Cambrian rocks and are not involved in faulting. Lithologic and paleontologic evidences indicate that the Cretaceous rocks are stratigraphically equivalent to the Edwards Limestone of the Fredericksburg Group. Rocks of Quaternary age are limited to a few very small deposits of alluvium and conglomerates that occur along the major streams.

The relief of the area prior to deposition of Upper Cambrian rocks was moderately high and rugged as is indicated by the occurrence of Precambrian gneiss extending upward into the Cap Mountain Limestone Member.

Cheney (1940, p. 105) suggested that the Llano uplift is structurally related to the Concho arch which trends northwestward from the Llano region. The main structural features in the Llano uplift are northeast-trending horsts and grabens. The Pontotoc area is situated on one of the horsts which has been named the Pontotoc axis by Cheney.

The Paleozoic strata in the northern half of the Pontotoc area form a northward-dipping cuesta and are cut by a series of southeast-trending transverse faults that are perpendicular to the normal northeast trend of the faults in the Llano region. The amount of throw along the faults varies from a few feet to about 200 feet. It is believed that differential uplift of the Pontotoc axis resulted in the strata being placed under stresses strong enough to produce faulting. The faulting in the Pontotoc area probably occurred during the time of major deformation of the Llano region.

The Llano region was extensively eroded during post-Canyon and pre-Early Cretaceous time with little or no deposition of Permian, Triassic, and Jurassic rocks.

Plummer (1950, p. 101) and Barnes (1941, p. 1994) stated that the first Cretaceous strata deposited over the entire Llano region were either the upper portion of the

Comanche Peak Limestone or the lower portion of the Edwards Limestone. Supporting this conclusion by Plummer and Barnes is the fact that the Cretaceous strata in the Pontotoc area are considered to be equivalent to the Edwards Limestone.

Land and ground water are the most important resources in the Pontotoc area. The land is used for ranching and farming, and the water is used for human and livestock consumption. A small deposit of caliche north of Pontotoc has been quarried for use as road material. The quarry is abandoned at the present time.

GEOLOGY OF THE PONTOTOC AREA, MASON, LLANO, AND SAN SABA COUNTIES, TEXAS

INTRODUCTION

STATEMENT OF PROBLEM

The principal objectives of this study were: (1) to map and describe the stratigraphic units which crop out in the Pontotoc area; (2) to determine the structure of the area; (3) to determine the age of the Cretaceous strata in the area; and (4) to reconstruct the geologic history of the area.

The first problem included the megascopic study of the exposed lithologies of the various formations and members and the determination of the boundaries of these formations and members. The second problem included the distribution and magnitude of the faults and the areal extent and attitude of the various stratigraphic units. The third problem involved the megascopic study of the lithology and paleontology of the Cretaceous strata exposed in the area. Analyses and interpretations of the relations of stratigraphy, structure, and physiography within the area were essential to the solution of the fourth problem.

The general objective of this study was to provide additional data that might contribute toward a better understanding of the geology and geologic history of the Llano uplift.

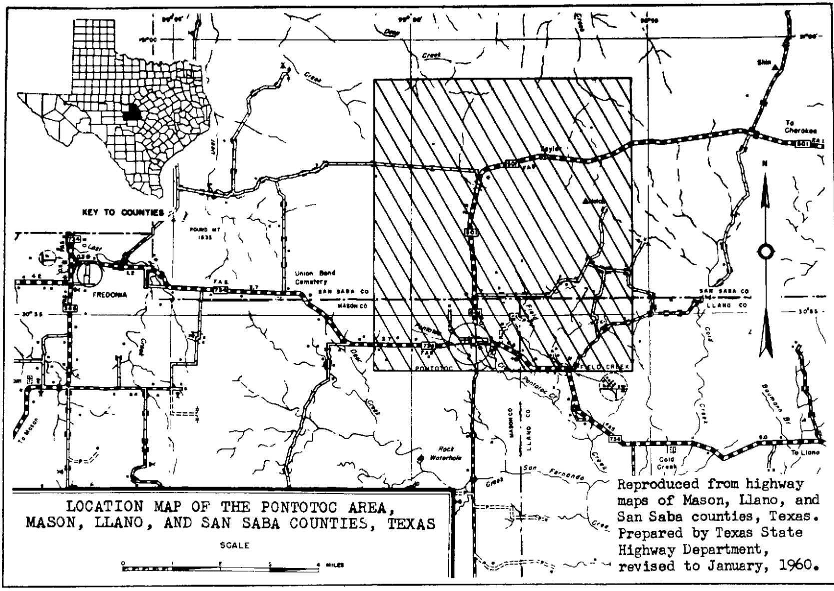
LOCATION

The Pontotoc area is situated on the northern flank of the Llano uplift; has an area of approximately 32 square miles, and includes portions of the northeastern corner of Mason County, the northwestern corner of Llano County, and part of southwestern San Saba County (fig. 1).

The Pontotoc area is rectangular, having a north-south length of 6.0 miles, and an east-west width of 5.3 miles. The northern boundary is a line 4.5 miles north of and parallel to the San Saba-Mason county line, and the west boundary is a fence line 3.0 miles west of and parallel to the Mason-Llano county line. The southern boundary is a line 1.5 miles south of and parallel to the San Saba-Mason county line, and the eastern boundary is a line 2.3 miles east of and parallel to the Mason-Llano county line.

ACCESSIBILITY

The Pontotoc area is easily reached from all neighboring towns by Ranch Roads 734 and 501. Accessibility to most of the area is very good as the two major highways are intersected by a number of unpaved but well-maintained county roads from which many private ranch trails lead to windmills, stock tanks, and feeding areas. Most of these ranch trails are passable by car, but a few require the use of a pickup or jeep.



LOCATION MAP OF THE PONTOTOC AREA, MASON, LLANO, AND SAN SABA COUNTIES, TEXAS

Reproduced from highway maps of Mason, Llano, and San Saba counties, Texas. Prepared by Texas State Highway Department, revised to January, 1960.

Figure 1

METHODS OF FIELD WORK

The field work was conducted between June 13, 1961 and September 7, 1961. An additional weekend was spent in the field in the company of Mr. C. L. Seward and Dr. K. J. Koenig for the purpose of confirming the geologic interpretations at a few localities.

Mapping of the various stratigraphic units and faults was done on acetate overlays of U. S. Department of Agriculture aerial photographs of series BRH-4W, numbers 114-120, 36-42, and 26-33 dated November 6, 1958. The scale of these photographs is 1:20,000 or three inches equal about one mile. Older sets of U. S. Department of Agriculture aerial photographs were used as aids in locating geologic contacts and alignments of possible faults. These older photographs are of series BRH-4E, numbers 206-210, 212, and 131-138 dated October 10, 1948; of series BRH-6E, numbers 90-95, and of series BRH-8E, numbers 33-38 and 40 dated November 29, 1948. The newer photographs were more useful because they showed the locations of new roads and areas that have been cleared of vegetation since 1948.

Geologic contacts and faults were traced in the field and their locations were plotted on the acetate overlays. Stereoscopic examination of the aerial photographs aided in locating some of the geologic contacts and faults which were partially obscure and difficult to recognize by field work alone.

A Brunton compass was used to determine the dips and strikes of the beds of the various stratigraphic units. The topographic relief shown in the structure sections on Plate I was taken from the U. S. Geological Survey topographic map of the Pontotoc Quadrangle, Texas dated 1955.

FIELD CONDITIONS

Although the topographic relief of the Pontotoc area is sufficient to provide good exposures in many places, there are several low areas covered by soil and vegetation where the location of contacts and faults can only be inferred. The thicknesses of a few exposed and unfaulted stratigraphic units were measured with a Brunton compass and a level rod; whereas, the thicknesses of poorly exposed units were estimated from widths of exposures and dips.

ACKNOWLEDGMENTS

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The author expresses thanks to the Bureau of Economic Geology at the University of Texas for permission to reproduce the map in figure 2 from one of their publications. Acknowledgment is expressed to Dr. K. P. Young, professor of Geology, at the University of Texas for his assistance.

Sincere thanks are expressed to the ranchers and local residents of Pontotoc whose friendliness and courtesy were a great help to the author. Appreciation is also extended to Mr. Dallas Miller who furnished living quarters for the author and his colleagues.

G E O G R A P H Y

CLIMATE

The Pontotoc area is located in a semi-arid region. Precipitation is somewhat unevenly distributed throughout the year; the average amount of rainfall per month is 2.17 inches. During the fall and spring months precipitation occurs in the form of heavy rains which produce fast, torrential run-offs.

The temperature of the area ranges from below 15°F in the winter months to about 105°F in the summer months. The annual mean temperature of the Pontotoc area is about 66°F.

VEGETATION

The vegetation of the Pontotoc area is limited to those plants which can survive in a semi-arid climate. Such plants include prickly pear, barrel catus, Spanish dagger, Mexican persimmon, needle grass, mesquite, scrub oak, and juniper (commonly called cedar).

The types and distribution of the plants are affected by soil types which, in turn, are related to the stratigraphic units from which they are derived. In general, the vegetation is fairly dense on Precambrian rocks, on uncultivated Hickory, Lion Mountain, and Welge sandstones, and on Cap Mountain, Morgan Creek, and San Saba limestones. The vegetation is sparse on the Point Peak shales. The Cretaceous limestones normally support a very dense growth of vegetation, but in recent years ranchers have cleared the land of cedar as a measure of ground water conservation.

INDUSTRY

The main industry of the Pontotoc area is the raising of cattle, sheep, goats, and hogs. Farming, with cotton, peanuts, watermelons, and grain as the principal crops, plays a secondary role in the area. Most of the cultivated fields are small and are located on soils derived from the Hickory Sandstone Member and the Precambrian gneiss-schist unit. A few fields located on Lion Mountain and Welge sandstones are not in cultivation at the present time.

PHYSIOGRAPHY

TOPOGRAPHY

REGIONAL

Topographically, the Llano uplift is an erosional basin in which Precambrian rocks exposed in the center are surrounded by a higher area of Paleozoic and Cretaceous rocks forming the rim of the basin. The basin area is the center of the uplift where the Precambrian rocks are structurally high, but less resistant to erosion than the surrounding Paleozoic and Cretaceous rocks, thus accounting for the basin. The total relief in the Llano region is about 1,600 feet.

LOCAL

The Pontotoc area is located in the northern part of the Llano uplift erosional basin. A fairly steep south-facing escarpment extends from west to east across the entire width of the area (Plate II). The average relief of the escarpment is about 260 feet. This escarpment, which is composed of nearly the entire Cambrian section and in part of the Cretaceous section, is cut by a number of canyons and small gullies.

One notable physiographic feature in the area is Round Mountain, an erosional remnant near the eastern end of the escarpment. This hill is elliptical in aerial view and

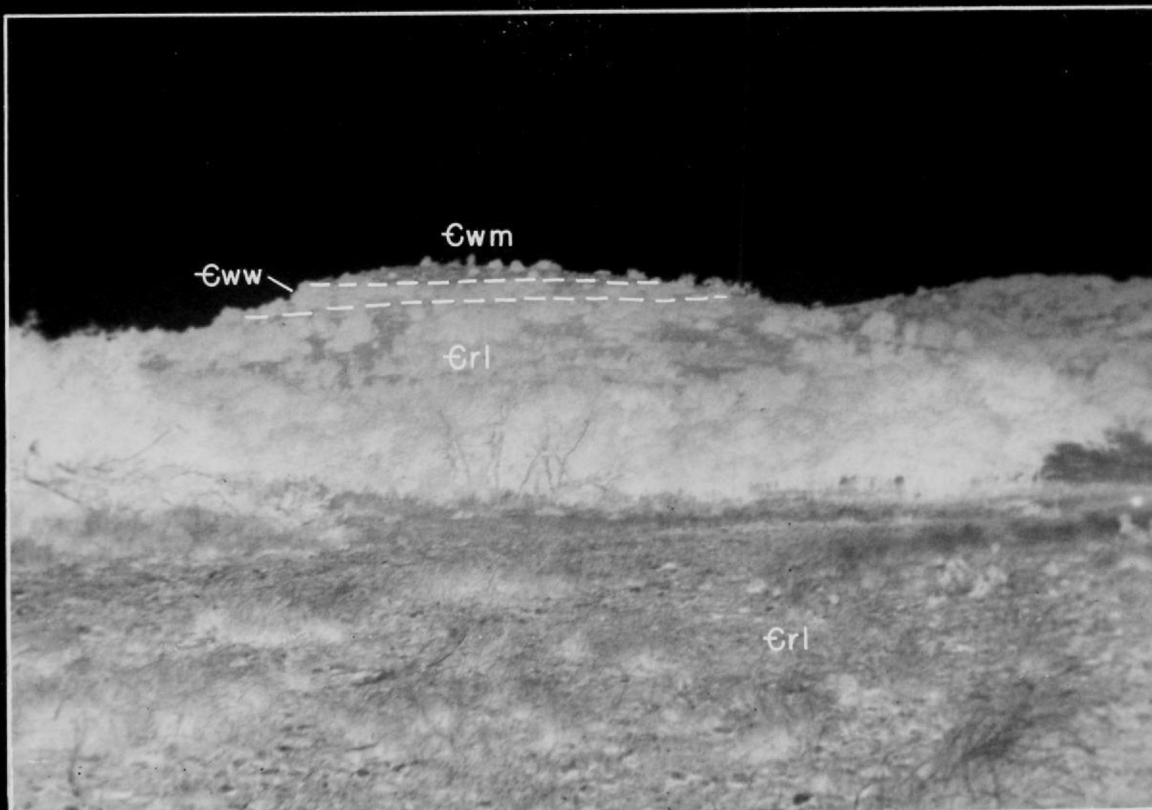
PLATE II

PANORAMIC VIEW OF ESCARPMENT

Panoramic view of escarpment two miles north of Pontotoc. The escarpment is formed in part of Cambrian rocks, ranging from the upper portion of the Hickory Sandstone Member to the lower portion of the Morgan Creek Limestone Member, and in part of Cretaceous rocks. The average relief of the escarpment is about 260 feet.

PLATE III

VIEW OF ROUND MOUNTAIN



View of Round Mountain on the W. H. Taylor property about four miles northeast of Pontotoc. This view illustrates some of the typical weathering characteristics of the Cambrian members which form Round Mountain. The Lion Mountain Sandstone Member(Ꞓrl) weathers to a gentle slope; the Welge Sandstone Member(Ꞓww) weathers to a ledge, and the Morgan Creek Limestone Member(Ꞓwm) forms a protective cap for the underlying sandstone members.

has a relief of about 100 feet. Round Mountain consists of Lion Mountain and Welge sandstones capped by basal Morgan Creek limestones (Plate III).

The relief of the area north of the escarpment is low except along the northern boundary of the Pontotoc area where the bioherm unit and the San Saba Member form hills having a relief of nearly 100 feet.

The basin area to the south of the escarpment consists of Precambrian gneisses, schists, and fine-grained granites, and of the Cambrian Hickory Sandstone Member. The area slopes to the south as a gentle, undulating plain above which rise a few low hills of Hickory Sandstone, and some higher, more ragged hills of Precambrian gneiss.

The highest elevation is 1,981 feet at Flag Ridge, and the lowest elevation is estimated to be about 1,390 feet at Field Creek Community; thus the maximum relief is nearly 600 feet in the Pontotoc area.

DRAINAGE

REGIONAL

The Llano region is drained by the Colorado River which flows southeastward and its tributaries which flow eastward. The tributaries are the San Saba River which drains the northern flank, the Llano River which drains the central area, and the Pedernales River which drains the southern flank of the Llano uplift.

The tributary streams of the San Saba, Llano, and Pedernales rivers are: Brady Creek which flows east into the San Saba River, Wallace Creek which flows north into the San Saba River, Cherokee Creek which flows northeast into the Colorado River, and Big Sandy Creek which flows east into the Llano River.

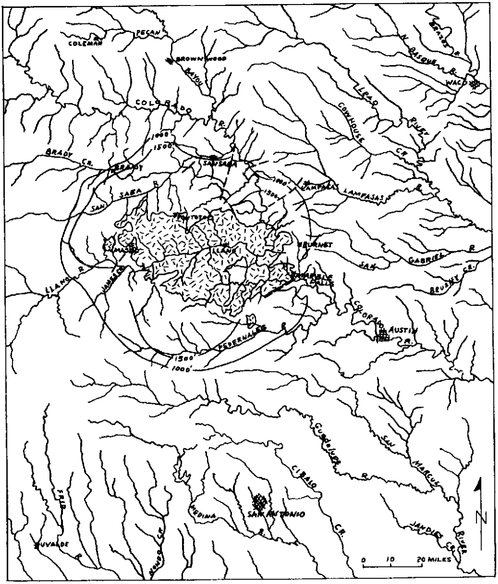
R. S. Tarr (1890) pointed out that the drainage pattern (fig. 2) clearly shows that the major stream sources were established on a former eastward sloping plain, and that the present streams are superimposed on Precambrian and Paleozoic rocks. Smaller streams do show some adjustment to local structures; whereas, the major rivers and streams do not.

LOCAL

There are two principal directions of drainage in the Pontotoc area. The northern half of the area is drained by West Deep Creek and East Deep Creek which flow northward to the San Saba River. The southern half of the area is drained by Pontotoc, Barrett, Field, and Panther creeks which flow southward to San Fernando Creek, a tributary of the Llano River. All of the streams are intermittent, but carry large amounts of water for short periods following heavy rains.

With the exception of Pontotoc and Panther creeks, none of the streams shows adjustment to local structure. Pontotoc Creek flows along a fault between Precambrian gneiss and Hickory Sandstone, and Panther Creek flows parallel to the strike of foliation and joints of the Precambrian gneiss.

Figure 2



Principal streams of central Texas showing drainage pattern. Contours are drawn on top of the Ellenburger Limestone showing the approximate size of the uplift. (After Plummer, 1950, p. 9)

REVIEW OF LITERATURE

The first published report describing the strata and fauna of the Llano region was made by Ferdinand Roemer (1848). In this report Roemer briefly described some of the older Paleozoic and Mesozoic strata. In a later publication, Roemer (1852) listed and described thirteen species of fossils from rocks of Cambrian and Ordovician ages.

Barrande (1853) concluded that Roemer had found the Primordial (Cambrian) fauna in Texas, and that the Primordial fauna was equivalent in age to the lowermost Paleozoic fauna in Wisconsin and New York.

B. F. Shumard (1860) reported on rocks of Cretaceous age in central Texas. In his report he named and described the Caprina Limestone, the Comanche Peak Group, and the Caprotina Limestone, all of which he considered to be of Late Cretaceous age.

B. F. Shumard (1861) confirmed the work of Barrande, described the Paleozoic rocks of Burnet County in great detail, and described nine new species of Cambrian fossils.

In 1883 Walcott (1884) visited the Llano area and described the Cambrian strata. Walcott proposed the name Llano Group for the pre-Potsdam strata. He correlated this Llano Group with the Grand Canyon Group on the basis of lithologic character and stratigraphic relationship with the overlying Potsdam Group, and referred the Llano Group to the Lower Cambrian Series.

G. G. Shumard (1886) briefly described the strata of the Llano area from his observations made in 1855 and 1856 while accompanying an expedition of army engineers.

B. F. Shumard's (1860) age determination of the Cretaceous strata was revised by R. T. Hill (1887). Hill placed the formations named by Shumard in the Lower Cretaceous Series, and proposed the name Fredericksburg Group. In a later report, Hill (1891) substituted Comanche Peak Chalk for Shumard's Comanche Peak Group. Hill also proposed the name Walnut Clay for the clay underlying the Comanche Peak Chalk, and removed the Caprotina Limestone from the Fredericksburg Group, thus making the Walnut Clay the oldest formation of the Fredericksburg Group.

The importance of the work done by Walcott (1884) in correlating the lowermost Paleozoic strata in the Llano region with the Cambrian Potsdam Group in Wisconsin was noted by Hill (1887) in his review of the geology of Texas. In another report, Hill (1889) named and established the correct age of the Carboniferous rocks at Marble Falls.

It was not until 1889, when the Texas Geological Survey was established, that a systematic geologic survey of the Llano region was undertaken. As a part of the Survey's investigation, T. B. Comstock (1890) published a report on the minerals and ores of the Llano region. Comstock (1890) also proposed the names Valley Spring Gneiss and Packsaddle Schist in subdividing the Precambrian metamorphic rocks, and proposed the terms Hickory Series (Lower Cambrian), Riley Series (Middle Cambrian), Katemcy Series (Upper Cambrian), and San Saba Series (Silurian) in his subdivisions of the Lower Paleozoic strata. Since that time, the Katemcy Series has been dropped from usage, and the other series names have been modified and redefined.

R. S. Tarr (1890) reported on the coal resources of the Llano region. Tarr also noted that the major streams in the Llano region cut across the Paleozoic strata without regard to the structure, and concluded that the streams originated on Cretaceous strata and are presently superimposed on the older Paleozoic rocks.

Hill and Vaughan (1897) did a comprehensive study of the Cretaceous strata in the Austin quadrangle, and changed the name Caprina Limestone to Edwards Limestone without modifying Shumard's definition of the formation. Hill (1901) proposed the name Comanche Peak Limestone in place of Comanche Peak Chalk.

Sidney Paige (1911) divided the Upper Cambrian strata into the Hickory Sandstone, the Cap Mountain Formation, and the Wilberns Formation in addition to naming and defining the Ellenburger Limestone (Lower Ordovician) and the Smithwick Shale (Middle Pennsylvanian). Paige also redefined the Precambrian metamorphic rock units. Paige (1912) published a detailed geologic folio which included topographic and geologic maps and structural cross-sections of the Llano-Burnet quadrangles. In this report Paige described and discussed the geology of the two quadrangles.

Udden, Baker, and Bose (1916), of the Texas Bureau of Economic Geology, published the first comprehensive geologic map of the State of Texas. The Paleozoic strata of the Llano uplift were divided into Pennsylvanian, Paleozoic undivided, and Cambrian-Ordovician.

A new geologic map of the Carboniferous formations was published by Plummer and Moore (1922). Plummer and Moore mapped the Lower Bend Shale as a separate formation having a distinctive fauna, and they proposed the name Barnett Shale. Girty and Moore (1919) discussed the age of the Barnett, and Girty concluded that it was Mississippian in age, and correlated the Barnett with the Moorefield Shale in Arkansas and the Lower Caney Shale in Oklahoma. Roundy, Girty, and Goldman (1926) reported locating a crinoidal limestone underlying the Barnett Shale, and assigned an age of Early Mississippian to the limestone. Sellards (1932) proposed the name Chappel for the crinoidal limestone.

W. S. Adkins (1928) published a comprehensive list of Cretaceous fossils. Descriptions of many of the fossils were also given.

In his description of the stratigraphic units along the Pedernales River in Gillespie and Blanco counties, Jones (1929) stated that the granites are of Precambrian age and are not intruded into the rocks of Paleozoic age.

Stenzel (1935) reported that the granites in the Llano region are intrusive in the gneiss and schist, and that the granites can be subdivided into three units on the basis of lithology and structural relationships. Stenzel also proposed a different interpretation from the interpretation by Paige (1911) regarding the ages of the Valley Spring Gneiss and the Packsaddle Schist. Stenzel considered the Valley Spring Gneiss to be younger than the Packsaddle Schist; whereas, Paige considered the Valley Spring Gneiss to be older than the Packsaddle Schist.

Sellards, Adkins, and Plummer (1932) compiled a review of the stratigraphy of Texas and included the Llano section. A geologic map of Texas was published by the same three men in 1933. A newer geologic map of Texas was prepared by Darton, Stephenson, and Gardner (1937) of the U. S. Geological Survey.

Sellards (1934) reported on the structure of the Llano region and suggested that the thinning of the Barnett Shale (Mississippian) over the Llano uplift indicated the first uplift of the area.

The Paleozoic fossils of the Central Mineral region originally described by Roemer (1848, 1852) were redescribed by Bridge and Girty (1937).

Bridge (1937) correlated the Upper Cambrian section of the Llano area with the Upper Cambrian sections of Missouri and of the upper Mississippi Valley. Bridge also named the

Lion Mountain Sandstone and designated it as a member of the Cap Mountain Formation.

Barnes and Parkinson (1939) described the ventifacts from the basal Hickory Sandstone. They reported that the ventifacts continued to form after deposition of the Hickory Sandstone began, and that a part of the Hickory Sandstone may represent wind-blown deposits.

Cheney (1940) proposed a new classification of the Pennsylvanian strata of north-central Texas on the basis of subsurface data. Cheney also suggested the structural relationship between the Llano uplift and the Concho arch.

A geologic map of San Saba County which covered part of the Pontotoc area was published by Plummer (1940).

Bridge and Barnes (1941) proposed a four-fold division of the Wilberns Formation consisting of a basal sandstone, a glauconitic limestone, a calcareous shale, and a limestone at the top. These members were not named until Bridge, Barnes, and Cloud (1947) redefined and described the units of the Cambrian section. They divided the Cambrian strata into the Riley Formation consisting of three members, and the Wilberns Formation consisting of four members. This work is now used as the standard reference for the Cambrian section in the Llano region.

In a progress report by Cloud, Barnes, and Bridge (1945), the Ellenburger Limestone was elevated to group status and restricted to the Lower Ordovician. They divided the group into three formations which are, in ascending order: the Tanyard Formation which consists of two members, the Gorman Formation, and the Honeycut Formation.

Cloud and Barnes (1948) reported on the Ellenburger Group of central Texas and the pre-Ellenburger strata at various localities in the Llano region. This report was a basic study of the Ellenburger rocks with an emphasis on features of possible significance to the search of new sources of petroleum. The authors also included a brief summary of the structural geology and geologic history of the Llano uplift.

A posthumous publication on the Carboniferous stratigraphy of the Llano uplift by Plummer (1950) included descriptions of the entire Paleozoic and Cretaceous stratigraphy.

H. R. Blank (1951) described and discussed weathering and exfoliation features of granite domes in the Llano uplift. Blank concluded that exfoliation was caused by the release of stresses within the granite masses.

Flawn (1956) reported that zircon age determinations of the granites in the Llano uplift showed an average age of 1,000 million years, and that the sedimentary rocks which were intruded by the granites are still more ancient. Earlier determinations indicated ages of 1,100 million years (Holmes, 1931), and of 1,050 million years (Hurley and Goodman, 1943).

A symposium on the Edwards Limestone in central Texas was prepared by Lozo et al. (1959). This report reviewed the classification and description of the Cretaceous section.

Jennings (1960) made a detailed study of the Pontotoc Northwest area which borders the Pontotoc area on the west. Other detailed studies of areas bordering the Pontotoc area have been conducted in the Pontotoc North-Northwest area by A. L. Chauvin, and in the Smoothingiron Mountain North area by B. M. Greenwood. Their reports are presently being prepared.

STRATIGRAPHY

GENERAL STATEMENT

The Pontotoc area contains rocks of Precambrian, Cambrian, Cretaceous, and Quaternary ages. The stratigraphic column for the Pontotoc area is given below:

Quaternary System

Conglomerate and alluvium

Cretaceous System

Comanchean Series

Fredericksburg Group

Edwards Limestone
Basal conglomerate and sandstone

Cambrian System

Croixian Series

Wilberns Formation

San Saba Limestone Member
Point Peak Shale Member
Morgan Creek Limestone Member
Welge Sandstone Member

Riley Formation

Lion Mountain Sandstone Member
Cap Mountain Limestone Member
Hickory Sandstone Member

Precambrian Rocks

Igneous rocks

Fine-grained granite
Aplite dikes

Metamorphic rocks

Gneiss-schist unit

PRECAMBRIAN ROCKS

The Precambrian rocks in the Pontotoc area include a few small granite masses, aplite dikes, and a gneiss-schist unit.

METAMORPHIC ROCKS

Walcott (1884, p. 431) applied the name Llano Group to the metamorphic rocks in the Llano uplift. The terms Valley Spring Gneiss and Packsaddle Schist were first used by Comstock (1890). Paige (1911, 1912) and Stenzel (1932, 1934) later redefined the Valley Spring Gneiss and the Packsaddle Schist, and discussed the structural relationship between the two units in the Llano-Burnet quadrangles.

Valley Spring Gneiss

Paige (1912, p. 4) reported that the oldest rocks recognized in the Llano uplift comprise the Valley Spring Gneiss which was derived by metamorphism of a thick series of sediments of rather uniform composition. According to Paige:

"The Valley Spring Gneiss is dominantly light-colored and pinkish-toned and comprises feldspathic and quartzitic schists, quartzites, wollastonite bands, granular acidic gneisses and rare amphibolitic portions.

The light-colored portions are as a whole more or less schistose, are sugar-granular or aphanitic in texture, and are in many places distinguished with difficulty from rocks which may be granular granitic gneisses. The quartzites are light-colored, fine-grained, recrystallized equivalents of very quartzose sediments."

Packsaddle Schist

The other major Precambrian metamorphic unit is the Packsaddle Schist which was defined by Paige (1912, p. 4) as a metamorphic series of sedimentary rocks that include:

> "...mica, amphibole, and graphite schists and crystalline limestone. Some lighter-colored, more feldspathic bands, resembling quartzites, are included."

The schists have a good cleavage which coincides with the original bedding of the sediments from which the schists were derived.

Structure of the Precambrian Metamorphic Rocks

Stenzel (1934, p. 74) reported that in the Llano-Burnet quadrangles the gneisses and schists are intricately folded as one unit in isoclinal and zig-zag folds, which in turn are folded in broad and open folds with a northwest-southeast trend and pitch 15 degrees to the southeast. The foliation of the gneisses and schists is strictly parallel to the axes of the broad and open folds.

Paige (1912, p. 4) reported that the Valley Spring Gneiss is found predominantly in the cores of the anticlines while the Packsaddle Schist occurs along the flanks of the anticlines and in the centers of the synclines. According to Paige, such a structural relationship indicated that the Packsaddle Schist overlies the Valley Spring Gneiss and is younger in age.

Stenzel (1934, p. 74) proposed a different interpretation regarding the ages of the two metamorphic units. Stenzel stated that such a clear-cut structural relationship between the gneisses and schists as proposed by Paige does not exist. According to Stenzel, there are many gneiss sills in the schists and many schist lenses in the gneiss, and the number of gneiss sills increases toward the centers of the anticlines. The gneiss sills conform very strictly to the planes of schistosity of the Packsaddle Schist. It is this structural relationship between the two units that led Stenzel to consider the gneiss as an intrusive body of rocks which intruded during and aided the folding and metamorphism of the schists, and to date the Valley Spring Gneiss as younger than the Packsaddle Schist.

There is, however, one important fact that must be considered regarding the different interpretations by Paige and by Stenzel. Paige recognized that the Valley Spring Gneiss was derived in part from sedimentary rocks and in part from igneous rocks, and that it is difficult to distinguish clearly between the gneisses derived from sedimentary rocks and the gneisses derived from igneous rocks. Stenzel on the other hand restricted the Valley Spring Gneiss to include only the very uniform orthogneiss (gneiss derived from granite), and considered the Packsaddle Schist to include all schistose rocks and associated metamorphic rocks that are of sedimentary derivation.

Additional studies of the Precambrian rocks in the vicinity of Red Mountain about 17 miles southeast of Llano were done by Romberg and Barnes (1949), Barnes, Schock, and Cunningham (1950), Barnes (1952), and Clabaugh and Boyer (1961).

In the Red Mountain vicinity, gneisses derived from igneous rocks have intruded into the Valley Spring Gneiss and Packsaddle Schist. The terms Red Mountain Gneiss, named by Barnes (Romberg and Barnes, 1949, fig. 1), and Big Branch Gneiss, named by Barnes (1945, p. 56), have been applied to these igneous-derived gneisses. Barnes (1945, p. 57) stated that "In the field it is often difficult to determine which portion of the outcrop should be designated as igneous and which as sedimentary in origin."

These investigations of the Precambrian rocks in the Llano uplift indicate that the structural relationship between the various types of gneisses, schists, and igneous rocks is very complicated. The soil cover also prevents locating and tracing the boundaries between the various units in the field. It is for these reasons that this author believes that no definite conclusions concerning the ages of the two metamorphic units (Valley Spring Gneiss and Packsaddle Schist) can be made at the present time.

Gneiss-Schist Unit

The exposed Precambrian metamorphic rocks in the Pontotoc area consist predominantly of gneiss with minor amounts of schist, and for this reason were mapped as a single unit.

The geologic contact between the gneiss-schist unit and the Hickory Sandstone Member in the southern part of the area is covered by soil except in a few localities. For this reason the contact was mapped as an inferred contact. The gneiss-schist unit has been intruded by small aplite dikes and granite masses.

Lithology

In the Pontotoc area the gneisses are light pink to reddish-gray and consist predominantly of quartz and feldspathic minerals along with some ferromagnesian minerals which include biotite and hornblende. Most of the gneiss is equigranular and aphanitic with poorly developed foliation, but a coarser texture and a better development of foliation were observed in a few exposures of the gneiss.

A large vein of milky quartz was observed in the gneiss-schist unit (Plate IV). This vein has the same northwest trend as does the foliation of the gneiss-schist unit.

Where exposed, the schists were yellowish- to reddish-brown, and contained muscovite, biotite, hornblende, and some pink feldspar.

PLATE IV

QUARTZ VEIN

Vein of milky quartz located in the southeast corner of the Foster Casner property about 1.3 miles east of Field Creek Community. The width of this vein is about four feet.

Distribution and Topography

The gneiss-schist unit is exposed in the southern and southeastern parts of the Pontotoc area. As previously stated, the gneiss predominates over the schist in the area. The predominantly gneissic unit is part of the large band of Valley Spring Gneiss mapped by Paige (1912) in his geologic folio of the Llano-Burnet quadrangles. Paige's map showed a band of Valley Spring Gneiss extending from the town of Pontotoc southeastward to Sandy Creek, a few miles south of the town of Oxford, Llano County. This band of gneiss, according to Paige (1912, p. 3), represents an anticline which trends northwest-southeast and plunges to the southeast. Strike and dip readings taken on the foliation in the gneiss showed an average strike of N 45° W with dips to the northeast which indicated that the gneiss-schist unit in the Pontotoc area is part of the northeastern flank of this anticline. The dips of the foliation of the gneiss-schist unit range from 15 to 58 degrees.

The schists, being less resistant to erosion than gneiss, are located principally in low areas and are covered by soil derived from the schist in many places. The gneiss occurs both in low areas covered by soil and in the steep rugged hills in the southeastern part of the Pontotoc area (Plate V).

In the area south of Pontotoc the maximum relief is about 170 feet, but the change in elevation is gradual;

PLATE V

PRECAMBRIAN GNEISS

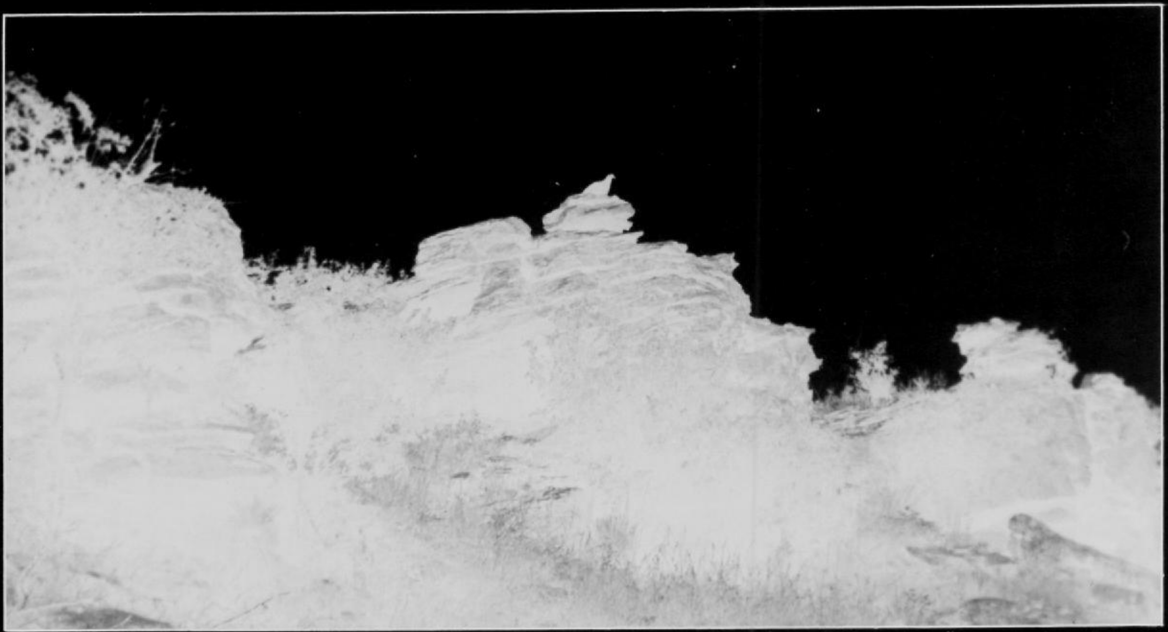


Fig. 1. Precambrian gneiss on Foster Casner's land directly west of High Rock about 1.2 miles northeast of Field Creek Community. The rugged topography is characteristic of many of the hills formed by the gneiss.

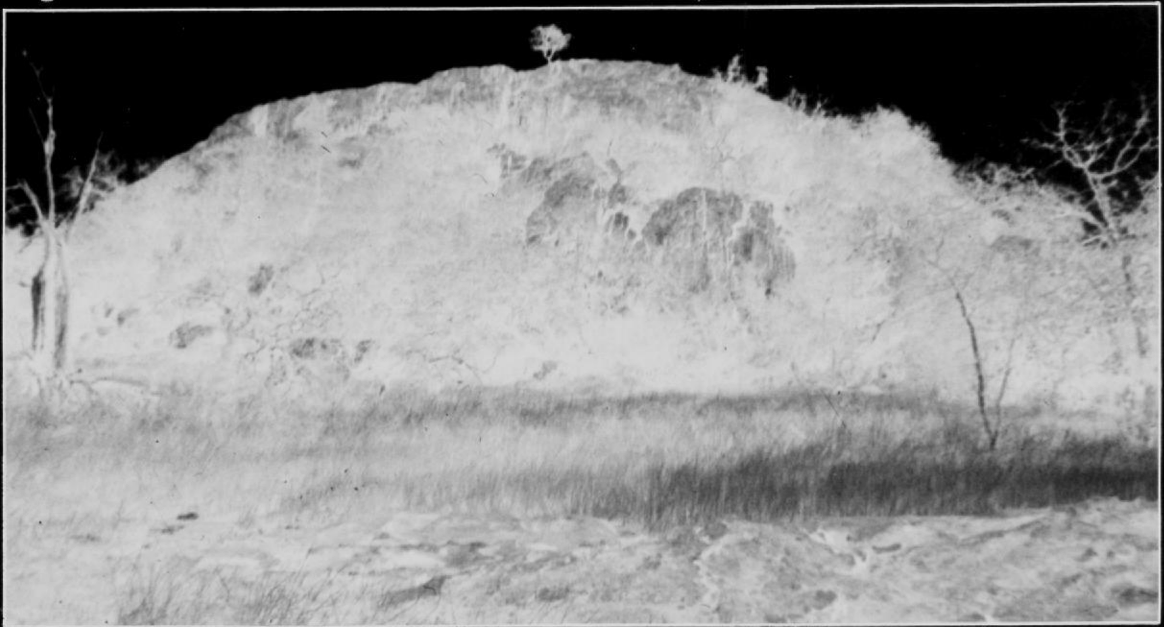


Fig. 2. View of the southwest side of Panther Rock about 0.6 miles northeast of Field Creek Community. Panther Rock is formed by the gneiss unit. The tree on top of the hill is ten feet in height. (Photograph by B. M. Greenwood)

whereas, in the area northeast of the community of Field Creek the topography consists of steep, rugged, and barren hills of gneiss with a maximum relief of about 300 feet and an average relief of about 100 feet. Panther Rock and High Rock are the two highest hills of gneiss in this area having elevations of 1,664 feet and 1,713 feet respectively. Another steep hill of the gneiss-schist unit forms part of the escarpment in the properties owned by Nell Harris and M. L. Roberts about 2.4 miles northeast of Pontotoc. The elevation of the gneiss on this hill is about 1,780 feet.

IGNEOUS ROCKS

Fine-Grained Granite

Granite is exposed in several localities in the Pontotoc area. The majority of these granite outcrops are nearly circular in plan view with diameters of 5 to 10 feet. In these outcrops the granite is poorly exposed, and for this reason, they were not shown on the geologic map (Plate I). These small granite intrusions were observed on properties owned by Foster Casner, von Simpson, John McLeod, Jr., and M. L. Roberts.

Three exposures of granite located west and southwest of Pontotoc are shown on the geologic map (Plate I). Two of these exposures consisted of small granite boulders protruding from a granite-derived soil. The third and largest exposure consists of large boulders forming a small hill with a relief of about 15 feet (Plate VI).

PLATE VI

FINE-GRAINED GRANITE

Fine-grained granite at the intersection of the New Pontotoc Cemetery road and Ranch Road 734 about one mile west of Pontotoc.

In all of the exposures the granite is fine-grained, equigranular, pink in color, and contains pink feldspar, quartz, biotite, and some muscovite. The relationship of the granite to the surrounding rocks could not be determined due to soil cover. The contacts were placed at the outermost occurrences of the granite boulders.

Aplite Dikes

The gneiss-schist unit is cut in many places by very small aplite dikes which vary from 1/4 to 1 inch in width. The aplite dikes consist of fine-grained pink feldspar and quartz.

CAMBRIAN SYSTEM

The oldest known Paleozoic rocks found in the Llano uplift are the Riley and Wilberns formations of the Upper Cambrian Series.

RILEY FORMATION

The Riley Formation was defined by Cloud, Barnes, and Bridge (1945, p. 154) "...to include all of the Cambrian strata in central Texas beneath the Wilberns Formation." The Riley Formation is divided into three members which are, in ascending order: the Hickory Sandstone Member, the Cap Mountain Limestone Member, and the Lion Mountain Sandstone Member.

The Riley Formation takes its name from the Riley Mountains in southeastern Llano County where the three members are well exposed. Bridge, Barnes, and Cloud (1947, p. 109) reported that the thickness of the Riley Formation averages about 680 feet, and ranges from a little less than 200 feet to about 800 feet. According to Cloud, Barnes, and Bridge (1945, p. 154), the Riley Formation is thickest in southeastern Llano County and thinnest in the northwestern portion of the Llano uplift.

Hickory Sandstone Member

Definition

Comstock (1890, p. 285) used the term Hickory as a series name in his subdivision of the Paleozoic rocks in the Llano region. Paige (1911, p. 23) retained the name Hickory, but revised the Hickory Series to the Hickory Sandstone. Cloud, Barnes, and Bridge (1945, p. 154) redefined the Hickory Sandstone and designated it as the basal member of the Riley Formation. Goolsby (1957, p. 53) stated that the Hickory Sandstone could be divided into three members and proposed that formational rank be given to the Hickory Sandstone.

Lithology

The sandstones of the Hickory are noncalcareous, nonglauconitic, and are yellow, brown, and red in color. Most of the Hickory Sandstone Member has weathered to a sandy soil in the Pontotoc area. The upper part of this member is exposed in the escarpment north of Pontotoc, and the middle and basal portions of the member are exposed in a few road cuts along Ranch Road 501 north of Pontotoc and in stream banks in the southern half of the Pontotoc area.

The basal part of the Hickory Sandstone Member consists of medium- to coarse-grained, tan and brown, cross-bedded, quartzose sandstones. A few thin layers of shale and siltstone were also observed in the lower portion. In most places where the Precambrian-Cambrian contact is exposed, the Hickory Sandstone contains angular to subangular grains and pebbles of quartz derived from the Precambrian rocks (Plate VII). These quartz grains and pebbles vary from about 4 mm. to about 20 mm. in diameter. Cross-bedding is also quite common in the lower part of the Hickory (Plate VIII).

The middle Hickory sandstones are thin- to medium-bedded, fine- to medium-grained, tan and yellowish-brown. Thin layers of siltstone are interbedded in this middle portion of the Hickory Sandstone Member. Plate IX shows an exposure of the middle portion of the Hickory Member.

The sandstones of the upper Hickory are red to brownish-red, and fine- to coarse-grained. The uppermost 15 to 20 feet of the member is dark red in color due to a hematitic matrix and coating of the sand grains. This upper portion weathers to a dark red soil, and is clearly defined on aerial photographs.

PLATE VII

QUARTZ PEBBLES IN BASAL HICKORY

Conglomeratic basal Hickory Sandstone Member with angular to subangular pebbles of quartz overlying the Precambrian gneiss. This exposure is located on the J. F. Barrett property just north of Ranch Road 734 and 0.5 miles east of Pontotoc.

PLATE VIII

CROSS-BEDDING IN THE HICKORY

Fig. 1. Cross-bedding in the Hickory Sandstone Member. This exposure is in Pontotoc Creek about 1.2 miles west-northwest of Pontotoc on the L. P. Pankey property.

Fig. 2. Outcrop of the lower Hickory Sandstone Member just east of the locality in figure one above. The beds in the background display cross-bedding.

PLATE IX

MIDDLE HICKORY SANDSTONE MEMBER

The middle portion of the Hickory Sandstone Member on the Nell Harris property about two miles northeast of Pontotoc.

Thickness

According to Bridge, Barnes, and Cloud (1947, p. 112), the Hickory Sandstone Member averages about 360 feet in thickness and ranges from 0 to 415 feet in thickness. The variation in thickness is attributed to the topography of the Precambrian surface, irregularities in deposition, and lateral gradation to limestone of the upper beds.

It appears that the thickness of the Hickory Sandstone Member in the Pontotoc area ranges from 0 to about 100 feet or more. This estimate is based on the fact that the Hickory does not cover all of the Precambrian rocks, and that about 100 feet of Hickory is exposed in the escarpment. The exact thickness of the Hickory Sandstone Member in the Pontotoc area is difficult to estimate for the following reasons: (1) the relief of the Precambrian surface is not known, and (2) the wide outcrop suggests a repeated section caused by undetected faults.

Distribution and Topography

The Hickory Sandstone Member is exposed in a large area in the southern half of the Pontotoc area. The upper portion of the member forms the lower half of the escarpment while the rest of the member forms a rather flat surface broken by a few low hills of middle Hickory Sandstone.

Stratigraphic Relationship

The Hickory Sandstone Member unconformably overlies the Precambrian gneiss-schist unit. Lower to upper portions of the Hickory Sandstone are in contact with the gneiss-schist unit in the Pontotoc area. The upper portion of the Hickory Sandstone grades upward into the Cap Mountain Limestone Member. Plate X shows the upper and lower contacts of the Hickory Sandstone Member.

Cap Mountain Limestone Member

Definition

Cloud, Barnes, and Bridge (1945, p. 154) redefined Paige's (1911) Cap Mountain Formation, and designated it a member of the Riley Formation. The Cap Mountain-Hickory contact is placed at the top of a noncalcareous sandstone zone and beneath a zone of alternating impure, dark brown limestones and calcareous sandstones which grade upward into argillaceous, granular limestones. There is a distinct topographic and vegetational break at the Hickory-Cap Mountain contact. The Cap Mountain forms a steeper slope and supports a thicker growth of vegetation than does the Hickory Sandstone.

Lithology

The lower part of the Cap Mountain Limestone Member consists of alternating beds of medium-grained, brown to light brown, calcareous sandstones and arenaceous limestones.

PLATE X

HICKORY SANDSTONE MEMBER CONTACTS

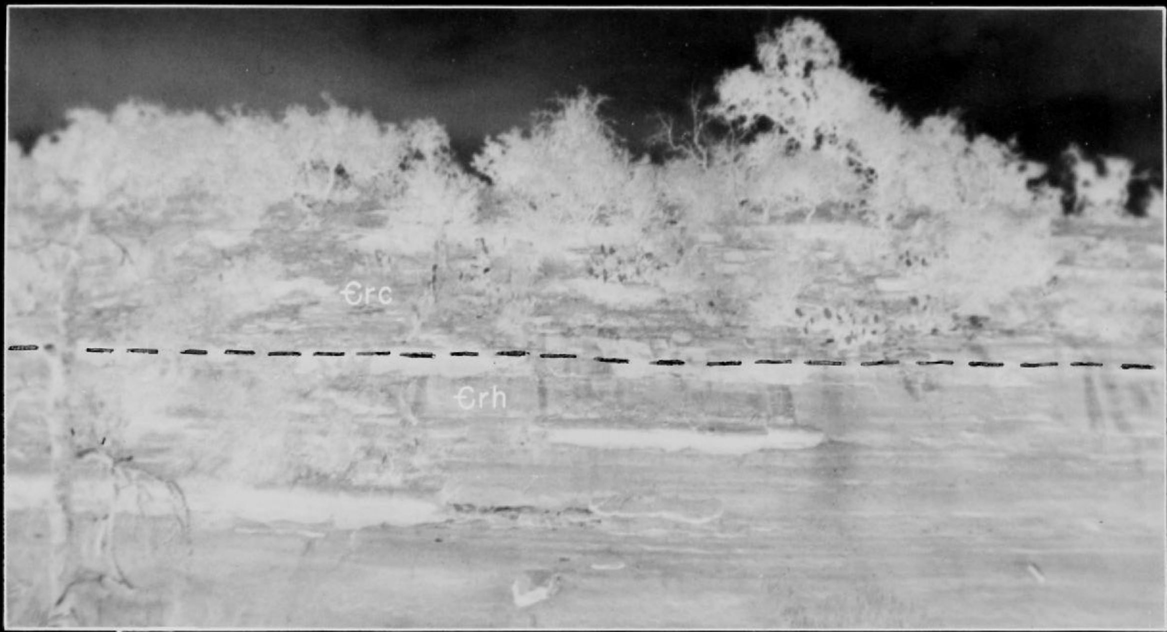


Fig. 1. The Hickory-Cap Mountain contact on the W. H. Taylor, Jr. property about 2.5 miles north of Field Creek Community.

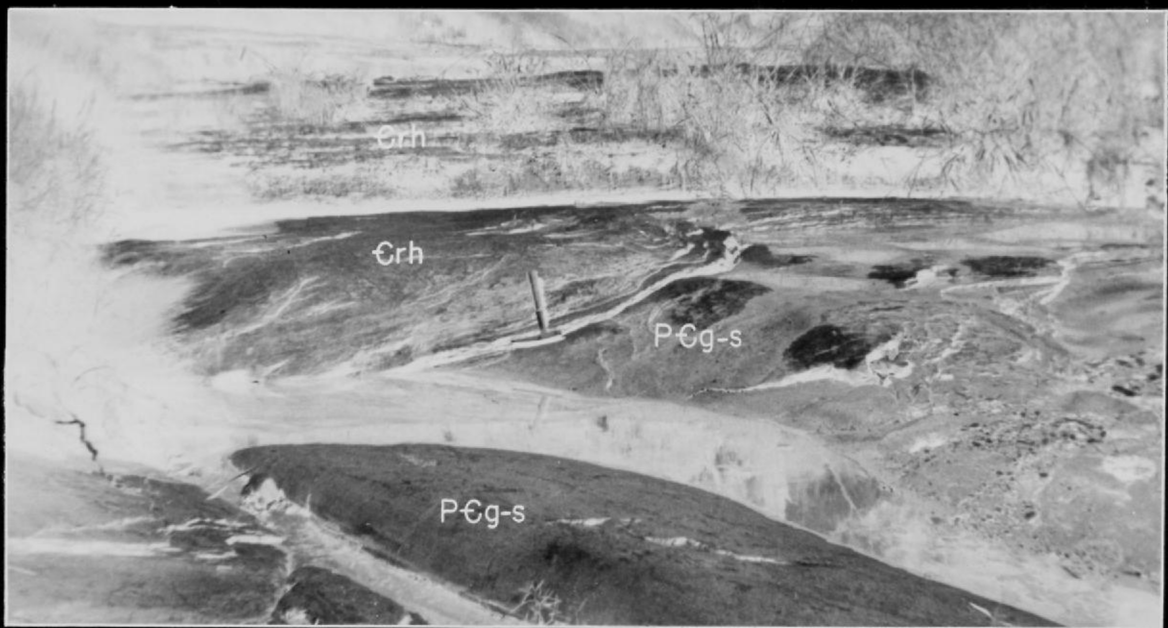


Fig. 2. The Hickory-Precambrian contact in Panther Creek on the W. C. Davis property about 1.7 miles north of Field Creek Community.

The beds average about one foot in thickness and some beds display cross-bedding. A few thin layers of gray limestone occur in the lower portion of this member. This zone of alternating limestones and sandstones grades upward into brown and yellowish-brown, thin- to medium-bedded, granular, argillaceous limestones that comprise most of the Cap Mountain Limestone Member (Plate XI).

The upper portion of the Cap Mountain contains layers of brown, silty, fine-grained, glauconitic limestones interbedded with some layers of brown, glauconitic, calcareous siltstones. One layer of greenish-gray, fine-grained, slightly calcareous sandstone about six inches thick was observed in the silty facies.

Thickness

The thickness of the Cap Mountain, as reported by Bridge, Barnes, and Cloud (1947, p. 113), ranges from about 135 to 455 feet and averages about 280 feet.

A thickness of about 260 feet was estimated for the Cap Mountain in the Pontotoc area. This estimate is based on the dip and the width of the outcrop of the Cap Mountain Limestone Member.

Distribution and Topography

The Cap Mountain Limestone forms part of the escarpment north of Pontotoc, and in the east-central part of the area the Cap Mountain forms low hills which have a relief of about 40 to 80 feet.

PLATE XI

CAP MOUNTAIN LIMESTONE MEMBER

Cap Mountain Limestone Member in road cut where Ranch Road 501 cuts through the escarpment about two miles north of Pontotoc.

Stratigraphic Relationship

The Cap Mountain Limestone conformable overlies the Hickory Sandstone except along the escarpment slope directly east of Simpson Hollow and about 2.4 miles northeast of Pontotoc. At this locality the Cap Mountain unconformably overlies the Precambrian gneiss along the escarpment slope (Plate XII).

The Cap Mountain Limestone is conformably overlain by the Lion Mountain Sandstone Member except in the vicinities of the three Cretaceous outliers. At these localities the Cretaceous rocks unconformably overlie the middle to upper portions of the Cap Mountain Limestone Member.

Lion Mountain Sandstone Member

Definition

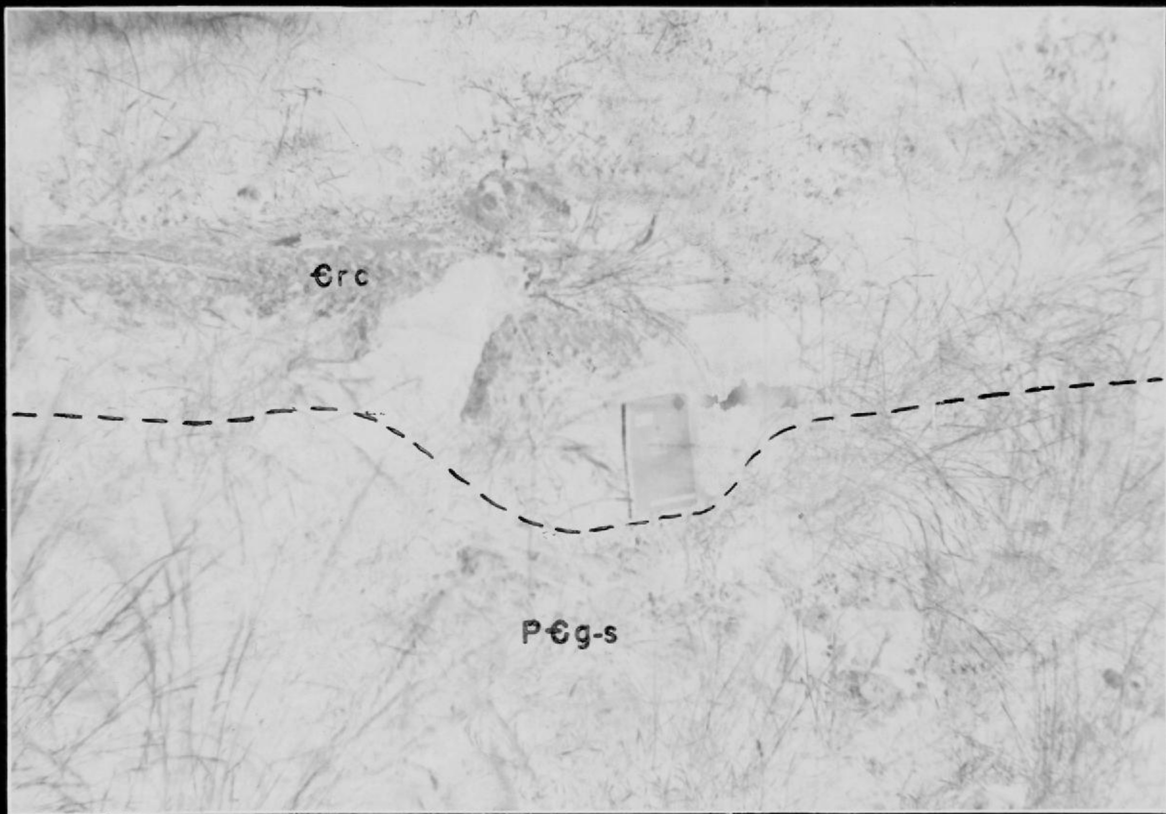
The Lion Mountain Sandstone Member was first named by Bridge (1937, p. 234) and was defined as the top member of the Cap Mountain Formation. Lion Mountain in the northwestern part of the Burnet quadrangle was designated as the type locality. Cloud, Barnes, and Bridge (1945, p. 154) redefined the Lion Mountain Sandstone Member as the top member of the Riley Formation.

Lithology

In exposures observed along the escarpment and in Round Mountain, the Lion Mountain Sandstone Member consists essentially of green to brown, coarse-grained, glauconitic

PLATE XII

CAP MOUNTAIN-PRECAMBRIAN CONTACT



Contact of Cap Mountain Limestone Member overlying Precambrian gneiss on the Nell Harris property about 2.4 miles northeast of Pontotoc. The notebook lies on the contact.

sandstones. Lenses of limestone composed of trilobite fragments, referred to as "trilobite hash", occur in the lower portion of the member. Cross-bedding is observed in some of the sandstone layers.

The upper portion of this member contains greenish-gray, shaly siltstones (Plate XIII) with brachiopod fragments. This silty zone is exposed at the junction of Ranch Road 501 and the road leading to the abandoned câliche quarry about 2.2 miles north of Pontotoc.

The upper half of the Lion Mountain Member includes dark green, highly glauconitic, cross-bedded sandstones. Black, rounded to subrounded, hematite nodules occur in the sandy soil which weathers from the Lion Mountain Sandstone (Plate XIV).

Thickness

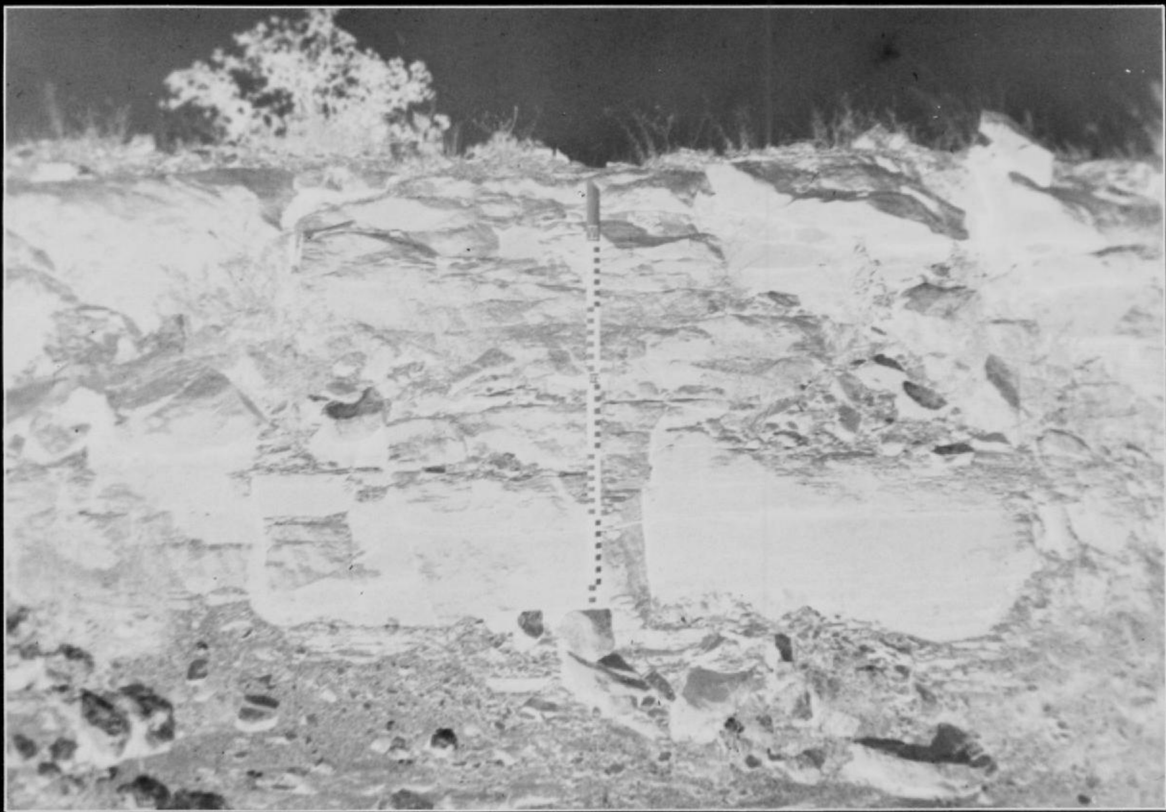
According to Bridge, Barnes, and Cloud (1947, p. 114), the Lion Mountain Member is 20 feet thick in the type section, but attains a maximum measured thickness of 50 feet elsewhere. In the Pontotoc area the Lion Mountain is 40 feet thick at Round Mountain.

Distribution and Topography

The Lion Mountain is exposed at the top of the western and central portions of the escarpment and along the slope of the eastern portion of the escarpment. This member weathers quite readily into a sandy soil.

PLATE XIII

LION MOUNTAIN SANDSTONE MEMBER



Lion Mountain Sandstone Member in road cut on Ranch Road 501 about 2.2 miles north of Pontotoc and just south of road leading to the abandoned caliche quarry.

PLATE XIV

HEMATITE NODULES IN LION MOUNTAIN

Fig. 1. Hematite nodules of the Lion Mountain Sandstone Member on the southern slope of Round Mountain about four miles northeast of Pontotoc.

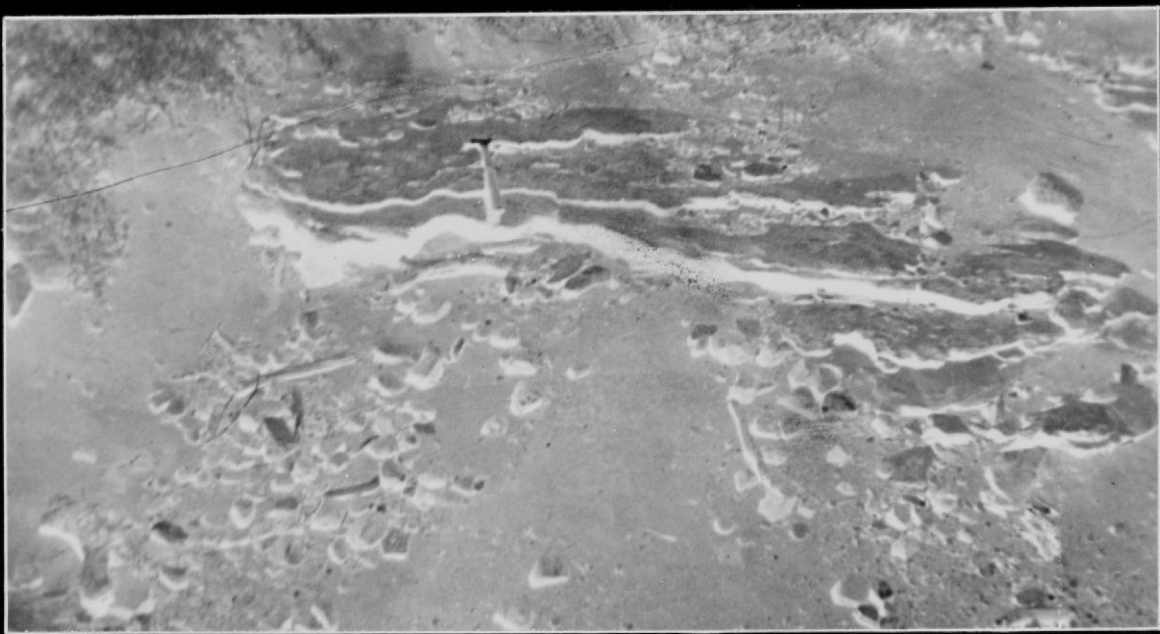


Fig. 2. Roadside exposure of hematite nodules in the Lion Mountain Sandstone Member on W. H. Taylor's land about 0.6 miles east of Round Mountain.

Stratigraphic Relationship

The Lion Mountain Sandstone overlies the Cap Mountain Limestone and is the upper member of the Riley Formation. The upper boundary between the Lion Mountain and the overlying Welge Sandstone is sharp and represents a disconformity. The lower portion of the Lion Mountain grades downward into the Cap Mountain Limestone. In mapping, the lower boundary was located at the lower edge of a sparsely vegetated bench. In some places where the rocks are poorly exposed, the lower boundary was placed at the base of the first sandstone layer which contained a large amount of glauconite.

The Lion Mountain Sandstone is overlain by rocks of Cretaceous age in the vicinities of the three Cretaceous outliers.

In the area north of the abandoned caliche quarry the Lion Mountain Sandstone has been cut by a number of faults which repeat this member as well as bringing it into fault contacts with the Welge Sandstone and Cap Mountain members.

WILBERNS FORMATION

The Wilberns Formation was named by Paige (1911, p. 23) for the rocks exposed at Wilberns Glen in Llano County. Present usage retains the lower boundary of the Wilberns Formation as defined by Paige (1912, p. 6) at the "...top of the glauconitic sandstone which forms the upper member of the

Cap Mountain Formation." Paige located the upper boundary at the base of the overlying massive chert-bearing beds, but the upper boundary was redefined and placed at the top of the Cambrian System by Cloud, Barnes, and Bridge (1945, p. 151). The Wilberns Formation is divided into four members and ranges in thickness from 540 to 610 feet.

Welge Sandstone Member

Definition

The Welge Sandstone Member of the Wilberns Formation was named by Barnes (1944, p. 37) from the Welge land surveys between Threadgill and Squaw creeks in Gillespie County, and was designated as the bottom member of the Wilberns Formation. The member was later described by Bridge, Barnes, and Cloud (1947, p. 114).

Lithology

The Welge Sandstone consists of brownish-yellow, medium-grained, nonglauconitic and noncalcareous sandstone which contains quartz grains with recomposed faces which are the result of secondary growth of quartz about a quartz grain. These recomposed grains glitter in sunlight and are considered a characteristic feature of the Welge Sandstone.

In the Pontotoc area the Welge Sandstone has all of the properties just mentioned, and is also very friable. The individual grains are well rounded.

Thickness

According to Bridge, Barnes, and Cloud (1947, p. 114), the Welge Sandstone is 27 feet thick in the type locality. This member ranges in thickness from 9 to 35 feet and averages 18 feet. In the Pontotoc area 25 feet of Welge Sandstone was measured at Round Mountain.

Distribution and Topography

The Welge is exposed as a topographic bench in Round Mountain (Plate III) and along the slope of the eastern portion of the escarpment. In the western and central parts of the Pontotoc area the Welge Sandstone weathers to a sandy soil (Plate XV).

Stratigraphic Relationship

The Welge-Lion Mountain contact is abrupt and is easily traced along the escarpment and in Round Mountain, while in the low areas the contact is extremely difficult to locate in the sandy soil which is covered by tall grasses. The Welge-Morgan Creek contact is transitional and was placed at the base of the dark maroon, arenaceous limestones of the Morgan Creek Member. This contact is easily detected in good exposures (Plate XVI). The Welge Sandstone is unconformably overlain by Cretaceous rocks in the west-central and central portions of the Pontotoc area. In the central portion of the Pontotoc area, faulting has repeated the Welge and has brought it into fault contacts with the Morgan Creek, Lion Mountain, and Cap Mountain members.

PLATE XV

WELGE SANDSTONE MEMBER

The Welge Sandstone Member on the W. H. Taylor property about 100 yards east of Round Mountain.

PLATE XVI

WELGE-MORGAN CREEK CONTACT

The Welge-Morgan Creek contact about 100 yards east of Round Mountain.

Morgan Creek Limestone Member

Definition

The Morgan Creek Limestone Member of the Wilberns Formation was named by Barnes (Bridge, Barnes, and Cloud, 1947, p. 114) from exposures on both the north and south forks of Morgan Creek in Burnet County.

Lithology

The basal Morgan Creek limestones are sandy, dark maroon in color, and grade upward into well-bedded, gray and greenish-gray, medium-grained, glauconitic limestones.

The upper half of the member contains several thin-bedded, gray siltstones interbedded with light gray, medium-grained, glauconitic limestones. Small subspherical bioherms about a foot in diameter and composed of dense, gray, non-glauconitic limestone are also found in the upper half of the member.

Plate XVII shows the upper limestones of the Morgan Creek Member. A zone of very thin-bedded to shaly, light gray siltstones occurs as the topmost five feet of the member. Two layers of medium-bedded, light gray limestone occur in the siltstones. The contact between the Morgan Creek Limestone Member and the Point Peak Shale Member is gradational and is difficult to locate accurately. Several criteria were used in locating the contact; they are: (1) the Point Peak Shale forms a topographic low while the Morgan Creek Limestone

PLATE XVII

MORGAN CREEK LIMESTONE MEMBER

Upper portion of the Morgan Creek Limestone Member exposed in East Deep Creek just south of Ranch Road 501 on the W. H. Taylor property about one mile northwest of Round Mountain. This exposure illustrates typical Morgan Creek weathering.

forms a topographic bench, (2) vegetation is sparse on the Point Peak Shale while the Morgan Creek vegetation is fairly dense, and (3) the weathered shales of the Point Peak Member are very thin to platy and display minor folding; whereas, the siltstones at the top of the Morgan Creek Member are well-bedded, but are not as thin or platy as the Point Peak shales nor do the siltstones display any folding.

Thickness

According to Bridge, Barnes, and Cloud (1947, p. 114-115), the Morgan Creek Member in the type locality in Burnet County is about 110 feet thick. This member ranges in thickness from about 70 feet in the Point Peak and Carter ranch sections [Llano County] to 160 feet in the Salt Branch section [San Saba County], and averages about 120 feet. In the Pontotoc area the thickness of this member is estimated to be about 100 feet.

Distribution and Topography

The Morgan Creek strata dip northward and crop out in the low area north of the escarpment and extend the entire width of the Pontotoc area. In the eastern part of the area the Morgan Creek Member forms the upper slope and top of the escarpment.

Stratigraphic Relationship

The Morgan Creek Member occurs in the normal stratigraphic sequence with the other Upper Cambrian members in most places, but is overlain unconformably by Cretaceous rocks in several areas north of the escarpment. The lower boundary is placed at the base of the zone of maroon limestones and the upper boundary is placed at a topographic and vegetational break as previously described in the discussion of the Morgan Creek lithology.

Point Peak Shale Member

Definition

The name Point Peak Shale was applied by Bridge (Bridge, Barnes, and Cloud, p. 115) to the rocks exposed on the south slope of Point Peak, a conspicuous, isolated hill about four miles northeast of Lone Grove in Llano County.

Lithology

The Point Peak Shale Member consists of tan to greenish-gray, calcareous, thin to platy shales interbedded with light gray siltstones, gray, thin- to medium-bedded limestones, and thin beds of intraformational conglomerates. Minor folding of the shales is observed in some exposures (Plate XVIII). The limestones are similar to those in the upper portion of the Morgan Creek Member, but are finer-grained. Thin beds of intraformational conglomerates occur in the upper half of the member. These beds vary from 4 to 6 inches in thickness and consist of angular pebbles of various sizes, lithologies, and colors in a matrix of fine-grained, silty limestone.

PLATE XVIII

FOLDING AND BIOHERMS IN POINT PEAK

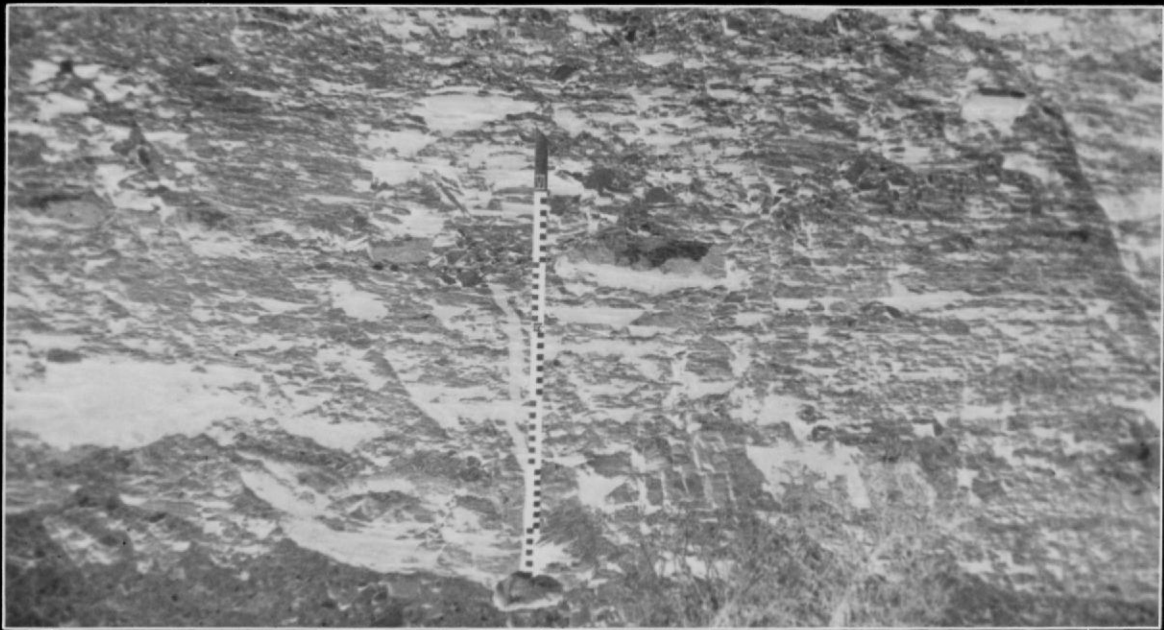


Fig. 1. Minor folding due to compaction in the Point Peak Shale Member exposed in road cut on Ranch Road 501 about 1.3 miles northeast of Round Mountain.

Fig. 2. The "cabbage-head" structure of the Point Peak bioherms on the T. M. Myrick property about 4.8 miles north of Pontotoc.

A zone of stromatolitic bioherms forms the upper portion of this member. The bioherms, which range from 1 to 20 feet or more in diameter, are composed of dense, varigated, sublithographic limestone and usually display a "cabbage-head" structure on the surface (Plate XVIII, fig. 2). This zone of bioherms is interbedded with coarse-grained, medium-bedded, gray to brownish-gray limestones which are folded around the bioherms. Some of the limestone beds below the bioherm zone display large ripple marks about three inches in amplitude and about one foot in wave length. Although this zone of bioherms was mapped as a separate unit, it is commonly considered to be the upper part of the Point Peak Shale Member.

Thickness

Bridge, Barnes, and Cloud (1947, p. 115) reported that the Point Peak Member ranges in thickness from 25 to 270 feet and averages about 160 feet, and that the member thins from the northeastern to the southeastern parts of the Llano uplift. They also reported that the bottom boundary of the Point Peak Member is not at a constant stratigraphic horizon. It ranges from 90 feet above the base of the Wilberns Formation in the Point Peak area [Llano County] to about 170 feet above the base of the Wilberns Formation in the Salt Branch area [San Saba County]. According to Bridge, Barnes, and Cloud (1947, p. 116), the difference in position of the boundary above the base of the Wilberns Formation is believed to be due chiefly to facies change from Point Peak shales to Morgan Creek limestones.

The thickness of the Point Peak in the Pontotoc area is estimated to be about 150 feet. The bioherm zone, with an average thickness of about 50 feet, forms the upper portion of the Point Peak Member.

Distribution and Topography

The Point Peak Shale crops out in the northern one-fourth of the Pontotoc area. Because the lower portion of this member erodes readily, it forms low, relatively flat areas except where it is capped by the bioherms; then it forms hills having a relief of about 50 feet or more.

Stratigraphic Relationship

The Point Peak Shale grades into the underlying Morgan Creek Limestone and is conformably overlain by the San Saba Limestone. The Point Peak Shale is also unconformably overlain by Cretaceous rocks in the area north of Bush Windmill and in the area directly east of the Fay Miller ranch house about 3.7 miles north of Pontotoc.

San Saba Limestone Member

Definition

The name San Saba was first used by Comstock (1890, p. 566) as a series term for the limestones exposed at Camp San Saba in McCulloch County. Bridge, Barnes, and Cloud

(1947, p. 117) redefined the San Saba Limestone as the top member of the Wilberns Formation.

Lithology

The lower half of the San Saba Member consists of light gray, thin-bedded, sublithographic to fine-grained limestones that weather to medium gray and tan colors. These limestones display folding over the Point Peak bioherms. The contact between the San Saba limestones and the Point Peak bioherms is easily traced in the field. In the middle to upper portion of the member the limestones are more granular, gray to brown, medium- to thick-bedded, slightly glauconitic, and silty. The beds weather into large blocks with crinkly surfaces on the sides of the blocks (Plate XIX). It is believed that the crinkly surfaces are caused by differential weathering of limestone and silt.

The presence of joints within the San Saba Member is suggested by : (1) the limestones weather to large blocks at the surface, and (2) aerial photographs of the San Saba Member show closely-spaced tree alignments which have a general northeast trend.

Thickness

According to Bridge, Barnes, and Cloud (1947, p. 117), the average thickness of the San Saba Member is about 280 feet. About 100 feet of the San Saba Member is exposed in the Pontotoc area. The San Saba-Ellenburger contact occurs some distance north of the Pontotoc area.

PLATE XIX

SAN SABA LIMESTONE MEMBER

Weathered San Saba Limestone Member blocks with the typical crinkly ridges on the surface. This exposure is on the T. M. Myrick property about 4.9 miles north of Pontotoc.

Distribution and Topography

The San Saba Limestone Member is exposed in the hilly terrain along the northern border of the Pontotoc area. The member caps some of the hills and dips gently to the north.

Stratigraphic Relationship

The San Saba-Point Peak contact is conformable; the boundary being placed at the top of the Point Peak bioherm zone.

CRETACEOUS SYSTEM

Three outliers of Cretaceous strata consisting of a conglomerate-sandstone unit, a siltstone unit, and a limestone unit are found in the Pontotoc area. A Cretaceous age is given to the strata in the three outliers on the basis of lithology, structure, and paleontology. Because of their high chalk content and white to yellow colors, these rocks are distinctly different from any of the Paleozoic rocks. The chalky rocks dip very gently to the north, unconformably overlie the Cambrian units from the Cap Mountain Limestone Member to the Point Peak Shale Member inclusive, and are not involved in the faulting. The fossils that were found in these beds are characteristic Cretaceous organisms and include: Lunatia sp., Monopleura marcida White, Pecten sp., cf. Caprinuloidea sp., cf. Toucasia patagiata White, and cf. Turritella sp.

The strata comprising each outlier were measured and described in detail. The measured sections are found in the appendix of this report. In measuring these sections it was found that the Cretaceous rocks in the Pontotoc area consist of three lithologic units, which are, in ascending order: a basal conglomerate-sandstone unit, a siltstone unit, and a limestone unit. The boundaries between these units are gradational, and in most places, are covered by soil and vegetation. For these reasons, the Cretaceous rocks were mapped as one unit instead of three separate units.

The general lithology of each of the three units will be described in the following sections. Discussion of the age of the Cretaceous rocks in the Pontotoc area will follow the description of the rocks.

Basal Conglomerate-Sandstone Unit

Lithology

The conglomerate consists of various sizes of subrounded to subangular pebbles and cobbles derived from the Cambrian strata in a matrix of light brown to reddish-brown, fine- to coarse-grained, ferruginously stained, calcareous sandstone (Plate XX).

The conglomerate grades vertically and laterally into yellow to white, fine- to medium-grained, calcareous sandstones. The amount of calcareous cement appears to vary in places, because the sandstone is both friable and hard and weathers to rubble (Plate XXI).

PLATE XX

CRETACEOUS BASAL CONGLOMERATE

Fig. 1. Boulders of basal Cretaceous conglomerate exposed on the slope of the west branch of Simpson Hollow on the Nell Harris property about 2.2 miles north-northeast of Pontotoc. (Photograph by E. J. Graczyk)

Fig. 2. Weathered basal Cretaceous conglomerate on the slope directly east of the caliche quarry on the Nell Harris property about 2.2 miles north of Pontotoc.

PLATE XXI

CRETACEOUS BASAL SANDSTONE

Basal Cretaceous sandstone at the base of the "Bush Windmill" section on the W. H. Taylor property about 3.1 miles northeast of Pontotoc.

Thickness

The upper contact of the conglomerate-sandstone unit is difficult to observe due to soil cover and to the transition from sand to silt. In general the thickness of this unit varies from less than 10 feet to 20 feet. It is believed that this variation in thickness is due to a slightly uneven Cambrian depositional surface and the gradation into the overlying siltstones.

Distribution and Topography

The basal conglomerate-sandstone unit erodes very readily and forms a gentle slope which is partially to completely covered by soil and talus from the overlying units. Fair exposures of the conglomerate were found in Rattlesnake and Simpson hollows and on the west side of Poker Hollow. The sandstone unit is partially exposed along the escarpment face between Bush Windmill and Flag Ridge. In the rest of the area the basal unit is covered by sandy, silty, chalky soil and rock debris.

Siltstone Unit

Lithology

The contact between this unit and the underlying conglomerate-sandstone unit was picked where chalky, silt-sized material becomes predominant over sand-sized material. The siltstone unit consists of white to yellow, thin- to thick-bedded, argillaceous, chalky siltstones. The chalk content increases toward the top of the unit while the sand content decreases.

Thickness

Thicknesses ranging from 9 to 35 feet were measured for the siltstone unit in the Pontotoc area. The gradation of this unit into the under- and overlying units accounts for the variation in thickness.

Distribution and Topography

The siltstone unit occurs in all three Cretaceous outliers. The siltstones are fairly susceptible to erosion, forming moderate slopes covered by soil and rock debris (Plate XXII).

Paleontology

A fossil zone containing casts of *Monopleura marcida* White, cf. *Turritella sp.*, and a few unidentifiable pelecypods were found in a layer of siltstone at the bottom of the east side of the abandoned caliche quarry about 2.2 miles north of Pontotoc. A few pelecypod molds and one echinoid cast were found at other siltstone localities, but could not be identified.

PLATE XXII

CRETACEOUS SILTSTONES

The siltstone unit (Nos. 2 to 4) in the "Bush Windmill" section on the W. H. Taylor property about 3.1 miles northeast of Pontotoc. Unit 5 shows weathered beds of the overlying limestone unit. The unit numbers 2 to 5 refer to the different lithologic units in the section measured at Bush Windmill. The measured section is given in the appendix of this report.

Limestone Unit

Lithology

The limestone unit consists of hard, light and yellowish-gray, thick-bedded to massive, fine- to coarse-grained, chalky, argillaceous limestones which weather to light gray, flat, vuggy, thick-bedded blocks and to black soil on the top of the outliers (Plate XXIII, fig. 1), and to light gray, massive boulders and to gray soil along the escarpment (Plate XXIV, fig. 2). The black soil is characteristic of Cretaceous limestones.

This unit also contains a few thick-bedded, yellowish-gray, granular, slightly arenaceous limestones that crop out along the escarpment slope.

The uppermost limestone beds at the Bush Windmill locality contain very thin seams of chert and chert nodules. Fragments of the chert nodules are found on the surface at the top of the hill (Plate XXIV, fig. 1). This was the only locality where chert seams and nodules were found.

Thickness

The thickness of the limestone unit ranges from 20 to 46 feet. This variation in thickness is due to gradation between the siltstone and limestone units, and to the varying amounts of limestone removed by erosion.

PLATE XXIII

CRETACEOUS LIMESTONES

Fig. 1. Cretaceous limestones south of the caliche quarry on the Nell Harris property about 2.1 miles north of Pontotoc.

Fig. 2. View showing the vuggy appearance of weathered Cretaceous limestones at the same locality as in figure one above.

PLATE XXIV

WEATHERED CRETACEOUS BOULDERS AND CHERT FRAGMENTS

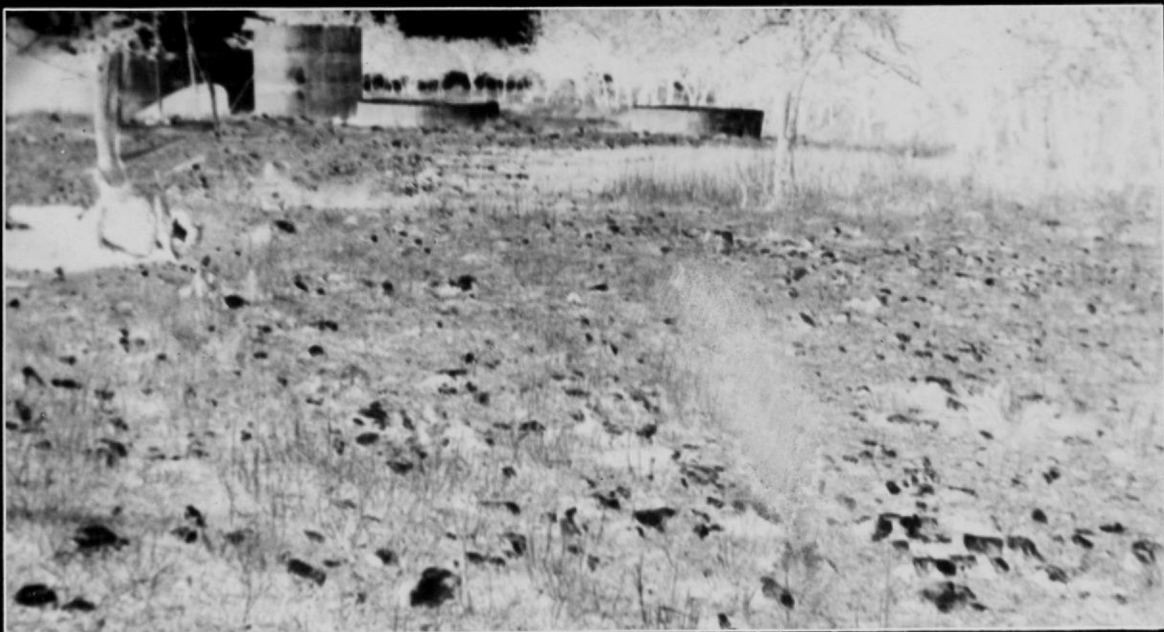


Fig. 1. Chert fragments covering the surface at Bush Windmill about 3.1 miles northeast of Pontotoc.

Fig. 2. Cretaceous limestone displaying large weathered boulders on hillside directly south of the microwave relay station about 1.8 miles north-northwest of Pontotoc.

Distribution and Topography

The limestone unit caps about one-half of each Cretaceous outlier in the Pontotoc area. The surface of the outliers is fairly even (Plate XXV). The limestone unit is relatively resistant to erosion thus forming a protective cap for the underlying siltstone unit.

Paleontology

A massive layer of yellowish-gray, coarse-grained limestone, containing a large number of siliceous fossils that are similar to Toucasia patagiata White, Caprinuloidea sp., and Turritella sp., occurs along the escarpment face west of Bush Windmill. Unidentifiable pelecypods were also found in the limestone beds capping the hill just south of the abandoned caliche quarry.

Age

Previous Investigations

In his geologic map of the Llano-Burnet quadrangles, Paige (1912) mapped the three Cretaceous outliers in the Pontotoc area as the Edwards Limestone, but did not specifically state the evidence used in identifying the strata.

Sellards, Adkins, and Plummer (1933) mapped the outliers as the Fredericksburg Group in their Geologic Map of Texas. No mention of the outliers in the Pontotoc area was given in the accompanying report, "Stratigraphy of Texas", by Sellards (1932).

PLATE XXV

CRETACEOUS OUTLIERS

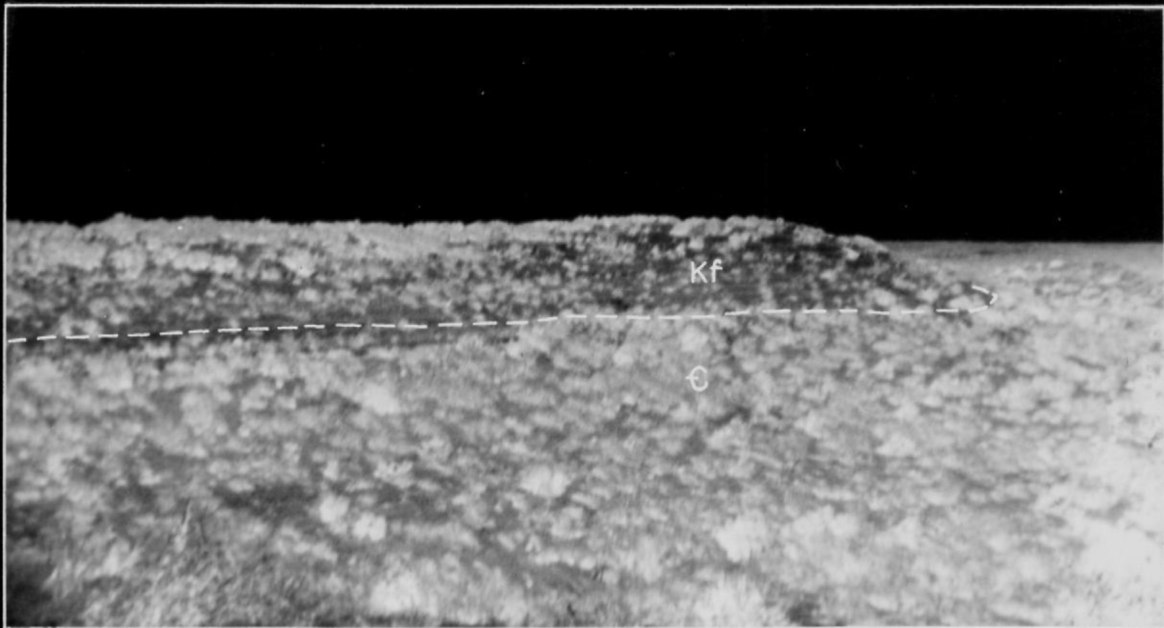


Fig. 1. The Cretaceous outlier in the vicinity of Bush Windmill about 3.2 miles northeast of Pontotoc.

Fig. 2. The Cretaceous outlier west of Ranch Road 501. The arrow points to the microwave relay station which is located about 1.8 miles north-northwest of Pontotoc.

Plummer (1940) published a geologic map of San Saba County in which he mapped the outliers as Lower Cretaceous, but did not specify the exact formation or formations. As there was no report accompanying this geologic map, no evidences were given by Plummer for his general classification of the Cretaceous strata in the Pontotoc area.

The Cretaceous outliers were remapped by Plummer (1950). He mapped the rocks of the outlier at the microwave relay station as the Travis Peak Formation, and the rocks of the outlier at the Bush Windmill as the Comanche Peak Limestone. The rocks occurring in the central outlier were not designated. Plummer did not refer to these three outliers in his report, but he did refer to a measured section at Shin Oak Mountain which is about four miles northeast of the Pontotoc area. The measured section given by Plummer (1950, p. 114) is as follows:

	Thickness Feet	Thickness Inches
Edwards		
3. Limestone, light gray to white, hard, breaks with conchoidal fracture, mostly unfossiliferous..	6	2
Walnut[1]		
2. Marl, chalky, soft, fossiliferous, interbedded with at least four layers of fairly hard, chalky limestone........................	43	0
Basal conglomerate		
1. Limestone, light gray, hard, subcrystalline containing a great number of small, subangular to angular chert pebbles a fraction of an inch in size................	2	5

[1] It is believed that the term Walnut, as used in the measured section above, is a printer's error, and that

Based on studies by Taff (1892), Cuyler (1931), and Barnes (1941), Plummer (1950, p. 101) stated that the Cretaceous strata were deposited in a transgressing sea. The older Cretaceous units are overlapped by the suceeding younger Cretaceous units toward the center of the Llano region until, in the Shin Oak Mountains in southwestern San Saba County, Comanche Peak Limestone is found overlying Cambrian rocks. According to Plummer, this stratigraphic relationship indicated that the Llano region was an island during most of Early Cretaceous time, and that the first Cretaceous rocks deposited over the entire region were either the upper portion of the Comanche Peak Limestone or the lower portion of the Edwards Limestone.

Discussion

Lithology

The similarity in lithology between the Cretaceous strata in the Pontotoc area and the Cretaceous strata in other parts of the Llano region is not very close. Some of the Cretaceous limestones in the Pontotoc area display lithologic and weathering characteristics similar to those of the Edwards Limestone in that they are coarse to granular, hard,

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it should have read Comanche Peak. In his report Plummer referred only to the Comanche Peak at the Shin Oak Mountain locality, and on the geologic map, only Comanche Peak and Edwards are shown at the Shin Oak Mountain locality.

and contain chert seams and nodules. The limestones in the Pontotoc area are resistant to erosion and form a nearly level protective cap over the underlying siltstone and basal conglomerate-sandstone units. The limestones weather to vuggy and pitted surfaces and to black soil.

The sparsely fossiliferous, chalky siltstones erode readily to moderate slopes which, in most places, are covered by soil and rock debris. The presence of Monopleura mareida White in the siltstone unit suggests that this unit is also equivalent to the Edwards Limestone. The basal conglomerates and sandstones represent initial Cretaceous sediments which were deposited on an erosional surface.

The vertical transition from conglomerate to sandstone to siltstone to limestone in the Pontotoc area seems to indicate that the rocks were deposited in a transgressing sea, which would be in agreement with Plummer's (1959, p. 101) conclusion that in the Llano region, the contact of the Cretaceous strata with the Precambrian and Paleozoic strata is that of a progressive overlap toward the center of the uplift.

Cartwright (1932, figs. 1, 2, and 3) presented contour maps of the pre-Cretaceous and pre-Fredericksburg depositional surfaces which showed high areas to the south and southwest of the Pontotoc area. Cartwright's isopach map of the Trinity division (1932, fig. 2) showed the absence of the Trinity in the Pontotoc vicinity. These maps also showed that the Pontotoc area was a topographic high during the time rocks of the Trinity and the lower Fredericksburg groups were deposited. This evidence and the lithologic characteristics of the limestones, and possibly the siltstones, indicate that the Cretaceous rocks in the Pontotoc area are equivalent to the Edwards Limestone which is the upper formation of the Fredericksburg Group.

Paleontology

The fossils found in the Cretaceous strata in the Pontotoc area were poorly preserved, occurring mostly as casts and fragments of siliceous replacements. Two forms which were identified, with the assistance of Drs. K. J. Koenig and K. P. Young, are: Toucasia patagiata White and Monopleura marcida White which are Upper Fredericksburg in age and commonly occur in the Edwards Limestone. Other forms which were identified, with the assistance of Dr. K. J. Koenig and Mr. F. E. Smith, are similar to the genera: Caprinuloidea sp., Turritella sp., and Lunatia sp.. Fragments of a Pecten sp., a few pelecypods, and one echinoid were also found, but could not be identified. Caprinuloidea is a characteristic fossil of the Edwards Limestone.

The fact that some of the limestones in the Pontotoc area contain fairly large numbers of foraminifera suggests an age equivalent to that of the Edwards Limestone which also has a high foraminiferal content (F. E. Smith, 1962, personal communication). The foraminifera in the limestones in the Pontotoc area could not be identified.

The general assemblage of the fossils found in the Pontotoc area indicates that the Cretaceous rocks in the area represent the Edwards Limestone of the Fredericksburg Group.

Conclusion

On the basis of lithology and fossil content, the author believes that the Cretaceous rocks in the Pontotoc area are a part of the Upper Fredericksburg Group, and that the limestones and siltstones represent the Edwards Limestone. The basal conglomerates and sandstones in the Pontotoc area may represent either pre-Edwards (upper Comanche Peak Limestone) or Edwards Limestone deposits.

QUATERNARY SYSTEM

Quaternary deposits include conglomerates and alluvium which consist of silt, sand, and rock debris derived from Mesozoic, Paleozoic, and Precambrian rocks. These deposits are small and occur principally in the major streams. The major portions of the Recent sediments are carried away from the Pontotoc area by the occassional torrential rains and floods, thus keeping the amount of Recent sediments in the area to a minimum.

STRUCTURAL GEOLOGY

REGIONAL STRUCTURE

The Llano uplift is a structural dome which is expressed topographically as a basin exposing Precambrian and Paleozoic rocks. Relatively flat-lying Cretaceous strata form the rim of the basin. The basin area is somewhat elliptical in shape with the long axis being 80 miles in length and extending in a west-northwest direction. The length of the minor axis is about 40 miles. The surface area affected by the uplift is about 100 miles in diameter with an area of about 8,000 square miles (Plummer, 1950, p. 7). The Pontotoc area is located on the northern flank of the Llano uplift.

Precambrian rocks, which occur at depths of 4,000 to 5,000 feet below sea level in Sutton, Schleicher, Tom Green, Coke, Eastland, and Erath counties adjacent to the Llano uplift, are found exposed at elevations over 1,000 feet above sea level in the center of the uplift indicating that the amount of uplift is between 5,000 and 6,000 feet (Sellards, 1932, p. 30).

The thinning of the Chappel and Barnett formations over the Llano uplift indicated that uplifting of the Llano region began in Mississippian time (Sellards, 1934, p. 84). Cloud and Barnes (1948, p. 121) inferred that the final stages of deformation occurred prior to the deposition of

Canyon strata. They reported that the Strawn Formation is faulted whereas strata of Canyon age overlap the faulted Ellenburger Group and are not involved in the faulting. Cloud and Barnes also stated that it is not known whether the faulting was in progress during the deposition of Strawn rocks or was a post-Strawn and pre-Canyon event.

The general trend of the faults in the Llano region is northeast-southwest and has been designated the "Llano system of faults" by Sellards (1934, p. 85). According to Cloud and Barnes (1948, p. 118), the faults are normal or vertical and range in dip from about 60 to 90 degrees.

The Paleozoic strata are not strongly folded in the Llano region. Some gentle anticlinal and synclinal folds have been reported by Paige (1912), Cloud and Barnes (1948), Grote (1954), Sweet (1957), Mounce (1957), and Miller (1957). Cloud and Barnes (1948, p. 121) reported that the axes of many of the folds within the Paleozoic strata are aligned in a northwest-southeast direction, but recognized that other alignments are also present. In his review of the literature pertaining to Paleozoic folding, Pool (1960, p. 71) reported that the fold axes trend between northwest and northeast, and that the folds generally plunge away from the uplift. Pool also reported that the faults antedated the folds, and that the faults are both parallel to and perpendicular to the fold axes. Minor folds caused by drag along faults, slumping into limestone sinks, and compaction of beds around the bioherms are common to most of the Llano region.

Several arches extend outward from the Llano uplift. Two of these arches, the Concho arch trending northwest, and the San Marcos arch plunging southeast, coincide in position and trend with the known Precambrian folds. The other arches, the Lampasas arch trending northeast, the Edwards arch trending southwest, and the Bend arch trending north-northeast, are nearly perpendicular to the Precambrian folds and are nearly parallel to the trends of post-Bend faults (Sellards, 1934, p. 87).

The Bend arch was recognized as a northward-plunging anticline by Cheney (1918, p. 109-110). Sellards (1934, p. 91) reported that the Bend arch is parallel to the post-Bend fault system of the Llano uplift and may have an actual relationship to that faulting. Such a relationship would account for the asymmetric form of the arch and for its relatively steep, probably faulted, east slope. Both Levorsen (1927, p. 679) and Cheney (1929, p. 11) stated that the Bend arch was formed by two separate earth movements: the first movement occurred during or prior to Strawn time forming an eastward-dipping homocline; the second movement occurred during Late Pennsylvanian and Permian time causing the region to be tilted to the west, thus forming the arch.

The Lampasas arch is a broad arch which begins in the northeastern part of the Llano uplift and trends northeastward through the western part of Lampasas County. This arch is recognized from relatively few well records, and it is not possible to determine to what extent the arch is limited at either side by faulting (Sellards, 1934, p. 89).

According to Sellards (1934, p. 44), the San Marcos arch was a broad positive element which resulted in the thinning of Upper Cretaceous formations. The arch was submerged during Early and most of Late Cretaceous time.

The Edwards arch is a broad fold trending southwestward from the Llano uplift and is perpendicular to the San Marcos arch. Data obtained from the few wells drilled in the area of the Edwards arch indicate the possible presence of faults along the southeast boundary of this structure (Sellards, 1934, p. 87). Sellards stated that these probable faults do not cut the surface formations, and for this reason, he believed that they may be part of the Llano system of faults.

The Concho arch was first recognized by Cheney (1929, p. 557). This arch parallels the trend of the Precambrian folds and the San Marcos arch, and extends northwestward from the Llano uplift. Cheney (1940, p. 29) stated that the Concho arch had started to develop by Early Ordovician time as indicated by loss of beds of Early Ordovician age toward the arch. The arch was re-elevated and severely eroded during post-Bend time.

Cheney (1940, p. 105) considered the major structural features of the Llano region to be narrow, northeast-trending grabens between stable areas or horsts, and inferred that the horsts and grabens were tilted parts of the Concho arch. Cheney applied the names Richland Springs, Pontotoc, San Saba, and Lampasas axes to the horsts. The Pontotoc area is situated on the Pontotoc axis which is about 12 miles wide and is bordered on the west side by the Fredonia fault, and on the east side by the Smoothingiron Mountain fault.

Several theories have been proposed to explain the origin of the faulting in the Llano uplift. Paige (1912, p. 10) stated that the nearly vertical faults which have the same northeast trend as the folds are indicative of compressive stresses. Paige stated that if the folds were produced by tensional stresses, as would be involved in doming by direct vertical uplift, elongation of the beds would have resulted and normal faults with moderate dips would have been developed. Such evidences were not found in the Llano region. Paige believed that vertical or nearly vertical faults alone are not indicative of appreciable elongation of the surface, but when combined with folds they are an expression of relief from compression by vertical movement.

The following paragraphs discussing the origin of the faulting in the Llano region are taken from Paige (1912, p. 10).

"A consideration of the ancient geography of North America suggests that during the entire period or succession of periods during which deposition was taking place in this region there were land masses both to the northwest and to the southeast, and it is believed that such a condition existed immediately prior to the post-Permian uplift which again brought this region above sea level. It is probable that the seas in which these sediments were deposited occupied troughs trending in a northeast-southwest direction.

Subsidence in the floor of the Gulf of Mexico would initiate deep-seated rock flowage, under the influence of which the central Texas region would be compressed between the two land masses mentioned above. Such compression might have produced the folding of the strata parallel to the shore of the Gulf of Mexico in the Llano-Burnet region, accompanied by vertical faulting, the expression, it is believed, of relief from compressive stresses in this lightly loaded area where vertical movements might more easily take place."

Cloud and Barnes (1948, p. 118) proposed a theory involving tensional stresses. They considered the Llano uplift as having been a relatively stable mass with the Ouachita geosyncline on the eastern and southern sides. According to Cloud and Barnes, the faulting in the Llano region probably accompanied the Late Paleozoic folding that involved the sediments of the geosyncline, and movement in the geosynclinal areas to the east and south placed the Llano region under a torque which resulted in faulting. These theoretical "tensional couples" developed by active compression from the east and south resulted in fractures aligned dominantly in a northeast-southwest direction (Cloud and Barnes, 1948, p. 118).

The theory involving "tensional couples" was not adequately explained by Cloud and Barnes to allow a complete understanding of their proposal. Paige's proposal concerning compression caused by deep-seated rock flowage was also inadequately explained. It is the author's opinion that additional evidence concerning the structural relationship between the various arches and the Llano uplift; a more complete knowledge of the types of faults present in the Llano region, that is, the possible presence of other types of faults besides vertical and normal faults, and the locating of the various fault trends are needed for a better understanding of the possible stresses involved in the deformation of the Llano region.

LOCAL STRUCTURE

The structure of the Pontotoc area resulted from two periods of deformation. The first period of deformation occurred during Precambrian time and resulted in the metamorphism and strong folding of a thick series of ancient sediments, and the later intrusion of igneous rocks. The foliation of the gneiss-schist unit in the Pontotoc area has an average strike of N 45° W and moderate dips to the northeast, and represents the northeast flank of a northwest-trending anticline. The gneiss-schist unit is cut by small masses of fine-grained granite and by aplite dikes. Soil cover obscures the metamorphic-igneous contacts.

The second period of deformation occurred during the Paleozoic Era and resulted in uplift, faulting, and erosion of the Precambrian and Paleozoic rocks prior to the deposition of Cretaceous strata. Strikes of the Paleozoic beds in the Pontotoc area vary between N 70° W and N 65°E with a few nearly east-west and north-south strikes. The beds dip mostly to the northwest and northeast except for a few beds which dip to the north, west, and southwest. The dips of the beds range between 1 and 11 degrees. The Cretaceous strata dip about one degree to the north and are not involved in the faulting. The present elevation above sea level of the Llano region was caused by a broad uplift of the continent during Cenozoic time (Cheney, 1952, p. 2259).

FOLDING

As previously stated, the Precambrian gneiss-schist unit is folded and forms the northeast flank of a northwest-trending anticline in the Pontotoc area. Folding of Paleozoic rocks is limited to small folds within the shales of the Point Peak Member (Plate XVIII, fig. 1), and to the limestones interbedded with the Point Peak bioherms and the basal San Saba limestones which overlie the bioherms.

FAULTING

The faults recognized in the Pontotoc area are vertical or nearly vertical as indicated by their relatively straight traces (Plates I and XXVI) and by the dips, which vary from 87 to 90 degrees (Plates XXVII and XXVIII). The faults cut the Paleozoic strata into a number of tilted blocks and a few small horsts and grabens.

The throws along the faults range from a few feet to about 200 feet. A throw of about 200 feet occurs along the fault where the Cap Mountain Limestone Member has been upthrown opposite the Welge Sandstone Member (see inset, Plate I). A throw of about 90 feet occurs at the fault

PLATE XXVI

EXPOSURE OF A SMALL FAULT

A fault striking across the small hollow just west of Ranch Road 501 on the Nell Harris property about 2.2 miles north of Pontotoc. This photograph illustrates the straight trace that is characteristic of most of the faults in the area.

PLATE XXVII

THE PONTOTOC CREEK FAULT

The Pontotoc Creek fault about 0.2 miles directly west of Pontotoc. This exposure occurs on Pontotoc Creek on the G. H. Willis property.

PLATE XXVIII

EXPOSURES OF SMALL FAULTS

Fig. 1. Exposure of a fault occurring within the Welge Sandstone Member just west of Ranch Road 501 about 2.2 miles north of Pontotoc. The dip of this fault is 87 degrees.

Fig. 2. Small fault occurring within the Welge Sandstone Member at the head of Spring Hollow about 2.2 miles north of Pontotoc.

between the Morgan Creek and Point Peak members in the northwestern quadrant of the Pontotoc area. At this locality nearly the entire shale portion of the Point Peak Member is downthrown bringing the base of the bioherm unit opposite the upper five feet of the Morgan Creek Limestone Member. The throw along this fault appears to decrease to the southeast where the Morgan Creek, Welge, and Lion Mountain members occur on both sides of the fault with smaller horizontal displacements of the contacts. This fault is an eastward continuation of the fault mapped by Jennings (1960, Plate I) in the Pontotoc Northwest area. A throw of about 25 feet was observed in the small horst just east of Bush Windmill about 3.1 miles northeast of Pontotoc, and about the same amount of throw occurs along the fault southwest of Bush Windmill. The fault in the northwest corner of the D. E. Davis property has a throw of five feet. Throws along the other faults are very small.

It is believed that a number of the short faults shown on the geologic map (Plate I) may be segments of longer faults, but the small throws, soil cover, and thick growths of vegetation have prevented tracing the faults continuously in the field or on the aerial photographs. The rather wide outcrops of some of the Cambrian units also suggest the possible presence of a number of undected faults which repeat the section.

The one notable feature of the faults in the area is that they trend nearly perpendicular to the normal northeast-southwest trend of the Llano fault system. As previously stated, the Pontotoc area lies on an upthrown block or horst referred to as the Pontotoc axis by Cheney. This horst trends northeast and is bounded along the western side by the Fredonia fault and along the eastern side by the Smoothingiron Mountain fault. The average width of the Pontotoc axis is about 12 miles.

In his review of the literature pertaining to the Fredonia fault, which was named by McGrath (1952, p. 19), Jennings (1960, p. 68) reported that the throw along the Fredonia fault varies from 200 to 1,400 feet and appears to increase northeastward from the James River in Mason County. Jennings (1960, p. 68) reported a throw ranging from 450 feet to a probable maximum of 1,200 to 1,300 feet along the Fredonia fault in the Pontotoc Northwest area which borders the Pontotoc area on the west. Chauvin (1962, personal communication) estimated a throw of 900 feet for the Fredonia fault in the Pontotoc North-Northwest area which borders the Pontotoc Northwest area on the north. Greenwood (1962, personal communication) estimated a maximum throw of about 1,000 feet for the Smoothingiron Mountain fault in the central portion of the Smoothingiron Mountain North area which borders the Pontotoc area on the east. Greenwood also stated that the throw along the Smoothingiron Mountain fault decreases southward to about 400 feet and decreases northward to about 300 feet.

The author regards the faults in the Pontotoc area as transverse faults between two major northeast-trending fault zones. These transverse faults appear to be connected to the major fault zones in two ways: (1) by curving along strike and assuming the trend of the major fault zone (see Jennings, 1960, Plate I), and (2) by intersecting the major northwest-trending faults (see Chauvin, 1962, Plate I). The relation of the transverse faults to the Smoothingiron Mountain fault could not be determined.

The author believes that differential uplift of the Pontotoc axis resulted in placing the strata, which form the horst, under stresses great enough to cause faulting. The incomplete fault pattern in the Pontotoc area and the lack of data regarding the number and the trends of possible undected faults and their throws prevent a detailed discussion of the stresses involved at the time of faulting in the Pontotoc area.

AGE OF FAULTING

In the Pontotoc area the faults cut Precambrian and Cambrian rocks, but do not cut the Cretaceous rocks. The faults located at the northern border of the area cut Ellenburger strata in the area north and northwest of the Pontotoc area. The faults in the Pontotoc area resulted from stresses produced by differential uplift of the Pontotoc axis. These faults probably were formed during the time that the Fredonia and Smoothingiron Mountain faults were active. Chauvin (1962, Plate I) mapped Marble Falls Limestone (Lower Pennsylvanian) on the downthrown side of the Fredonia fault, thus giving an Early Pennsylvanian age to the Fredonia fault. Both the Fredonia and the Smoothingiron Mountain faults have the same general northeast trend as the major faults in the Llano region. It is logical to assume that faulting in the Pontotoc area occurred as a part of and contemporaneous with the regional deformation which, according to Cloud and Barnes (1948, p. 121), occurred either during or after the deposition of Strawn rocks and before the deposition of Canyon rocks.

GEOLOGIC HISTORY

In order to determine the complete geologic history of the Pontotoc area, it is necessary to examine the sequence of geologic events in the entire Llano region of which the Pontotoc area is a small portion.

The geologic history of the Llano region has been discussed by Paige (1912), Sellards (1934), Cloud and Barnes (1948), and Barnes (1956). The following discussion is based primarily on these works and supplemented by evidence found in the Pontotoc area.

PRECAMBRIAN

A thick sequence of sedimentary rocks was deposited in the Llano region during Precambrian time. Subsequent deformation resulted in folding and metamorphism of the sedimentary rocks. The area was then intruded at three different times by major granitic batholiths (Sellards, 1934, p. 74). Uplift of the area resulted in the truncation of the folded metamorphic rocks and parts of the granitic masses. This truncated surface was observed in the Pontotoc area where the crest of the northwest-trending anticline was removed by erosion prior to deposition of the Riley Formation. The period of erosion probably lasted until Late Cambrian time since Lower and Middle Cambrian rocks are missing in the Llano region.

CAMBRIAN

The Precambrian depositional surface prior to invasion by Late Cambrian seas had a maximum relief of about 800 feet (Barnes, 1956, p. 8). In his study of the Hickory Sandstone, Goolsby (1957, p. 79) stated that this relief of 800 feet was restricted to local areas and cited Pontotoc as one of these local areas. Such high relief is evident in the Pontotoc area at the locality where the gneiss-schist unit extends upward into the Cap Mountain Limestone Member.

The presence of angular quartz and feldspar grains and the poor sorting in the basal Hickory Sandstone are indicative of rapid deposition in an advancing sea. The heterogeneous composition of the basal conglomerates of the Hickory Sandstone indicates derivation from the underlying Precambrian rocks. Barnes and Parkinson (1939, p. 665-670) reported the presence of ventifacts in the basal portion of the Hickory Sandstone, and suggested the possibility that the sandstones which covered the ventifacts were wind-blown rather than water-laid. Goolsby (1957, p. 59) stated that studies of the cross-bedding in the basal Hickory Sandstone indicated that deposition of the basal Hickory Sandstone occurred at "the mouths of fast, possibly temporary streams where they entered a quiet sea." This author is not in complete agreement with the postulation proposed by Barnes and Parkinson that "the sand which incorporated them [the ventifacts] must have been wind blown rather than water borne, otherwise many of the pebbles would have been turned over onto their faceted faces." The ventifacts have a wide, flat bottom and are faceted on the upper surfaces. It would seem likely that the ventifacts would tend to come to a final resting position on their wide, flat surfaces regardless of the medium in which they were deposited. No ventifacts were found in the Pontotoc area. This author is in agreement with Goolsby's conclusions concerning the depositional environment of the basal Hickory Sandstone.

The middle portion of the Hickory Sandstone is characterized by well-sorted, fine-grained sand, cross-bedding, intraformational conglomerates, and symmetrical ripple marks which indicated deposition in shallow waters.

In the western part of the Llano region the upper Hickory Sandstone is characterized by coarse quartz grains which are coated with hematite. Goolsby (1957, p. 86) reported that hematite is also found in the sandstone pore spaces, and that it appears to have been introduced along with the influx of coarser sands from a nearby source area. Goolsby's conclusion is based on observations made by Twenhofel (1950, p. 416) who stated that iron oxides and hydroxides are highly insoluble and are likely to remain at or close to the source area. The source area during Cambrian time is considered to have existed northwest of the Llano region, and as the heavy concentration of hematite occurs predominantly in the western part of the uplift, the proximity of a source area for the hematite seems reasonable. Hematite was observed in the pore spaces of the upper Hickory Sandstone in the Pontotoc area. The fact that the hematite occurs as very small grains in the pore spaces suggests the alternative possibility that the hematite may have been derived from the alteration of glauconite.

The Hickory Sandstone grades upward into the Cap Mountain Limestone due to a decrease in the supply of coarse clastics which may have resulted from a lowered source area; however, the impurity of the Cap Mountain limestones indicates a continous supply of silt-sized material. The presence of glauconite in the upper portion of the Cap Mountain Limestone indicates shallow water of a slightly reducing nature. A possible uplift of the source area is suggested by the occurrence of siltstone layers in the upper part of the Cap Mountain Limestone Member.

Regressing seas resulted in the deposition of the Lion Mountain Sandstone Member. The abundance of glauconite indicates relatively quite waters; whereas, turbulent waters are indicated by the presence of the "trilobite hash". Cross-bedding within the highly glauconitic layers in the upper part of the Lion Mountain Sandstone and the absence of silt- and clay-sized particles also indicate turbulent waters. It would seem possible that the Lion Mountain Sandstone was deposited in a neritic environment, and that either currents transported the glauconite and trilobite remains into the area or that reworking of the glauconite and trilobite remains by storm waves caused the cross-bedding and "trilobite hash".

A short period of emergence is indicated by the minor disconformity between the Lion Mountain and the Welge Sandstone members. The Welge sandstones are nonglauconitic, nonargillaceous, and consist of well-rounded, pitted and frosted sand grains which suggest wind-blown sand deposits that were reworked by water.

The seas continued to transgress resulting in a gradational contact between the Welge Sandstone and the Morgan Creek Limestone. The influx of clastics decreased and massive limestone beds were deposited. The presence of siltstone layers in the middle portion of the member suggests minor uplift in the source area. Quiet, shallow waters are indicated by the presence of glauconite and small algal reefs.

A slight withdrawal of the seas resulted in the deposition of the Point Peak Shale. Paige (1912, p. 11) suggested that the intraformational conglomerates were formed by shallow water reworking mud-cracked sediments consisting of silts and limey muds on tidal flats. The seas advanced once more depositing limestones which display symmetrical ripple marks and large reefs. The reefs are considered to have formed in well-lighted, clear, warm, quiet, and shallow waters (Cloud and Barnes, 1948, p. 112).

The bioherm zone is persistent throughout the Llano region, but migration of the depositional environment of the bioherms has caused the bioherm zone to transgress time boundaries. Barnes and Bell (1954, p. 25) reported that the bioherms extend well upward into the limestones of the San Saba Member. The bioherms occur in the top of the Point Peak Shale at White's Crossing, Mason County. Bridge, Barnes, and Cloud (1947, p. 117) reported that the bioherm zone occurs within the San Saba Limestone Member at Squaw Creek, Gillespie County.

The seas continued to advance depositing San Saba limestones. In the western portion of the uplift, sandstones and siltstones occur in the San Saba Member indicating a source area to the northwest. The amount of clastics is much smaller in the eastern portion of the region where sublithographic limestones and dolomites are present. In the Pontotoc area a relatively small percent of silt was observed in the San Saba limestones.

Cloud and Barnes (1948, p. 112) reported that the Cambrian strata are truncated below the Ordovician rocks in the southeastern portion of the uplift, but are not truncated in the northwestern portion. Cloud and Barnes stated that while sedimentation in the northwestern portion of the region appears to have been continous across the Cambrian-Ordovician boundary, erosion of the Upper Cambrian strata in the southeastern portion resulted from either a depression of sea level in that area or a tilting of the Llano region to the northwest.

ORDOVICIAN AND SILURIAN

According to Cloud and Barnes (1948, p. 112), the Llano region was relatively stable during Early Ordovician time. Land masses to the east and south were either submerged or very close to sea level. The Ellenburger Group was deposited in seas which were about 100 fathoms in depth, well-oxygenated, and intermittently turbulent. The limestones were probably derived from chemically precipitated lime-muds.

The Llano region was later tilted to the southeast resulting in the truncation of the Ellenburger Group in the northwestern part of the region.

Rocks of Middle Ordovician age are not found in the Llano region. A few deposits of Upper Ordovician age occur in collapse structures. No evidence of Silurian strata has yet been found which suggests that the region was emergent during this period.

DEVONIAN

Barnes, Cloud, and Warren (1947, p. 126) reported that rocks of Devonian age, with the exception of the Stribling Formation, occur as small, isolated outcrops confined to collapse structures within the Ellenburger Group. The occurrence of older Devonian rocks in the eastern part of the Llano region and of younger Devonian rocks in the western part indicated that the Devonian seas invaded the Llano region from the east. Emergence of the region resulted in the removal of most of the Devonian strata prior to the deposition of Mississippian rocks.

MISSISSIPPIAN AND PENNSYLVANIAN

During Carboniferous time the Llano region was invaded several times by seas. The sediments deposited consisted of fossiliferous limestones and shales with lesser amounts of conglomerates and sandstones.

Thinning of the Chappel and Barnett formations toward the center of the region indicates that the uplift of the region began in Late Mississippian time. The final stages of deformation occurred either during or after the deposition of Strawn rocks and before the deposition of Canyon rocks. This age for the deformation is based on the fact that strata of Strawn age are faulted; whereas, strata of Canyon age are not faulted, and that in some places Canyon rocks overlie partially eroded Ellenburger rocks (Cloud and Barnes, 1948, p. 121).

PERMIAN, TRIASSIC, AND JURASSIC

The Llano region underwent an extensive period of erosion following Pennsylvanian time and prior to the deposition of Lower Cretaceous rocks. The fact that the Precambrian rocks were exposed by erosion during this time is strong evidence against any great amount of deposition during the Permian, Triassic, and Jurassic periods.

CRETACEOUS

By the beginning of Early Cretaceous time, the Llano region was reduced to a peneplain by erosion. The Cretaceous seas invaded the region and continued to advance as is indicated by the progressive overlap of younger Cretaceous strata over older Cretaceous strata in the Trinity and Fredericksburg groups.

Plummer (1950, p. 103) reported that the distribution of the conglomerates of the Sycamore Sand Member, its cross-bedding, the shapes and mode of assortment of the pebbles suggested to Damon (1940) that the conglomerates were non-marine in origin, having been deposited by streams as terraces or as alluvial fans that were later reworked to some extent by the encroaching Early Cretaceous sea.

The lithology and fauna of the Cow Creek Limestone Member of the Travis Peak Formation suggest shallow water during the time of deposition of this unit. The Hensell Sand marks a transgression of the sea in which the Glen Rose Limestone was later deposited. Beach and shallow-water facies are displayed in the basal portions of the Glen Rose Limestone.

The seas continued to transgress and deposited the rocks of the Fredericksburg Group. A shallow depth of the transgressing sea is indicated by the fauna and the reef facies as well as by lateral variations in the lithologic facies.

According to Plummer (1950, p. 101) and Barnes (1941, p. 1944), the first Cretaceous strata to completely cover the entire Llano uplift were either the upper portion of the Comanche Peak Limestone or the lower portion of the Edwards Limestone. This concept by Plummer and Barnes is supported by the fact that the Cretaceous rocks in the Pontotoc area are equivalent to the Edwards Limestone.

The Llano region remained emergent following the withdrawal of the Cretaceous seas. Subsequent uplift and erosion removed the Cretaceous rocks over the uplift exposing the structurally high, but less resistant Paleozoic and Precambrian rocks. Erosion of the less resistant Paleozoic and Precambrian rocks progressed faster than the erosion of the Cretaceous strata, thus resulting in the topographic basin. Deposition since Cretaceous time has been confined to stream valleys.

ECONOMIC RESOURCES

Land and ground water are the most important resources in the Pontotoc area. Cultivated fields are located on soils derived from the Hickory Sandstone and from the Precambrian rocks in the basin area around the communities of Pontotoc and Field Creek, but most of the area is devoted to ranching. A large number of water wells have been drilled in the area and all the production is from the Hickory Sandstone. Water is used for human and livestock consumption.

The small caliche deposit located at the central Cretaceous outlier north of Pontotoc was quarried in 1959 for use as road material in the construction of Ranch Road 501. This small quarry was abandoned upon completion of the highway.

According to Barnes and Dawson (1944, p. 229), caliche is a secondary calcium carbonate deposit varying in texture from a pulverant mass to hard, dense material, and occurs abundantly in surface and near-surface deposits in the arid and semi-arid parts of Texas. The chief use of caliche in Texas is for road material (Sellards and Evans, 1944, p. 96).

At the locality north of Pontotoc the caliche is white, soft, and poorly-bedded (Plate XXIX). A massive layer of medium-gray, sublithographic limestone and a few thin-bedded layers of cream-colored, sublithographic limestones are interbedded in the caliche material (Plate XXIX and Plate XXX, fig. 2).

PLATE XXIX

EXPOSURE OF CALICHE

Exposure of white, soft, poorly-bedded caliche and massive layer of medium-gray, sublithographic limestone in the south wall of the caliche quarry on the Nell Harris property about 2.2 miles north of Pontotoc.

PLATE XXX

CALICHE QUARRY

Fig. 1. The abandoned caliche quarry on the Nell Harris property about 2.2 miles north of Pontotoc. The view is to the south. (Photograph by E. J. Graczyk)

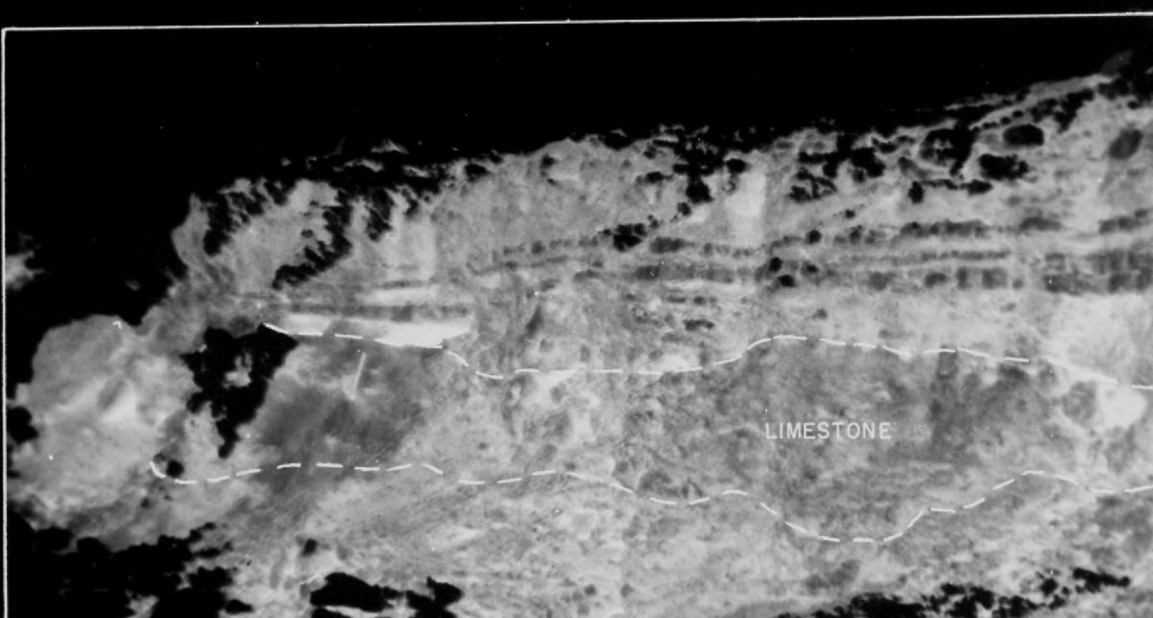

Fig. 2. Thin and massive layers of sublithographic limestone interbedded with caliche in the south wall of the caliche quarry.

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A P P E N D I X

DESCRIPTION OF THE SECTION OF CRETACEOUS ROCKS AT BUSH WINDMILL

The "Bush Windmill section" occurs on the escarpment directly south of and below the Bush Windmill on the W. H. Taylor property about 3.1 miles northeast of Pontotoc. The section extends upward from the Cambrian-Cretaceous contact to the top of the hill. At this locality the Cretaceous overlies the lower portion of the Morgan Creek Limestone.

The terms thin-bedded, medium-bedded, thick-bedded, and massive have been assigned absolute thicknesses which are: thin-bedded: less than 2 inches; medium-bedded: 2 to 6 inches; thick-bedded: 6 inches to 1 foot; and massive: greater than 1 foot.

Cretaceous System

Comanche Series

Upper Fredericksburg Group

Unit	Limestone Unit	Feet	Inches
7	Siltstone: yellow patches on white, thin- to thick-bedded, soft, argillaceous, chalky; weathers light gray. Interbedded with thin-bedded, yellowish-gray, arenaceous limestones containing chert nodules in the upper five feet of the unit. This unit is partially covered by soil and chert fragments on the top and slope of the hill..................................	28	0

Unit		Feet	Inches
6	Limestone: light gray to yellowish-gray, medium-bedded to massive, hard, argillaceous, chalky; weathers light gray, partially covered, forms ledge. Casts of cf. *Turritella* sp., cf. *Toucasia patagiata*, and cf. *Caprinuloidea* sp. were found.....	16	0
5	Limestone: yellowish-gray, massive, dense, argillaceous, silty, chalky, slightly arenaceous; weathers light gray, forms ledge..................................	2	6
	Siltstone Unit		
4	Siltstone: yellowish-gray, thin-bedded, soft, argillaceous, chalky, slightly arenaceous; weathers light gray..........	1	2
3	Siltstone: yellowish-gray, massive, soft, argillaceous, arenaceous, calcareous; weathers light gray, partially covered by rubble..............................	3	0
2	Siltstone: white to yellowish-gray, thin- to medium-bedded, soft to friable, calcareous, arenaceous toward the base; weathers light gray, partially covered...	5	0
	Basal Conglomerate-Sandstone Unit		
1	Sandstone: yellow to white, medium-grained, friable, calcareous; weathers light gray, partially covered by sandy soil and rubble	19	6
	Total measured thickness.................	75	2

DESCRIPTION OF THE SECTION OF CRETACEOUS ROCKS AT THE MICROWAVE RELAY STATION

The "Microwave section" occurs on the escarpment slope directly south of and below the Microwave Relay Station control house and tower on the Nell Harris property about 1.8 miles north-northwest of Pontotoc. This section extends upward from the Cambrian-Cretaceous contact to the top of the hill. At this locality the Cretaceous overlies the lower portion of the Cap Mountain Limestone Member.

The absolute thicknesses assigned to the terms thin-bedded, medium-bedded, thick-bedded, and massive are the same as those listed in the "Bush Windmill section".

Cretaceous System

Comanche Series

Upper Fredericksburg Group

Unit	Limestone Unit	Feet	Inches
8	Limestone: yellow streaks in whitish-gray matrix, fine- to medium-grained, medium- to thick-bedded, hard in upper part of this unit, massive, hard in lower part, argillaceous, chalky; weathers to light gray, medium- to thick, flat blocks in upper portion and to large, blocky boulders in lower portion. The limestones have a very vuggy surface. Unit is partially covered....................	20	0

Unit	Siltstone Unit	Feet	Inches
7	Siltstone: yellow, thick-bedded, hard, argillaceous, slightly arenaceous; weathers light gray, partially covered...	9	6
6	Siltstone: yellowish-gray, thick-bedded, soft, argillaceous; weathers light gray, mostly covered by talus and soil..........	8	9
5	Siltstone: yellowish-gray, thick-bedded, hard, argillaceous, chalky, fossiliferous containing fragment casts and impressions of pelecypods; weathers light gray, forms ledge..................................	4	0
4	Siltstone: white to yellowish-gray, medium-bedded, soft, argillaceous, chalky, slightly arenaceous; weathers light gray, partially covered by rubble.......................	8	0
3	Same as unit 5.........................	1	6
2	Siltstone: whitish- to yellowish-gray, thin- to medium-bedded, soft to friable, argillaceous, arenaceous, calcareous; weathers white, yellow, and gray, partially covered................................	3	4
	Basal Conglomerate-Sandstone Unit		
1	Sandstone: white to yellow, medium-grained, friable, calcareous; weathers to sandy soil and rubble, heavily covered..............	16	0
	Total measured thickness.................	71	6

DESCRIPTION OF THE SECTION OF CRETACEOUS ROCKS SOUTHEAST OF THE CALICHE QUARRY

The "Caliche section" occurs on the escarpment slope southeast of the abandoned caliche quarry on the Nell Harris property about 2.1 miles north of Pontotoc. This section extends upward from the Cambrian-Cretaceous contact to the top of the hill. At this locality the Cretaceous overlies the lower half of the Cap Mountain Limestone.

The absolute thicknesses assigned to the terms thin-bedded, medium-bedded, thick-bedded, and massive are the same as those listed in the "Bush Windmill section".

Cretaceous System

Comanche Series

Upper Fredericksburg Group

Unit	Limestone Unit	Feet	Inches
4	Limestone: yellow to light gray, thick-bedded, hard, coarse-grained, arenaceous, argillaceous, fossiliferous containing pelecypod fragments and abundant foraminifera; weathers light gray, very vuggy slabs on top of hill, partially covered........	20	0
3	Limestone: medium to light gray with yellow and gray streaks, irregular in bedding, hard, sublithographic; weathers to a smooth, but pitted surface, light gray.		

Unit		Feet	Inches
	Thickness varies from 8 inches to 3 feet-6 inches, averages about.........	2	0
	<u>Siltstone Unit</u>		
<u>2</u>	Siltstone: whitish- to yellowish-gray, thin- to thick-bedded, soft to friable, argillaceous, calcareous, arenaceous toward the base; weathers yellow to light gray, heavily covered by soil and talus..............................	22	0
	<u>Basal Conglomerate-Sandstone Unit</u>		
<u>1</u>	Sandstone: white to yellow, friable; weathers to sandy soil and rubble, heavily covered by soil and talus.......	11	0
	Total measured thickness................	55	0