GEOLOGY OF THE SOUTHWEST MASON-LLANO RIVER AREA, TEXAS

A Thesis

By

Robert Preston Parke

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Approved as to style and content by

Chairman of Committee

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Robert Preston Parke

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ABSTRACT

The Southwest Mason- Llano River area is located in south-central Mason County, southwest of the town of Mason. Rock units of Upper Cambrian, Lower Ordovician, Mississippian, and Lower Pennsylvanian age are found in the area. The Upper Cambrian strata are divided into the Riley and Wilberns formation.

The Riley formation is divided into the following members in ascending order: Hickory sandstone, Cap Mountain limestone, and Lion Mountain sandstone. The Hickory sandstone is yellowish-brown to red, coarse-grained and non-glauconitic. The sandstone grades upward into calcareous sands and arenaceous, dark, reddish-brown limestones of the lower portion of the Cap Mountain member. Grey, granular, slightly glauconitic and fossiliferous limestones make up the upper sections of the Cap Mountain member. The highly glauconitic Lion Mountain sandstone member overlies the Cap Mountain member.

The Wilberns formation is divided into the following members in ascending order: Welge sandstone, Morgan Creek limestone, Point Peak shale, and San Saba limestone. The Lion Mountain sandstone is in sharp contact with the yellowish-brown to brown, usually non-glauconitic, Welge sandstone. This sandstone grades upward into reddish to purple and very arenaceous lower Mor-

gan Creek limestones. These purplish beds grade upward into greenish grey, coarse-grained, highly glauconitic, very fossiliferous limestones. The Morgan Creek member is overlain by green, calcareous shales, limestones and conglomerates of the Point Peak member. The upper Point Peak consists of a distinctive, stromatolitic bioherm zone which grades gradually into calcareous sands and arenaceous, fossiliferous limestones of the San Saba member.

The Cambrian strata are overlain conformably by Lower Ordovician rocks. The Ordovician age is represented in the area by the Ellenburger group. The group was mapped as a unit, but is divided into formations in other localities. The Ellenburger group consists of white to steel grey, sub-lithographic, essentially non-glauconitic limestones.

Ellenburger strata are overlain unconformably by Mississippian rocks. They are divided into the Chappel limestone formation and the Barnett shale formation. These formations occur as a thin band in the northwest part of the area. The Chappel is a white to light-grey, thin, detrital limestone which is characterized by abundant fragments of crinoid stems. The Chappel limestone is overlain unconformably by predominantly tan-brown, petroliferous Barnett shales interfingered with limestones.

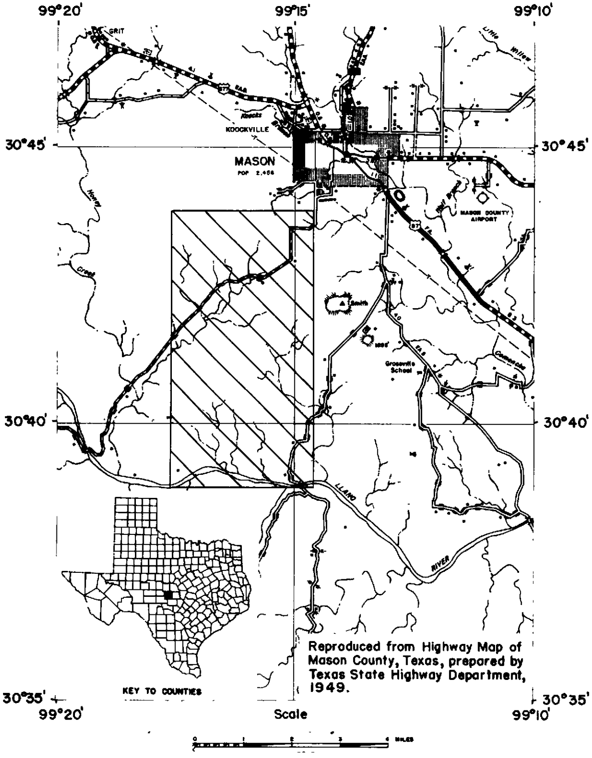
The Pennsylvanian strata of the area are represented by the Marble Falls group of the Bend Series. The group is divided into the Big Saline and Smithwick formations. The Big Saline overlies Mississippian beds unconformably and consists of coarsely crystalline, often siliceous, fossiliferous, light to dark grey limestones containing many layers and nodules of dark grey and light orange chert. All Smithwick shale beds in the area are covered by recent alluvial deposits.

Faulting near the end of Paleozoic time greatly affected the outcrop pattern in the Southwest Mason-Llano River area. The faults are normal, trend northeast and have an average throw of 200 feet, but range up to 1200 feet. The central portion of the area is least affected by faulting. All large faults in the area are downthrown to the northwest. The formations in the area have a regional northeast strike and an average 10° dip to the southeast.

Folding is limited to differential compaction over bioherm structures and small sink hole depression features. There is evidence of some folding southeast of the area.

Ground water is the most important resource of the area with the Hickory sandstone and Ellenburger limestone as the chief aquifers. Oil and gas possibilities have been discounted in the area. Rocks for building and road metal material have been quarried with moderate success.

PLATE III



INDEX MAP OF THE SOUTHWEST MASON—
LLANO RIVER AREA, MASON COUNTY, TEXAS

GEOLOGY OF THE SOUTHWEST MASON-LLANO RIVER AREA, TEXAS

INTRODUCTION

STATEMENT OF PROBLEM

The problems involved in this paper may be listed as follows:

1. The structure and stratigraphy of the Upper Cambrian rocks exposed in the Southwest Mason-Llano River area.

2. The stratigraphy of Carboniferous strata exposed in the area and their relation to the underlying formations.

3. Preparation of a geologic map of the area based on data gathered in the field.

4. The geologic history of the area.

LOCATION

The Southwest Mason-Llano River area is situated on the southwestern flank of the Llano Uplift. The northeast corner of the area is on the Mill Springs road one quarter mile south of the city limits of Mason, Mason County, and the southern boundary is along the Llano River. There are approximately eighteen square miles contained in the 3 by 6 mile rectangular area bounded by latitudes 30° 39' - 30° 44' North and longitudes 99° 15' - 99° 17' West.

ACCESSIBILITY

Accessibility is good in the northern one-third of the Southwest Mason-Llano River area. The all-weather Mill Springs road cuts diagonally through this portion with four small ranch trails extending short distances to the north and south. This road is being replaced at present by a Farm Highway which will follow the same general right-of-way through the area.

A limited portion of the southeast corner is accessible by the all-weather James River Road and one small road leading to Pat Rogers' ranch house.

There are three rock studded ranch trails extending into parts of the interior, one of which follows the Llano River. As a whole, however, the area is inaccessable by vehicle and must be traversed by foot.

METHODS OF FIELD WORK

The field work was started June 10 and completed August 24, 1952. All field observations were recorded on acetate overlays over contact prints of vertical aerial photographs prepared by the U. S. Department of Agriculture. The approximate photograph scale is 1:20,000 or one inch equals 1667 feet. The rectangular area mapped consisted of photographs 151, 152, 153, 154, and 155, series DFZ-5E, dated November 25, 1948. The aerial photographs were a great help in locating general formation outcrop patterns as well as fault traces. Many of the small faults in the area which are not apparent in the field show up clearly as faint vegetation breaks on aerial photographs. All contacts and faults observed on the photographs were checked in the field.

Precise location of contacts, as well as orientation, was accomplished with the aid of a magnifying stereoscope which was especially adaptable to the moderate relief and limited, though not sparse, vegetation of the area.

Key dips and strikes were obtained and plotted at what seemed to be controlling structural points. Random recordings at other points to augment structural interpretation were obtained by averaging several readings in the same locality. All dips and strikes were measured with a Brunton compass except in two measured and described sections, where a three point solution of dip and strike was used.

Selection of measured sections in the area was based on degree of exposure and continuity of strata exposed. Three of the measured sections lie within the area mapped and the remaining five are located immediately to the east of the area in photographs 92 and 93, series DFZ-5E. The two best sections were measured along the Llano River. Since an attempt was made to measure the better exposures only, section lines were not always perpendicular to the strike of the beds. Dips were averaged along the sections to improve the accuracy of thickness calculations. Most of the measurements were made with a plane table, the only exceptions being the portions of the section represented by vertical cliffs. These were measured with a steel chain or stadia rod where applicable, and corrections for dip applied. Most horizontal distances for cross-sections were scaled directly from the maps, and relative elevations determined with a stereoscope or field observation of the terrain.

REVIEW OF LITERATURE

The first published geologic descriptions of the Llano regions of Texas were by Dr. Ferdinand Roemer (1847). Roemer made observations while accompanying a party of German colonists. In his travels Roemer passed through the general locality of the Southwest Mason area. Roemer (1849, 1852) studied the formations, collected fossils, published descriptions of the fossils collected, and published an interesting account of his observations and travels. His work is classical in that he was the first to announce the presence of the older Paleozoic, Carboniferous, and Cretaceous rocks in this area. He described and named a number of fossils with such remarkable accuracy that many of his determinations remain unchanged to this date.

Dr. G. G. Shumard (1886), accompanying an expedition of Army engineers into West Texas and New Mexico in 1855 and 1856, made brief geologic notes along the return route through the San Saba valley, Fort Mason, and Fredricksburg. B. F. Shumard (1861) confirmed much of Roemer's work and was the first to describe the rocks and fossils of this region, assigning them to the Potsdam group of Upper Cambrian age.

Jules Marcou (1855) compiled the first map showing the extent of Carboniferous rocks in the region.

State Geologist S. B. Buckley (1874) arbitrarily and erroneously classified all granites in the Llano region as Azoic in age. He correctly observed that these granites are younger than the metamorphic rocks with which they are associated. He also made brief mention of the general geology of the region.

Considerable time lapsed before further investigation was made in the area. Walcott (1884) visited the area in 1883 and described the Potsdam group as definitely Cambrian in age.

In a review of the geology of Texas R. T. Hill (1887) discussed the Llano region briefly and especially noted the importance of the work of Walcott (1884). Two years later, Hill (1889), clearly named and established the correct age of the Carboniferous rocks at Marble Falls. Hill (1890), in the first of his two papers on the geographic features of Texas, also discussed the erosion of the Lower and Upper Cretaceous sediments from the central area.

In 1889 the Texas Geologic Survey was established with E. T. Dumble as State Geologist. This provided a means for a detailed and systematic geologic survey of the Llano region and investigations by the survey were published by several geologists. T. B. Comstock (1890) published a discussion of the geology and mineral resources of the area. He was the first to divide the pre-Paleozoic metamorphic rocks and granites of the Archean and Eparchean eras. In his discussion Comstock made the first reference to the names Valley Spring and Packsaddle series for the gneisses and schists in the region. In this paper he also introduced the terms Hickory series, Riley series, and San Saba series. Comstock's Riley series included part of the rocks in the present Riley formation, while the term San Saba series applied to all or part of the San Saba beds as most recently described. Comstock noted the occurence of the Hickory and Riley series in Mason County between the city of Mason and the Llano River. Other geologists contributing at this time were R. S. Tarr (1890) who reported on coal resources to the north and the drainage pattern of central Texas, J. A. Taff who reported on the Cretaceous rocks, and W. F. Cummins (1890, 1891) who reported on the Carboniferous rocks north of the region.

The geologic history of Texas was written by E. T. Dumble (1898) with a section devoted to the Central Mineral region. Comments were made on the Granite Highlands (p. 482), which is a mountain system fringed by Paleozoic rocks extending from Burnet County westward through Llano County and into the eastern part of Mason County.

In 1898 Sidney Paige (1912) made a detailed geologic map of the Llano and Burnet quadrangles which are in the central part of the region. He also named and described the Wilberns, Cap Mountain, Ellenburger, and Smithwick formations. The mineral resources and an excellent description of the pre-Cambrian geology was included in his report. In this report he used the name Hickory sandstone instead of the original "Hickory series" applied by Comstock.

In 1916 the first comprehensive geologic map of Texas was published by the Bureau of Economic Geology and Technology (Udden, et al, 1916). On this map with a scale of 1:1,500,000, the Ellenburger, Wilberns, Cap Mountain, and Hickory are combined as a unit and the pre-Cambrian rocks undifferentiated.

Work on the Carboniferous of the Llano region was undertaken when Plummer and Moore (1922) presented a new map of the Carboniferous formations and differentiated the lower Bend shale as a separate formation, naming it Barnett.

Girty and Moore (1919) studied a part of the Carboniferous strata and discussed the age of the Barnett shale. Girty concluded that the Barnett was Mississippian. In an unpublished report Roundy and Hearld made observations on the crinoidal limestone underlying the Barnett. Later Girty (Roundy, Girty, and Goldman, 1926) assigned the crinoidal limestone to the lower Mississippian. The name Chappel was applied to this limestone by Sellards (1933).

An observation on an algal limestone occurence in the Wilberns shales in Mason County was made by Deen (1931).

Dake and Bridge (1932) were the first to attempt zonation and faunal correlation of the older Paleozoic rocks in the region with strata in other states. It was first noticed during these studies that the Ellenburger could be divided into lithologic sequences. Recommendations were made at this time for the old name, "San Saba formation", to be revised and redefined.

The Valley Spring gneiss was redefined by Stenzel (1932) who stated that it was of igneous origin and intrusive in the Packsaddle schist. Sellards (1932) briefly reviewed the pre-Cambrian, Cambrian, and Ordovician systems of the Llano region in his report on the stratigraphy of Texas. In his report on the structure and economic geology of Texas Sellards (1934) discussed the deformation of the Llano region during Paleozoic time. Stenzel, in the same report (Sellards, 1934), reviewed the pre-Cambrian structural conditions of the Llano region. Later, Stenzel (1935) reported on the pre-Cambrian unconformities in

Llano County.

A new state geologic map (Darton et al, 1937) was compiled after Darton visited the Llano area in 1933 and investigated formation outcrops. The outcrop areas of Hickory sandstone, Wilberns and Cap Mountain limestones, and Ellenburger limestone were plotted for the first time on this map.

The rocks on the western side of the Llano region were studied by Bridge (1937). He collected fossils, named the Lion Mountain sandstone member of the Cap Mountain formation, and redescribed many of Roemer's type localities. Bridge and Girty (1937) redescribed Roemer's Paleozoic fossils and commented on the geology of the region.

Barnes and Parkinson (1939) were the first to describe the ventifacts which occur in the basal Hickory sandstone of the Llano region. They concluded that the Hickory was, in part, reworked eolian deposits. A map of Hickory sandstone outcrop areas showing ventifact localities in Mason, Llano, and Blanco counties was included in the report.

Keppel (1940) made a study of the larger bodies of pre-Cambrian, coarse-grained granites in the Llano-Burnet uplift with particular emphasis on their structure and texture.

In a report given before the Geological Society of America, Bridge and Barnes (1941) indicated that the Wilberns formation could be divided into four members, but proposed no names. These members are a basal sandstone, a glauconitic limestone, a green calcareous shale, and a limestone at the top.

Barnes (1944) published the names of these four members. He used present-day terminology of the members of the Wilberns formation, but continued to refer to the Lion Mountain sandstone as a member of the Cap Mountain formation.

A short paper was written by Plummer (1943) on the discovery of a new white quartz sand near the middle part of the Wilberns formation in northwestern Mason County near Erna.

In a progress report on the stratigraphy of the Ellenburger group of central Texas, Cloud, Barnes, and Bridge (1945) redefined the Riley series. This series was reduced to a formation and defined as Upper Cambrian strata of pre-Wilberns age. It included as members the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone. The top of the Wilberns formation was set as the top of the Cambrian. They also revised the Ellenburger formation to the Ellenburger Group, restricted it to Lower Ordovician, and named for the first time the three formations of the group. These three formations are in ascending order, the Tanyard, Gorman, and Honeycut.

The importance of the Hickory sandstone and Ellenburger limestone as aquifers was discussed by Plummer (1946) in his report on the water resources of Texas.

Bridge, Barnes, and Cloud (1947) published a paper on the stratigraphy of the Upper Cambrian with reference to the seven members and two formations representing the Upper Cambrian of the Llano uplift. A comprehensive and detailed description of the stratigraphy for all units was included in the paper.

A fundamental study of the Ellenburger group of central Texas was made by Cloud and Barnes (1948) with emphasis placed on features having a possible significance in the search for new sources of petroleum. The pre-Ellenburger strata of several localities in the Llano region were briefly discussed in the report.

Plummer (1947) published a summary of the classification of Lower Pennsylvanian strata in central Texas. Later a detailed analysis of the Carboniferous stratigraphy of the Llano region was posthumously published (1950) on Plummer's work. In this report a brief review of the pre-Carboniferous stratigraphy was included.

H. R. Blank (1951) described and discussed degradational processes in operation on the granitic masses in the Central Mineral region.

GEOGRAPHY

CLIMATE

The climate of the Llano region, in which the Southwest Mason-Llano River area is located, is sub-humid. Mason County receives a yearly mean precipitation of about twenty-four inches, but according to the records of Mason, Mason County, the annual precipitation may vary between the limits of 20 and 45 inches. Most of the rainfall occurs in the winter and spring months between November and April; however, the total rainfall is not uniformly distributed since one-third of the annual precipitation may occur within a week, followed by several months of drought.

The mean annual temperature is 70.5°F. Temperature fluctuates as much as 80°F through the year with 30° or lower common in the winter and 110°F common in mid-summer. During the hot, dry summer months the temperature averages around 90°F, but evenings and nights are cooled moderately by regular southeasterly breezes.

VEGETATION

The vegetation is that which is adapted to rocky slopes and to moderate and irregular precipitation. The most common trees on the higher slopes are the mesquite, oak, elm, and cedar, while in the valleys sycamore and pecan predominate. Exceptionally large pecan, sycamore, and oak trees occur in the valley of the Llano River.

The distribution and relative abundance of vegetation largely depends upon the type of rock yielding its soil. For this reason certain species preferentially grow on certain stratigraphic units, forming obvious boundaries. Generally the Mexican persimmon, mimosa, and white bush, as well as cacti grow on the limestone ridges. Post oak and cedar also grow abundantly on some of the limestones. The shale slopes, especially of the thin Mississippian Barnett, are extremely crowded with Mexican persimmon and to a lesser extent with mesquite. The thorn-like bush called catclaw grows abundantly on Marble Falls limestone. It is especially helpful in marking the Marble Falls boundaries.

In the grassy areas and valleys bee-bush occurs along with a variety of grasses growing in varied concentrations. Grasses commonly seen are buffalo, curly mesquite, crowfoot, sideoats grama, tobosagrass, plains lovegrass, hairy grama, and many other species of minor occurrence.

INDUSTRY

The chief industry in Mason County is medium scale ranching and stock farming. The ranching industry includes beef cattle, sheep, and goats, cattle being the most important. The rough terrain in parts of the Southwest Mason-Llano River area is better adapted to the sheep and goats.

Other agricultural products raised in Mason County are peanuts, cotton, corn, peaches, hay, and watermelons. The fields used for cultivation are small and limited to bottom lands or slopes and benches associated with the softer, sandy formations.

The city of Mason, located northeast of the mapped area, serves Mason County as a shopping and trading center.

PHYSIOGRAPHY

PHYSICAL FEATURES

The Southwest Mason-Llano River area lies on the southwestern flank of the Llano region of central Texas. The region is a topographic basin, although it is structurally a large area of uplift. In the center of the region pre-Cambrian rocks have been exposed and eroded to form the basin which is bordered by a rim of more resistant Paleozoic and Cretaceous rocks. The highest elevation in the basin is 2200 feet and the lowest is 650 feet, giving a total relief of 1600 feet for the region.

In the Southwest Mason-Llano River area the Llano River cuts into the Paleozoics rocks to give a total relief of 400 feet.

The area may be divided into two physiographic units: (1) the northern one-third consisting of a range of dissected hills, and (2) the central and southern portions consisting of rolling hills with well developed drainage patterns. The area is in the early maturity stage.

The lower sandy portions of the Cambrian strata in the area are generally eroded to form low cultivated plateaus. These small plateaus occur in the northeast and east central portions of the area. The upper limestone portions of the Cambrian form prominent cuestas or northeast trending ridges which are bordered by benches and gentle dip slopes.

The Ellenburger limestones form a rolling topography which is normally bordered by the lower San Saba limestone hills. The highest ridges in the area are formed from these Ellenburger limestones.

In the northern portion of the area Pennsylvanian limestones form a group of dissected, broad hills which rise above a prominent valley. The valley is situated along the Mason fault (Plate 1). It is terminated by a change in strike of the fault near Kirk Zesch's ranch house.

Both the Ellenburger and San Saba limestones have caves developed in them along fault planes. One such cave occurs along the Mason Fault 100 yards west of Kirk Zesch's ranch house. Another cave, which is partially filled with water, occurs along a small branch fault along the east central border of the area.

EROSIONAL AGENCIES

The principal erosional agency is running water which is especially effective in sparsely vegetated areas during the concentrated rainfalls. These rains cascade down the elevated mature drainage system with great velocity to transport large boulders and remove much of the limited soils from the surface. The effects of wind are less noticeable except in the loose sand fields where high spring winds are active in denuding the bedrock.

Many of the topographic features have been developed as a result of faulting which brought less resistant strata against more resistant strata. Fracturing along faults has further disrupted the strata, making the area more susceptible to erosion.

DRAINAGE

In the Llano region there are four principal streams which drain the topographic basin; the San Saba and Colorado Rivers on the north and east, the Llano River in the central part, and the Pedernales River in the south. All of these are consequent streams that are superimposed upon the domed Paleozoic and pre-Cambrian strata. As pointed out by Tarr (1890), the drainage pattern of the major streams began on an eastward-tilted plain of Cretaceous strata in Tertiary time. The streams became superimposed upon the pre-Cambrian and Paleozoic strata after the overlying, near horizontal strata had been removed. Numerous tributaries in the region are controlled by local structure, but the major streams have made little change in their original courses.

The Llano River, which forms the southern boundary of the mapped area, drains all of the water from the area. Rainfall in the northern part of the area is drained by tributaries into Honey Creek and Comanche Creek on the west and east respectively. Neither of these creeks traverse the mapped area.

The Mason Fault has formed a line of ridges which act as a stream divide in the area. This divide curves northeast through the area giving one large watershed to the south into the Llano River, and two smaller ones to the east and west, draining into Comanche and Honey Creeks respectively.

In the central and southern portions drainage is accomplished by four unnamed subsequent streams which maintain limited flows of spring water. Short, ephemeral, obsequent streams dissect the limestone ridges and sandstone slopes in the area.

Earthen dams have been built across some of the larger gullies in the area (Plate 1). These have greatly decreased the scouring effect of stream action.

STRATIGRAPHY

General Statement:

Strata of the Cambrian, Ordovician, Mississippian, and Pennsylvanian systems are exposed in the Southwest Mason-Llano River area. The Upper Cambrian strata lie unconformably upon metamorphic and intrusive pre-Cambrian rocks. The geologic column of the area is as follows:

QUATERNARY

Recent

PALEOZOIC ERA

Pennsylvanian system

Bend Series

Marble Falls Group

Big Saline formation

Mississippian system

Barnett formation

Chappel formation

Ordovician system

Lower Ordovician

Ellenburger Group

Cambrian system

Upper Cambrian

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

CAMBRIAN SYSTEM

Rocks of Upper Cambrian age crop out over a major portion of the area and are composed of a series of limestones, sandstones, and shales with stromatolitic bioherms in the upper members. The current and accepted division of the Upper Cambrian sequence into two formations and seven members was made through the combined work of Bridge, Barnes, and Cloud (1947).

Riley Formation

The name Riley was first used by Comstock (1890) to apply to a portion of the strata which make up the Riley formation as redefined by Cloud, Barnes, and Bridge (1945, p. 154). They amended the Riley formation to be "all of the Cambrian rocks occurring beneath the Wilberns formation," and divided the formation in ascending order into the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone members. These members are separated by gradational contacts.

The Riley formation is 750 feet thick at its type locality in the Riley Mountains. The average thickness as established by Bridge, Barnes, and Cloud (1947, p. 110), is 680 feet. A minimum thickness of 200 feet occurs where the Hickory sandstone and portions of the Cap Mountain limestone and Lion Mountain

Figure 1
Hickory sandstone - pre-Cambrian contact

Figure 2
Hickory cross-bedded beach sands

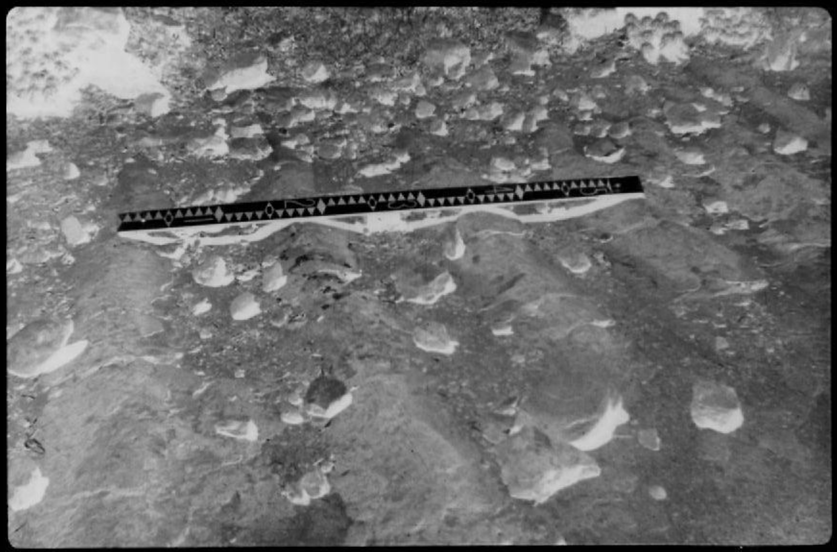


Figure 1
Hickory sandstone ripple marks

Figure 2
Hickory sandstone with brachiopods

sandstone members were not deposited. The thickness of the Riley formation in the Southwest Mason-Llano River area is estimated to be at least 695 feet.

Hickory sandstone member

Definition and thickness:

The term "Hickory series" was introduced by Comstock (1890) and was derived from Hickory Creek in Llano County. This name was changed to Hickory sandstone by Paige (1912). The boundaries described by Paige remained unchanged until Cloud, Barnes, and Bridge (1945) amended the original boundaries and assigned the Hickory to the Riley formation.

The Hickory has an average thickness of 369 feet over the Llano region and ranges from 0 to 415 feet (Bridge, Barnes, and Cloud, 1947, p. 112). The member is not completely exposed in the Southwest Mason-Llano River area; however, the thickness approaches 400 feet.

Lithology:

The Hickory sandstone member lies upon pre-Cambrian rocks with a marked unconformity. Basal Hickory sandstones are light-colored, slightly reddish and very coarse-grained. The quartz grains are sub-angular to rounded and are concentrated in uneven bands. The surface of this coarse grained sandstone is covered with large, protruding grains (Plate IV, Figure 1) and ventifacts.

The middle portion of the Hickory is made up of numerous maroon shales and clean, light-grey beach sands (Plate IV, Figure 2). Most of the sands are well cross-bedded and medium to coarse-grained.

The upper parts of the member exhibit very large ripple marks which are up to 2 feet from crest to crest. These ripple marks have symmetrical, rounded crests and troughs (Plate V, Figure 1).

Phosphatic brachiopods are common in the middle and upper Hickory sandstones, but seem to be more abundant in the upper portions (Plate V, Figure 2).

Topography and vegetation:

The Hickory sandstone forms open, cultivatable fields in the eastern part of the area. In the northeast portion of the area, the member occurs in an open field bordered by several gentle hills. These hills are covered with dense vegetation consisting of scrub oak and mesquite trees, Mexican persimmon, and prickly pear cacti. Along the open fields bee-bush is common. There are numerous grasses growing on the weathered outcrop surfaces.

Cap Mountain limestone member

Definition and thickness:

The Cap Mountain limestone was redefined and included as a member of the Riley formation by Cloud, Barnes, and Bridge (1945, p. 154). The type locality is Cap Mountain in Llano County.

In the region the Cap Mountain member ranges from 135 to 455 feet in thickness, averages 280 feet (Bridge, Barnes, and Cloud, 1947, p. 113), and in the mapped area has a minimum thickness of 420 feet.

Plate VI

Figure 1
Cap Mountain honeycombed surface

Figure 2
Cap Mountain limestone ripple marks

Lithology:

The Cap Mountain limestone member has a gradational contact with the Hickory sandstone member. The contact is generally placed at a topographic and vegetational break which is visible in the field and on aerial photographs. This break is normally represented by a Cap Mountain cuesta. The Hickory terminates at the top of a non-calcareous sandstone zone which is below a reddish-brown calcareous sandstone of the Cap Mountain.

Lower Cap Mountain beds are mostly dark reddish-brown, calcareous sandstones of medium to coarse-grained texture and medium bedding, alternating with, and grading laterally into, light grey, fine grained arenaceous limestones. These beds grade upward into dark brown, medium grained, slightly fossiliferous limestones which alternate with tan, fine-grained, non-calcareous sandstones. In the middle portion calcium carbonate becomes more abundant to form tan, thick-bedded to massive limestones. These limestone beds contain thin stringers and pockets of fine-grained, brownish-yellow sandstone.

A greater part of the Cap Mountain member consists of massive limestone ledges that exhibit strongly honeycombed surfaces (Plate VI, Figure 1). These weathering features are characteristic of thick limestone ledges in this area.

The upper portion of the Cap Mountain member is predominately a light grey to brown, medium to coarse-grained, glauconitic, fossiliferous limestone

Cap Mountain limestones

which has varying quantities of phosphatic brachiopods. Ripple marks occur in the upper portion of the member in the eastern part of the area (Plate VI, Figure 2).

Topography and vegetation:

The lower zones of calcareous sandstone and arenaceous limestone in the Cap Mountain form cuestas along the Cap Mountain-Hickory contact. On the dip slope of these cuestas the attitude of the resistant beds conforms to the ground surface. These dip slopes are covered with sandy soils which are usually cultivated. Overlying massive limestones weather to give a thin-bedded appearance (Plate VII) and form prominent ridges.

Vegetation on the Cap Mountain limestones consists of evenly distributed scrub oak, mesquite, Mexican persimmon, prickly pear, turkey pear, Spanish bayonet, and catclaw. Where natural vegetation exists, the lower contact is clearly marked.

Lion Mountain sandstone member

The Lion Mountain sandstone was defined as the top member of the Cap Mountain formation by Bridge (1937). This sandstone was later included as the upper member of the Riley formation by Cloud, Barnes, and Bridge (1945) in their work on the Upper Cambrian.

Bridge, Barnes, and Cloud (1947, p. 114) measured 20 feet of Lion Mountain sandstone at its type locality in the northwestern part of the Burnet quadrangle, and determined the average thickness to be 50 feet over the region. A thickness of 83 feet was measured in the Southwest Mason-Llano River area. This thickness is questionable because the contact between the members is gradational and is covered with soil on the ground surface.

Lithology:

The Lion Mountain member overlies the Cap Mountain member with a gradational contact. This contact is generally placed at a slight topographic and vegetational break which is apparent on aerial photographs.

The member is generally a coarse-grained, highly glauconitic sandstone. There are beds of "trilobite hash" or light greenish-grey limestone composed of trilobite fragments in the lower portion. Phosphatic brachiopods are also quite common in these beds.

Numerous black, round nodules (Plate VIII) having a metallic luster are found on the weathered surface of this member. These nodules are residual material from upper portions of the member and were derived from the chemical

Plate VIII

Lion Mountain ironstones

alteration of glauconite.

Topography and vegetation:

The Lion Mountain is represented topographically by a pronounced bench or open field. The sandy soils and level surface of the member make it desirable for cultivation.

Vegetation on the bench is limited and consists mostly of mesquite, needle grass, sideoats grama, scattered scrub oak and cacti. In places this lack of dense vegetation is detectable on aerial photographs.

Wilberns Formation

Sidney Paige named the Wilberns formation in 1911 (p. 23) and later described it in detail (Paige, 1912, pp. 6-7). The lower boundary established by Paige remained unchanged, but Cloud, Barnes, and Bridge, (1945) revised the upper limit to coincide with the Cambrian-Ordovician boundary.

Bridge, Barnes, and Cloud (1947) divided the Wilberns formation into five members and were the first to describe them in detail.

With the exception of the Johnson City area, the Wilberns formation has a thickness range from 540 to 610 feet. The Johnson City area has a thickness of only 360 feet because of truncation (Bridge, Barnes and Cloud, 1947, p. 110).

In the Southwest Mason-Llano River area the Wilberns was measured to be 596 feet thick. This is an unusual thickness and in part may be attributed to an abnormal thickening of the upper member of the formation.

Lion Mountain-Welge contact

Welge sandstone member

Definition and thickness:

Barnes (1944, p. 34) names the Welge sandstone member from the Welge Land surveys in Gillespie County. The thickness of the member at its type locality along Squaw Creek near the Gillespie County line is 27 feet. It varies from 9 to 35 feet over the Llano region and has an average of 18 feet (Bridge, Barnes and Cloud, 1947, p. 114).

Due south of Mason the Welge is 16 feet thick, but in the Southwest Mason-Llano River area it is 25 feet thick. This is confirmed by the thickness of 25 feet Cloud and Barnes (1948, p. 155) mentioned as occuring 3 miles southwest of the Mason Courthouse.

Lithology:

In the Southwest Mason-Llano River area the Welge sandstone member is exposed only in one open field. The base of the member is in sharp contact with the underlying Lion Mountain sandstone member. Bridge, Barnes, and Cloud (1947, p. 114) pointed out this sharp contact in their study of the region. In a measured section to the east of the mapped area the contact is clearly detected along a creek bank (Plate IX).

The Welge is a yellowish-brown to reddish brown, mostly non-glauconitic, slightly fossiliferous sandstone. It is usually massive, moderately cross-bedded, and well bedded in its upper portion. The sandstone is medium to coarse-grained with angular to sub-rounded quartz grains which sparkle due to the presence of recomposed faces. The lowest layers are slightly argillaceous, while the upper layers are interbedded with thin, orange shale. Phosphatic brachiopods occur sparsely throughout most of the layers. The base is marked by a sharp change from thin, greenish, cross-bedded, highly glauconitic laminae of silty Lion Mountain sandstone to the more massive reddish Welge sandstone.

Topography and vegetation:

There is little variation in relief between the Lion Mountain sandstone and the overlying Welge sandstone in the mapped area. A very slight, almost imperceptable rise in elevation between the members occurs northeast of Kirk Zesch's ranch house. A slight variation in soil color is visible, expecially where the Mill Creek road crosses the outcrops. There the Welge appears as a red band on the road exactly the width of its outcrop.

There is very little difference in vegetation between the Lion Mountain and Welge sandstone members. The most common vegetation of both are scrub oak, Mexican persimmon, and turkey pear. A slight change in grasses on the two members was noted in a brief study of the vegetation in the area by Gimbrede (personal communication).

Morgan Creek Limestone member

Definition and thickness:

Bridge (1937) named the Morgan Creek limestone member after its type locality near the junction of the north and south forks of Morgan Creek in Burnet County. At this type locality it is 110 feet thick, but it may vary from 70 to 160

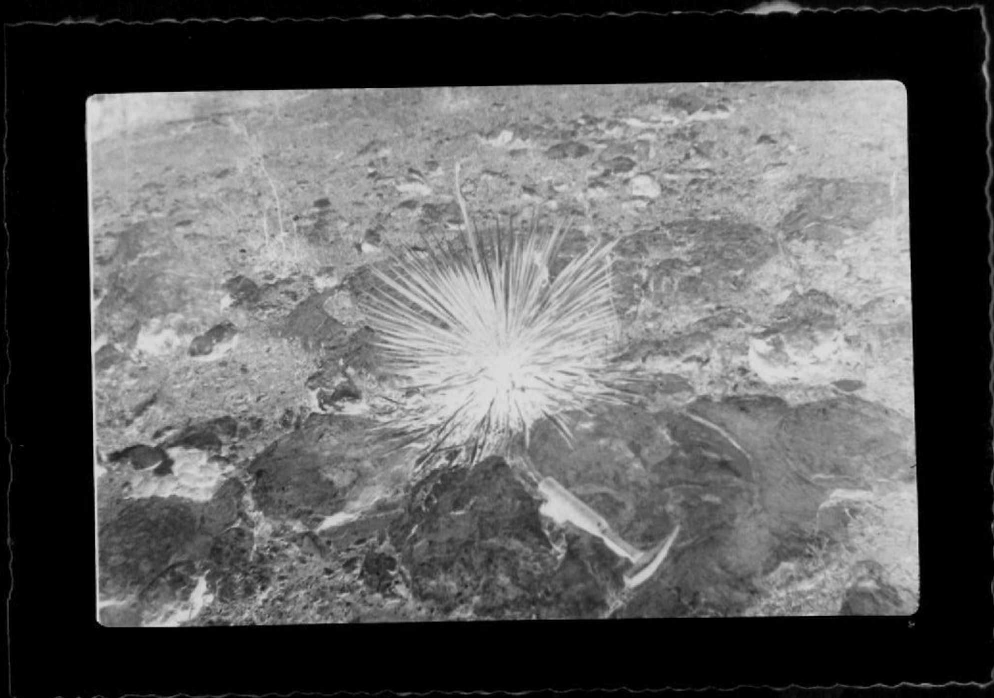


Figure 1
Morgan Creek bioherm reef structures

Figure 2
Morgan Creek limestone bedding

feet thick over the Llano Uplift region. An average thickness for the member is 120 feet (Bridge, Barnes and Cloud, 1947, p. 114 - 115). In the Southwest Mason-Llano River area a total thickness of 154 feet was measured and described.

Lithology:

The lower contact of the Morgan Creek member is gradational with the upper Welge sandstone member. This contact is placed at the base of the first reddish to purple, coarse-grained, granular, arenaceous limestone bed. These medium-bedded, sandy layers at the base of the Morgan Creek erode into indistinct ledges and grade upward into grey and greenish-grey, coarse-grained, highly glauconitic, fossiliferous limestones. A zone of conaspid fauna, containing Eoorthis texana, is present about 60 feet above the base. Upper Morgan Creek beds are greenish-grey to yellowish-brown, abundantly glauconitic, medium to coarsely crystalline, and fossiliferous limestones. Two thin beds containing crinoid stems (?) occur about 20 feet from the upper contact. Thin argillaceous limestone and grey shale zones occur in the upper portion. There are isolated masses of grey, stromatolitic bioherm reefs occuring in the upper margins of the Morgan Creek (Plate X, Figure 1). As a unit, the Morgan Creek is medium bedded, coarse- grained, and glauconitic, (Plate X, Figure 2).

Topography and Vegetation:

There is a distinct topographic and vegetational break between the Welge sandstone and Morgan Creek limestone members. The Morgan Creek forms a distinct ridge that is from 30 to 50 feet higher than the Welge outcrop. The

Morgan Creek slopes are stair-stepped by differential erosion of the evenly distributed limestone beds.

Vegetation is abundant and uniformly distributed. Scrub oak trees are the most abundant, but turkey pear, agerita, and Spanish dagger are also common.

Point Peak shale member

Definition and thickness:

Bridge (1937) named the Point Peak shale member from the type locality on the south slope of Point Peak in Llano County. This type locality is an isolated hill near the community of Lone Grove. Bridge, Barnes, and Cloud (1947, p. 115) measured 270 feet of Point Peak at its type locality and later arrived at an average thickness of 150 feet for the Llano region as a whole. In the Southwest Mason-Llano River area the Point Peak thickness was measured to be 265 feet.

Lithology:

The Point Peak shale member is made up of two zones, a lower shale zone and an upper bioherm zone. The member was mapped as one unit.

The lower Point Peak shale lies upon Morgan Creek limestones with a transitional contact. This contact is difficult to establish accurately in exposed sections. However, a sharp break in vegetation and topography clearly marks the contact for mapping.

The shale zone consists of greyish-green, thin-bedded, soft to medium hard, calcareous shales interbedded with thin layers of brownish-grey, fine to medium-grained limestones. These limestones closely resemble Morgan Creek beds, but are finer grained for the most part. Included in the beds are scattered intraformational, edgewise conglomerates. These edgewise conglomerate beds contain many yellowish-green, flat, fine to medium-grained limestone pebbles in a medium grained, brown, limestone matrix. Because of its softness, this shale zone weathers rapidly and is seldom exposed on the surface. It is consistently represented by a bench between the upper, more resistant bioherm zone and the underlying Morgan Creek cuesta. Excellent exposures are visible on the Llano River bank and in its tributary in the southwest portion of the area. The shales always weather back as a recession in cliff exposures (Plate XI). Near the base of the shales are found several small stromatolitic bioherms which are grey to purplish grey, sub-circular and sub-lithographic. The thin shale beds smoothly curve over and around these inclusions (Plate XII). Fragments of the more resistant edgewise conglomerate and small portions of weathered out, small bioherms are found on the surface of the shale slopes.

A thick zone of stromatolitic bioherms and limestones (Plate XIII, Figure 1) represent the upper portion of the Point Peak member. The limestones are brown to grey, medium-bedded, fine to coarse-grained, slightly glauconitic, and weather into thin slabs and fragments. The bioherms are grey, micro-granular to sub-lithographic, very hard, and weather to rounded boulders, large blocks, and large reticulated masses (Plate XIII, Figure 2). Many of the bioherms are

Point Peak thin bedded shales

Point Peak shale beds and small bioherms

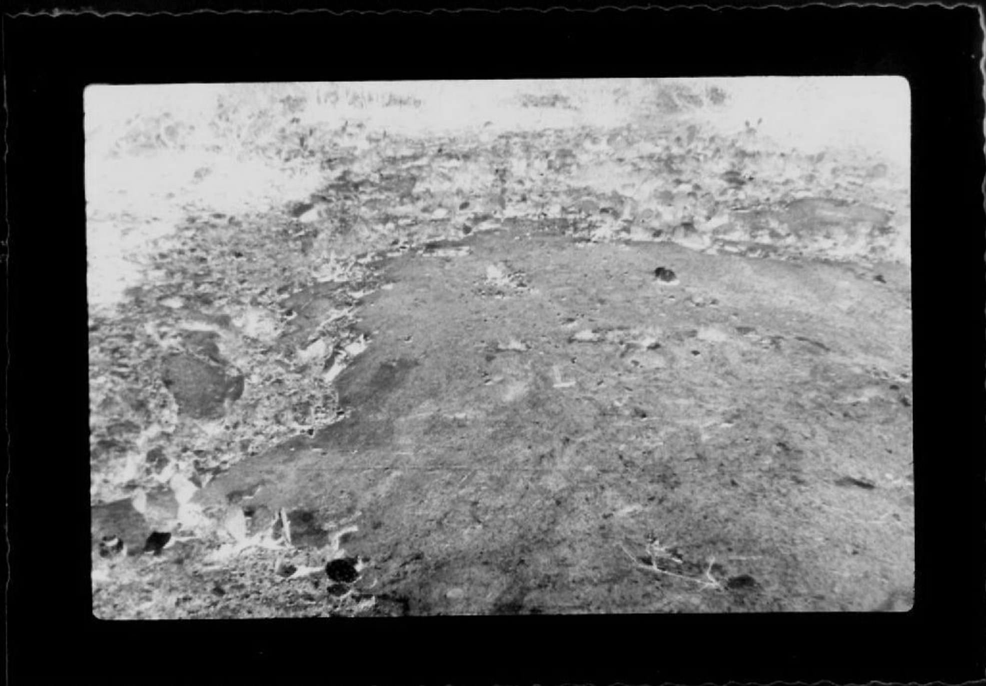


Figure 1
Point Peak reef structure

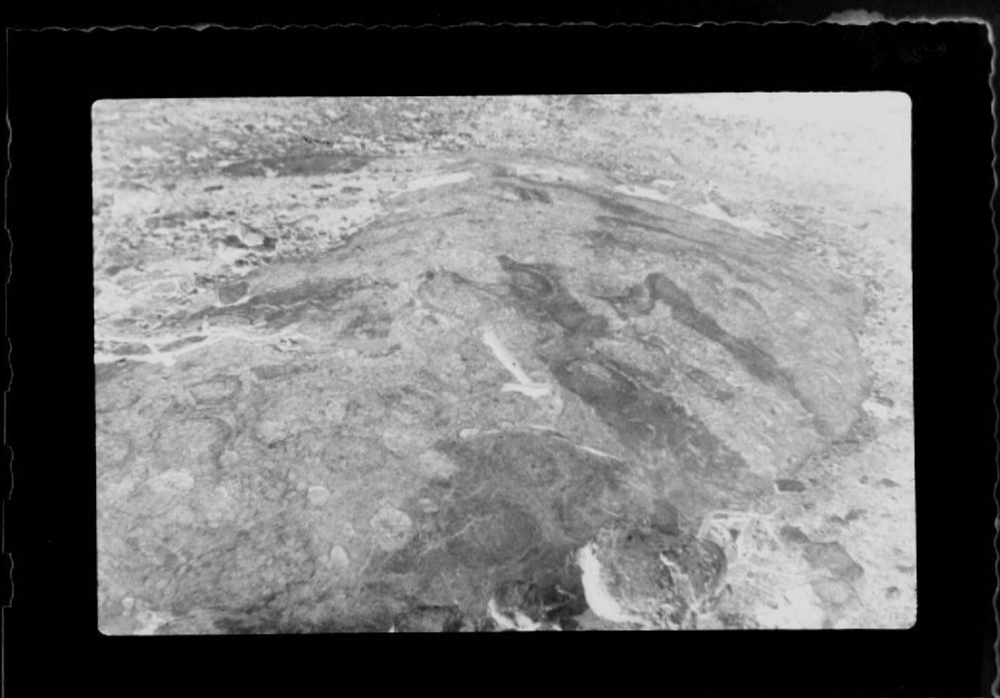


Figure 2
Point Peak bioherm and "cabbage heads"

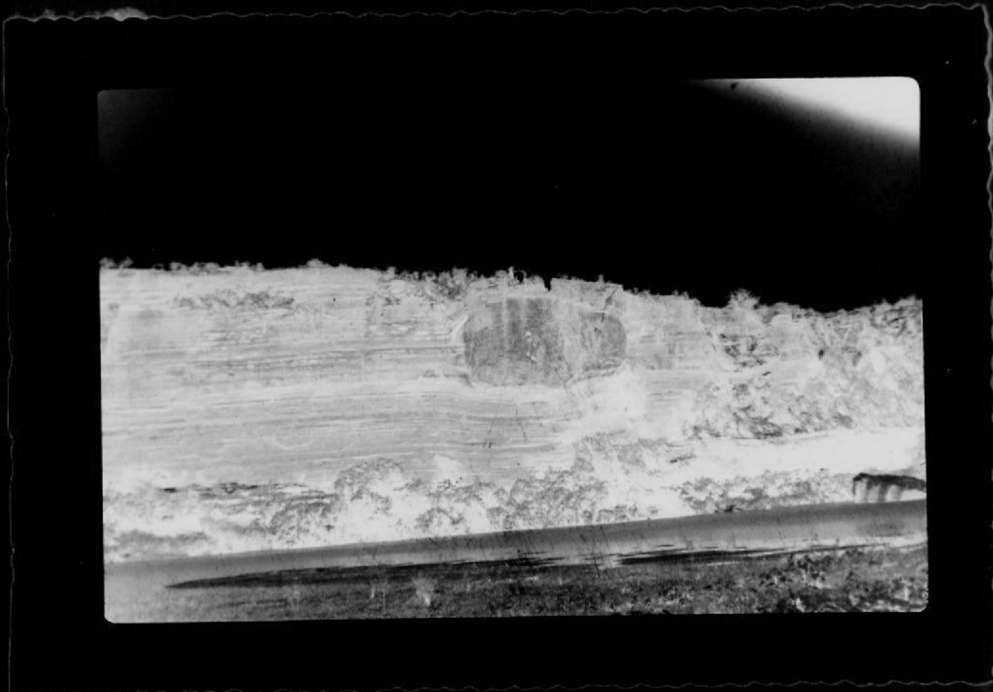


Figure 1
Point Peak bioherm and bedding

Figure 2
Point Peak weathered out bioherms

Plate XV

Point Peak shale bench

fifty feet in diameter. Their features are well represented by the classic exposure on the Llano River bank near White's crossing (Plate XIV, Figure 1). Less picturesque exposures are found in a cliff along the Llano River in the southwest portion of the mapped area (Plate XIV, Figure 2).

Topography and Vegetation:

The Point Peak is easily distinguished on aerial photographs by its vegetation pattern. The bench formed by the weathered shale zone and the contrasting resistant bioherm zone result in two color bands. The Point Peak shale bench is covered mostly with mesquite and grasses, giving an overall light color. The steep slope of the Point Peak bioherms is covered with thick growths of scrub oak and scattered mesquite, (Plate XV) giving an overall dark color. This rugged reef surface also supports an abundance of catclaw, Spanish bayonet, agerita and Mexican persimmon.

San Saba limestone member

Definition and thickness:

The name San Saba was originally used to refer to a series by Comstock (1890), but the term was revised to designate a member by Bridge (1937). This member was confined to the stratigraphic unit represented by the limestone exposures along the San Saba River near Camp San Saba in McCulloch County. Bridge, Barnes, and Cloud (1947, p. 117) defined the San Saba member as all of the series of "more or less glauconitic limestones" underlying the Threadgill member of Tanyard formation of the Ellenburger and overlying the Point Peak

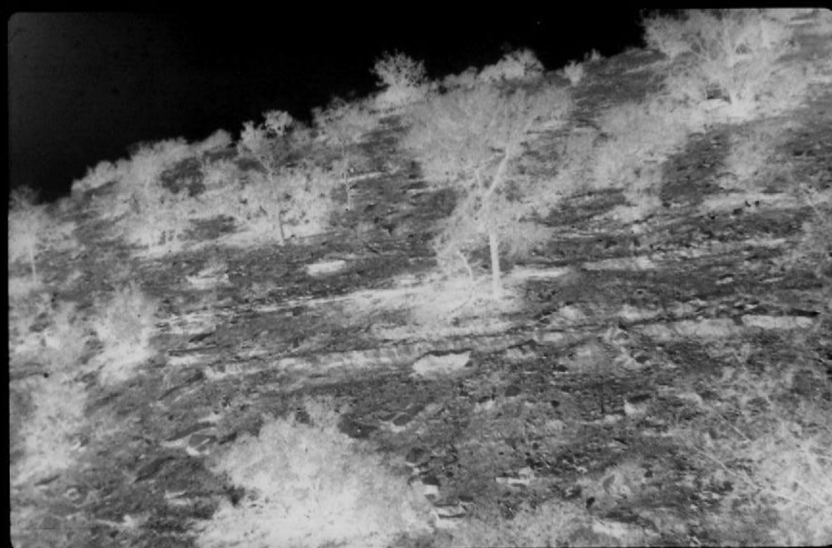


Figure 1
San Saba limestone bedding on weathered slope

Figure 2
San Saba coarse, glauconitic limestone bedding

shale member of the Wilberns formation.

The type section of the San Saba member on the Mason-Brady highway near the San Saba River bridge is 280 feet thick. A thickness of 261 feet was measured along the bed of the Llano River three-fourths of a mile upstream from the mouth of the James River.

Lithology:

The contact between the San Saba member and Point Peak member is gradational. It is placed at the last occurrence of bioherms since the boundaries of this zone show clearly on aerial photographs.

The San Saba member limestones are essentially thin to thick-bedded, medium to coarse-grained, and slightly sub-lithographic (Plate XVI, Figures 1 & 2). Colors vary widely from grey to greenish-grey, yellowish-brown to brown, and mottled brown surfaces are characteristic of upper zones. Glauconite is present in varying amounts throughout, but is less common toward the top. The member is fossiliferous, except near the top, with trilobites, brachipods, and gastropods common. Large ripple marks, expecially in the Llano River bed exposures are associated with beds having a higher fossil content (Plate XVII).

About 20 feet from the base, the San Saba contains a thin, persistant biostrom zone. This zone is distinguished from Point Peak reef structures by its almost white weathered color. It is mostly sub-lithographic and very hard. This zone is exposed as a domed hill in the east central part of the Southwest

San Saba beds showing ripple marks

Figure 1
San Saba honeycombed weathered surface

Figure 2
San Saba slabby limestone on weathered surface

Mason-Llano River area.

In an area of western Mason County the San Saba has an unusual occurrence of sandstone and calcareous sandstone (Bridge, Barnes, and Cloud, 1947). A thick ferruginous sandstone was also noted by the writer in west Mason County along Leon Creek. Abundant sand occurrence is limited in the mapped area, but zones of interbedded calcareous, buff-colored, fine-grained sands occur in the lower portions.

The upper part of the member commonly has numerous flaggy limestones which are mostly sub-lithographic, non-fossiliferous, and slightly glauconitic. Intraformational conglomerates begin about 30 feet from the base of the member and increase upward. These conglomerates are interbedded with thinly bedded limestone and calcareous sandstone.

Most of the thicker beds are weathered into rough, honeycombed surfaces (Plate XVIII, Figure 1). Near the top of the San Saba numerous resistant "excressences" occur, as well as characteristic "snail trails". These trails are yellowish-brown, interlaced "remains of snail secretions" (Bridge, Barnes, and Cloud, 1947).

The member is well exposed in the Southwest Mason-Llano River area, especially along the Llano River where a detailed section of the entire San Saba member was measured and described (Plate XXXII). The exposed surfaces are characterized by an abundance of small, thin, brownish-yellow slabs of limestone (Plate XVIII, Figure 2).

Topography and Vegetation:

The San Saba typically forms a rolling topography with limited, though sharp, relief. Outcrops of individual beds can be followed on hill slopes and are clearly visible on aerial photographs.

Vegetation is generally made up of scattered clusters of cedar, prickly pear, scrub oak, Mexican persimmon, and turkey pear. Near the Point Peak contact the vegetation is somewhat thicker, especially along the white San Saba reef zones. Cedar and scrub oak trees are quite concentrated on these reef zones.

ORDOVICIAN SYSTEM

Ellenburger Group

General Statement:

The Ellenburger limestone was first named from the Ellenburger Hills in southeastern San Saba County by Paige (1911). Paige's original term was revised to Ellenburger group and restricted to include rocks of Lower Ordovician age by Cloud, Barnes, and Bridge (1945). The group was divided at this time into the Tanyard, Gorman, and Honeycut formations in ascending order.

The Ellenburger group was not sub-divided into its formations in the Southwest Mason-Llano River area and no detailed study of its stratigraphy was made.

Lithology:

The Cambrian-Ordovician contact is transitional and difficult to establish within close limits. The contact was established on the basis of the last occurrence of glauconite in the San Saba and the first occurrence of the uncoiled gastropod, Lytospira gyrocera. This allows the contact to be established within a three to ten feet limit.

The Ellenburger limestones are extremely hard, thin to thick bedded, usually sub-lithographic and non-glauconitic. Their color varies from clean white to dull grey. The lower Tanyard is mostly dolomitic and is normally rather vuggy and irregular in bedding. Colors in the dolomitic zone vary from grey to dark yellowish-grey. In portions of the Ellenburger, especially in the

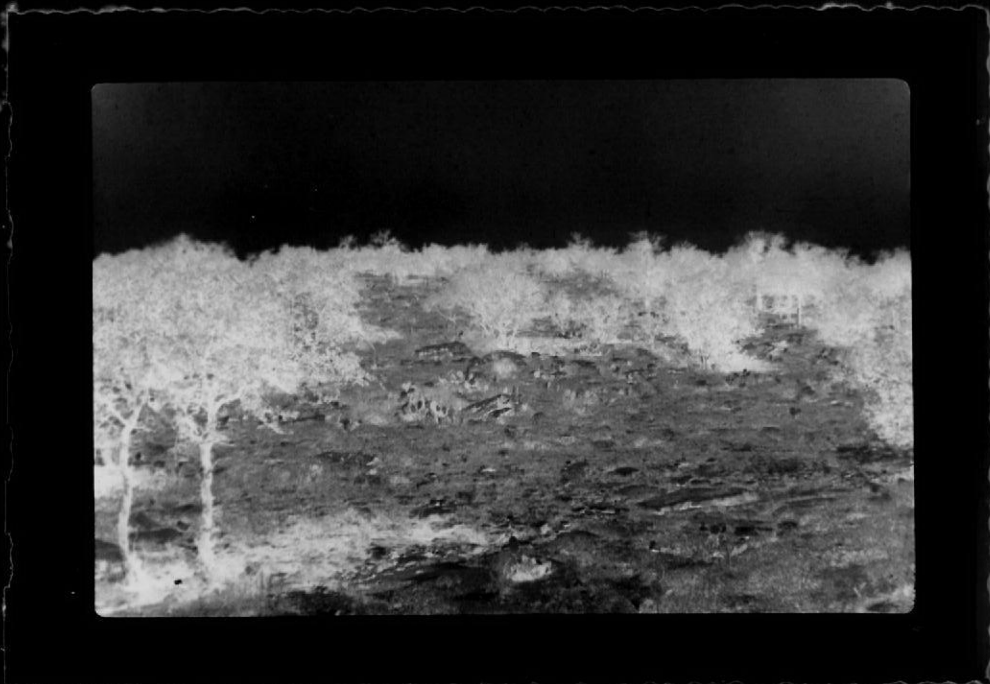


Figure 1
Ellenburger limestone weathered surface

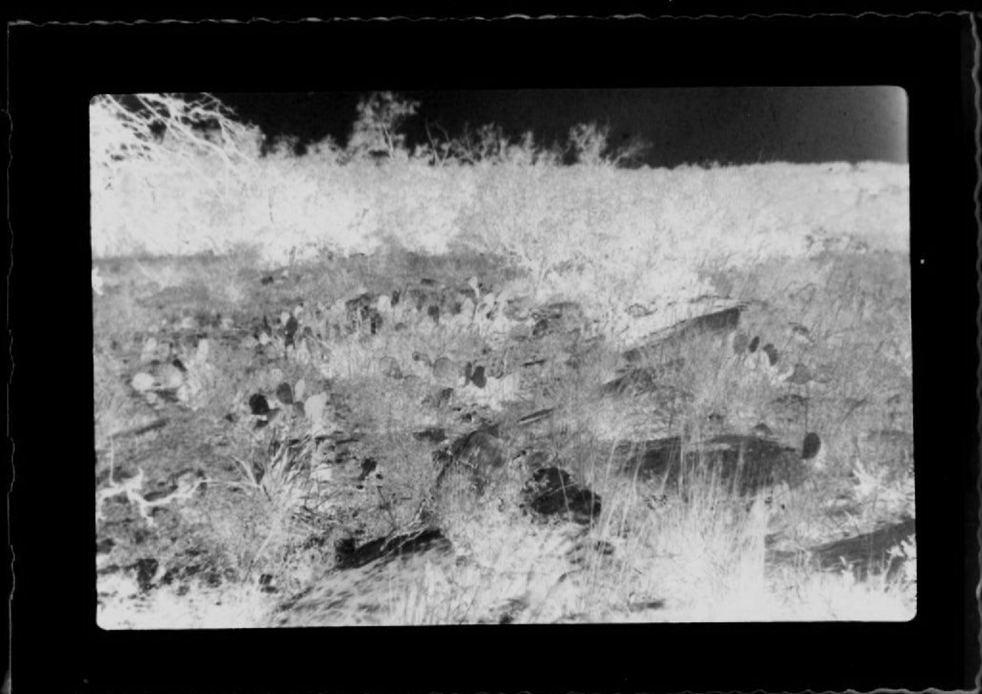


Figure 2
Ellenburger collapse feature

extreme northern portion of the Southwest Mason-Llano River area, chert is very abundant and often weathers out as white fragments on the limestone slopes.

Abundant calcite crystals are found in highly factured areas of the Ellenburger. It is probable that this calcite formed as ancient cavern deposits or as secondary filling along fractures.

The basal Ellenburger is typically a thick-bedded limestone which weathers into light colored blocks (Plate XIX, Figure 1). These blocks occur often as large slabs 20 to 30 feet wide, which are visible on aerial photographs.

Along the lower contact are found examples of "collapse contact" described by Cloud, Barnes, and Bridge (1945) (Plate XIX, Figure 2).

Topography and Vegetation:

Topographically the Ellenburger is represented by rolling, prounced hills with valleys bottomed by "slabby" stair steps which form small waterfalls. The highest hills in the area are topped by the Ellenburger limestones which weather into large blocks.

Ellenburger surfaces do not present the uniform vegetation alignment characteristic of upper Cambrian strata, but show up as lighter colors. There is also an absence of easily discernable bedding trends. Commonly found on Ellenburger slopes are cedar, scrub oak, prickly pear, bee brush, and Mexican persimmon.

MISSISSIPPIAN SYSTEM

General Statement:

Rocks of Mississippian age have been known to be in Texas since Roemer (1847) made his reports. Many of the early writers considered parts of the Mississippian to be included in the Pennsylvanian system. Girty and Moore (1919, pp. 4190420) were the first to differentiate Mississippian and Pennsylvanian strata in this region. Combined efforts of numerous geologists have led to the description and naming of the Chappel and Barnett formations, which make up the Mississippian rocks in central Texas.

In Mason County, Mississippian rocks reach a thickness of 140 feet, as compared to a minimum thickness of 90 feet in other areas. The northern portion of the Southwest Mason-Llano River area has several small exposures of Mississippian Rocks.

Chappel Formation

Definition and thickness:

Beds of Lower Mississippian age were first observed in Texas by Baker (1917) 3 miles southwest of Lampasas. However, the occurrence of strata between the Barnett and Ellenburger in Central Texas was first given acknowledged recognition by Liddle (1920) in an unpublished report under Dr. Udden's direction. Credit for the first published description of the Lower Mississippian strata belongs to Roundy, Girty, and Goldman (1926). The formation was first referred to as "limestone of Boone age". Sellards (1933, p. 91) redescribed the strata and named the formation Chappel, from the type locality, located on Chappel road 6 miles northwest of the town of that name. On the west side of the Llano region the Lower Mississippian strata were discovered by Dake and Bridge (1932, p. 731) in Mason County, just west of the Southwest Mason-Llano River area. Plummer (1950) made studies of the formation in conjunction with his study of Carboniferous rocks in Texas

The Chappel formation lies unconformably upon the Ellenburger limestone and is overlain unconformably by the Barnett formation. It occurs on all sides of the region from Lampasas to the Llano River southwest of Mason. It is very continuous, although it is normally little more than a foot thick. Its thickness ranges from 6 inches to more than 50 feet. In the area mapped it averaged approximately 2 feet thick with slightly greater thicknesses in small "sink hole" occurrences.

Lithology:

The Chappel is essentially a layer of detritus consisting of well cemented, broken and water worn fragments of crinoid stems. There are also minute, cemented, calcareous sand particles in the groundmass of the limestone. Where not covered by talus from the overlying Barnett shale, it forms fairly resistant bed exposures. This bed weathers to a white color, but fresh surfaces are darker and slightly yellowish-grey (Plate XX, Figure 1).

The Chappel is highly fossiliferous, fossil specimens being limited to fragments of water worn crinoid stems. On the larger crinoid fragments the

Figure 1
Chappel crinoidal limestone bed

Figure 2
Chappel limestone in sink hole along Ellenburger contact

edges are well beveled and, as Plummer (1950) said, "look like small buttons". Plummer also distinguished Chappel crinoids by their very small circular canals.

An occurrence of Chappel in two small Ellenburger "sink holes" along the contact were observed in the mapped area. These sink holes are not comparable in size with the one on Honey Creek described by Plummer (1950). The westerly "sink hole" was measured to be 100 feet in diameter and the easterly one only 25 feet wide and 40 feet long (Plate XX, Figure 2).

The Chappel is readily distinguished from the underlying Ellenburger limestones by its crinoid content. Mapping of this formation is further aided by the distinctive slope of Barnett shale overlying it.

Topography and Vegetation:

In the mapped area, the Chappel outcrops as a thin limestone ledge at the base of Barnett shale slopes. The Chappel also forms a thin, prominent ledge in the bed of streams which cut through the Mississippian outcrop belt. Its small outcrop width is not large enough to support vegetation; however, in the easterly Chappel "sink hole" accumulation, mesquites are abundant.

Barnett Formation

Definition and thickness:

"The strata now referred to as Barnett formation have been known since the days of the earliest geological work in central Texas" (Plummer, 1950). A number of geologists have observed and collected fossils from this formation, including Shumard (1863), Cummins (1890), Tarr (1890), Udden, Baker, and Bose

(1916) and several others. However, Moore and Girty (1919) were the first to differentiate them from overlying Marble Falls rocks. Girty (1919) clearly established the Upper Mississippian age of the brown shales and proved they merit formation designation. Plummer and Moore (1922, p. 23) were the first to designate these beds as Barnett after studying exposures north of Barnett Falls in San Saba County. Sellards (1933, pp. 92-94) followed this usage of Barnett formation and defined it as including "all Mississippian strata between the Chappel formation below the Marble Falls above." This is the accepted definition at present.

Like the Chappel, the Barnett formation occurs as a narrow outcrop band. Its outcrop is normally between 100 and 150 feet wide and is very persistent, except where interrupted by faulting. Exposures in the mapped area are limited to weathered slopes topped by resistant Marble Falls limestones.

Along Honey Creek, west of the mapped area, the Barnett reaches its maximum thickness of 90 feet. In the Southwest Mason-Llano River area the formation is only 40 feet thick and it crops out in a small portion of the northern part of the area.

Lithology:

Plummer (1950) mentioned that the Barnett formation is lithologically the most uniform stratigraphic unit in the region. Since the outcrops in the mapped area are limited to talus covered slopes with dense vegetation, only scattered fragments of buff brownish-tan, hard, often calcareous shale, with a distinctive

Barnett shale slope

petroliferous odor, were observed. This petroliferous odor is distinctive, but without other criteria, it does not identify the formation. The shale is fossiliferous with numerous Dictyoclostus elegans and other similar brachiopods.

In his report on the Carboniferous, Plummer (1950) set up two un-named members in the Barnett and described their lithology in detail.

Topography and Vegetation:

The Barnett formation shale is very soft and weathers into slopes covered by dense vegetation which make it easily discernable on aerial photographs (Plate XXI). Mexican persimmon trees are most common, but mesquite and white brush are also abundant on the Barnett shale slopes.

PENNSYLVANIAN SYSTEM

General Statement:

The Lower Pennsylvanian of central Texas is made up of strata of Bend and Strawn age. There is no pronounced break between the Pennsylvanian and Mississippian strata, but the Bend Series is separated from the underlying Mississippian (Barnett) by a disconformity. The Pennsylvanian System in the Llano region has been studied in detail by Plummer (1950). Plummer's definitions and nomenclature are used in this paper.

In the area studied, the Pennsylvanian formations are well represented. These formations are made up primarily of hard, commonly siliceous, limestones and brown to black shales.

BEND SERIES

MARBLE FALLS GROUP

Roemer (1847) was the first to describe strata which are now accepted as Marble Falls. He described the strata as "beds of black hard limestone containing large elliptical masses of black chert... designated Carboniferous limestone." These Carboniferous strata were called "encrinital" or Marble Falls by Hill (1889, P. 289). Cummins is usually credited with naming the Bend Division, but Dumble (1890) was the first to publish the name. The Marble Falls was restricted when Paige (1911, pp. 55-56) separated the upper black shales as Smithwick. No major changes have been made since this time, although Udden, Baker, and Bose altered the formation boundaries to include what are now Barnett shales. Plummer and Moore (1922, p. 22) restricted the Marble Falls when they established the Upper Mississippian age of the underlying Barnett brown shales. The terminology used by Plummer (1950) in describing the Marble Falls is listed below:

BEND SERIES

MARBLE FALLS GROUP

SMITHWICK FORMATION

BIG SALINE FORMATION

Soldier Hole member

Lemon Bluff member

Brook lentil

Gibbons conglomerate

Big Saline Formation

Cheney (1940) named the Big Saline formation from exposures at the type locality along Big Saline Creek in Kimble County. Plummer measured 190 feet of Big Saline exposures along Honey Creek in Mason County. In the Southwest Mason-Llano River area 160 feet of the formation were measured, but at least 30 feet of its lower beds were covered by talus.

Lithology:

The Big Saline of the mapped area consists of the upper portion of the Soldiers Hole lentil and a part of the Brooks lentil.

The Soldiers Hole lentil is composed of a series of very hard, usually dark or black limestones interbedded with brown shales. Many of the black limestone beds have a strong petroliferous odor when freshly broken. The limestones are often highly siliceous and vary in fossil content (Plate XXII).

An abundance of black or dark chert nodules are found along bedding planes and within thick beds. Although the bedding is quite variable in thickness, lateral variation is slight and beds may be traced readily for long distances. One of the key fossils to this group of beds is the Phanoceras compressum. This ammonoid is abundant along exposed bedding planes of the middle members. Corals are well distributed with Lophophyllum profundum being observed most frequently (Plate XXIII, Figure 1).

The limestones are predominantly black when fresh, but weather to a brownish-yellow color. There are a few distinctive beds which weather to al-

Marble Falls Big Saline limestone bedding

Figure 1
Big Saline limestone showing Phanoceras compressium and corals

Figure 2
Big Saline white limestone bed on weathered slope

Plate XXIV

Big Saline thick chert bed along Mason fault

Figure 1
Marble Falls chert fragments.

Figure 2
Mottled limestone of the Brooks lentil

most white and form a pronounced outcrop line on the surface (Plate XXIII, Figure 2). Shales are interbedded with the limestones in a uniform manner. All of these shales are brown colored and vary in hardness. In appearance they closely resemble Barnett shales in their thin-bedding, brown color, fossil content, and petroliferous odor.

The Soldiers Hole lentil is a large reef-like series. This is apparent in the upper beds where crinoids and fusilinids are abundant. Many of the upper beds have numerous large crinoid stems. Crinoids occur intermittently throughout the lentil, but only in the top beds are they abundant.

One reef structure in the lentil caused a small differential compaction dome 20 feet in diameter. This reef is exposed in a caliche road metal pit adjacent to the Mill-Creek road west of Kirk Zesch's ranch house.

In one measured section a distinct disconformity was observed, but its significance could not be correlated with the sections described by Plummer.

At the base of the Soldiers Hole lentil there is an abundance of chert which was not mentioned by Plummer in his report. Plummer set up a Lemons Bluff member for a series of high chert content limestones, but used dark chert as a standard. One zone, probably near the base of the Soldiers Hole Lentil, is 30 feet of grey and slightly orange chert (Plate XXIV). Another thinner chert bed was found separately, but could not be placed stratigraphically. The presence of faulting greatly hindered establishing correct stratigraphic sequences around chert bed occurrences. Adjacent to the narrow Mississippian outcrop band, all hills are capped by extremely large quantities of rough, irregular, orange chert fragments. These fragments resulted from solution removal of the limestone content in the chert beds (Plate XXV, Figure 1).

The Brook lentil, as described by Plummer, is distinguishable in the vicinity of the chert bed. The presence of a thin, but traceable, light tan limestone with rounded and irregular dark blotches resembling dark polka-dots on a light pattern, conclusively identifies the Brook lentil. This mottled limestone was described by Plummer as a part of the Bristol member on the east portion of the Llano region. The Bristol and Brook lentil strata are equivalent. This mottled pattern in the limestone was attributed to alga by Plummer (1950) (Plate XXV, Figure 2).

Topography and Vegetation:

The resistance of the Big Saline limestones has caused them to occur as a long chain of dissected hills. The topography on these hills is fairly rough with pronounced terrace patterns. The terraces result from alternation of the hard, resistant limestones and the less resistant shales (Plate XXVI). The Big Saline beds strike North 40° East and dip between 20° and 30° to the southeast. The hills formed by the formation parallel this strike trend. The south slope of these hills is formed by a series of dip slopes which drop from terrace to terrace. The underlying soft Barnett shale causes a north-facing cuesta to be formed from the Big Saline limestones.

Vegetation is rather abundant on terraces of the Big Saline slopes. On

Big Saline terraced slope

an aerial photograph the vegetation pattern forms uniform lines which parallel outcrops. Cedar and mesquite trees are the most common growth on the limestone slopes. There are a few scattered Mexican persimmon and scrub oak trees on the chert-laden hills. Areas underlain by crinoidal limestones preferentially support oaks. Cacti are common and large colonies of prickly pears cluster along the more resistant limestone ridges which form the terrace boundaries. A variety of catclaw grows preferentially on Pennsylvanian rocks as is illustrated by their distinct line of demarkation at an Ellenburger-Marble Falls fault line.

Smithwick Formation

Sidney Paige (1911) named the Smithwick after an old town in Burnet County. As defined by Paige, the formation included the black shales and lenticular sandstone strata of the Burnet quadrangle. The type locality is located at exposures along the Colorado River, southwest of old Smithwick. The name has since been used by all writers on the Carboniferous to identify the black shale beds above the old Marble Falls formation (now called the Big Saline formation) and below the sandstones of the sandy shales of the Strawn group (Middle Pennsylvanian). It has been proposed by Cheney (1940, pp. 66-80) that the Smithwick be given group status under the Lampasas series.

Lithology:

The Smithwick formation occurs in the Southwest Mason-Llano River area in an eroded valley between the Mason fault and the Big Saline formation hills. Recent stream wash obscures any possible evidence of the black fissile shales so characteristic of Smithwick beds; thus no study of its lithology is undertaken. Plummer (1950) described Smithwick shale outcrops along Honey Creek 4.4 miles west of the mapped area.

QUATERNARY SYSTEM

General Statement:

In the area, Quaternary sediments are limited to stream alluvium and caliche. The stream alluvium consists of gravels derived from Paleozoic rocks and Cretaceous limestones. These gravels occur only in one valley in the northern portion of the area and along the banks of the Llano River. Caliche occurs only in the valley north of the Mason fault. It generally forms the top of local rises within the valley.

STRUCTURAL GEOLOGY

GENERAL STATEMENT

The Southwest Mason-Llano River area lies on the western portion of the Llano Uplift where the Paleozoic strata have undergone intense faulting. All faults in the area trend northeast and range in dip from 60° to 90° (Cloud and Barnes, 1948, p. 118). These faults are consistently downthrown to the northwest.

The topography, drainage pattern, and outcrop pattern are largely controlled by the faulting in the area. Where undisturbed by faulting, the Paleozoic strata have an average regional strike of N60°E and dip approximately 10° to the southeast.

MAJOR FAULTS

Three major faults occur in the Southwest Mason-Llano River area. One of these faults was named "Mason fault" by Plummer (1950) on his "Geologic Map of the Carboniferous Formations in the Llano Region, Texas". The remaining two faults were named the "Schmidt fault" and the "Simons fault" by W. L. Alexander (1952). The Mason and Schmidt faults follow a distinct northeast trend pattern, but the Simons fault veers from this trend to a north-south strike along its southern extremities. Throw on these faults ranges from 1200 feet to less than 300 feet.

The Mason fault passes through the west portion of Mason, Texas, and

Plate XXVII

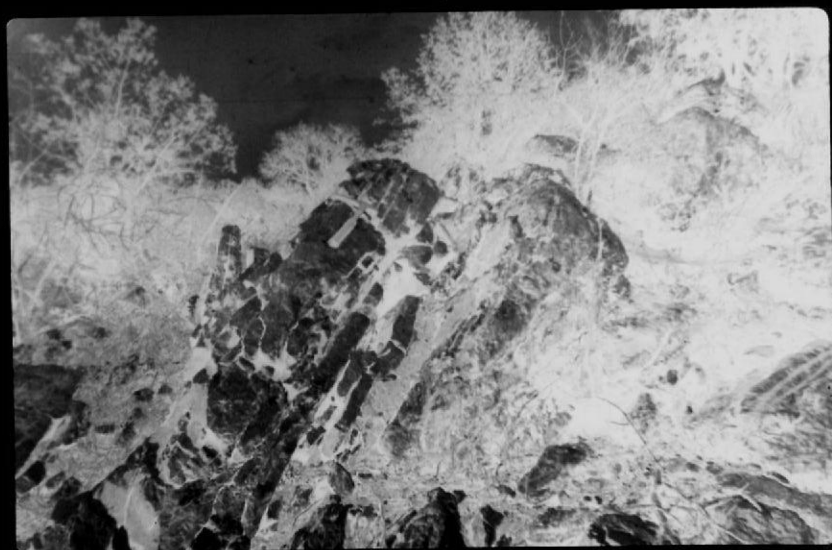
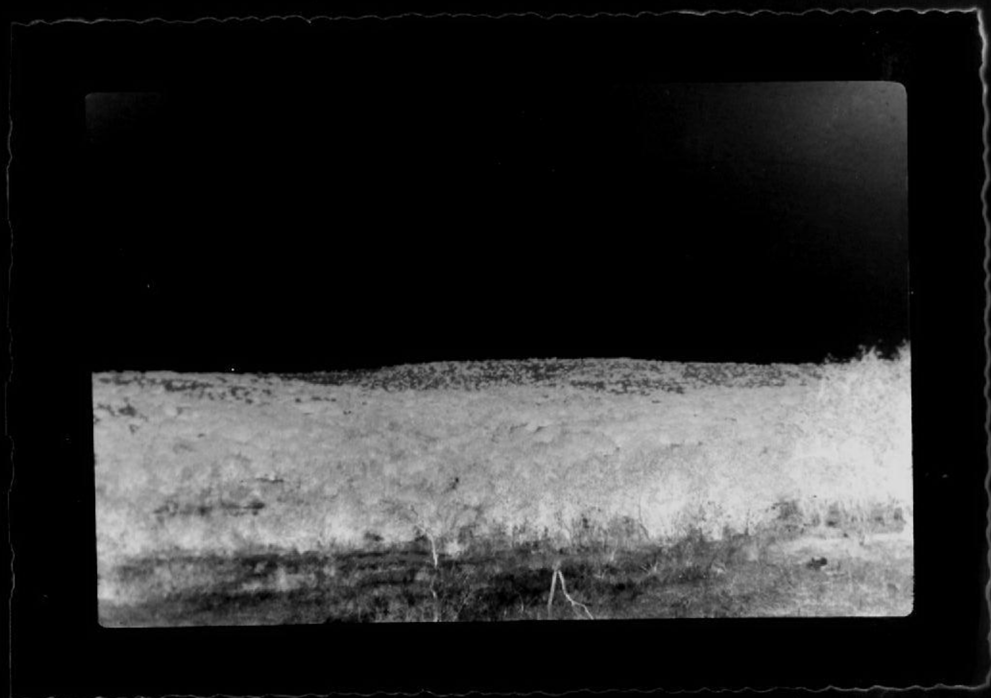


Figure 1
Big Saline crinoidal limestone dragged along Mason fault

Figure 2
Fault breccia along Mason fault

Plate XXVIII



Vegetational break along Schmidt fault

cuts across the north portion of the area. It is the largest fault in the area and has a throw of 1200 feet. The fault follows the typical north-northeast trend southward from Mason until it crosses the Mill Springs Road where it bends to a more westerly trend. Near Mason, along the fault the Upper Hickory sandstone has been brought into contact with the Lower Ellenburger. Farther south the Cambrian members have been brought against Pennsylvanian Marble Falls formations (Plate XXVII, Figure 1). The faulting of Smithwick shale against the hard, resistant San Saba limesones allowed the Smithwick to be removed almost completely in the area to form a broad valley paralleling the fault. North of Kirk Zesch's ranch house the fault forms a fault line scarp of Big Saline limestone. The scarp rises above the Lion Mountain and Welge plateau. One of the few visible fault breccia in the area is found on this scarp (Plate XXVII, Figure 2). The great displacement of this fault has formed a large number of associated faults and fractures. The complexity and irregularity of these associated faults made it necessary to map the fault pattern diagramatically in the more shattered zone north of Kirk Zesch's ranch house.

The Schmidt fault passes through the lower half of the area and cuts the Llano River at a point slightly west of Keller's ranch house. It has a throw of 350 to 500 feet with Ellenburger limestones faulted against Point Peak shales in the southwest part of the area. Along most of the fault, Ellenburger limestones have been brought against lower San Saba limestones, but along its northern portion the fault brings Ellenburger beds in juxtaposition. Surface detection of

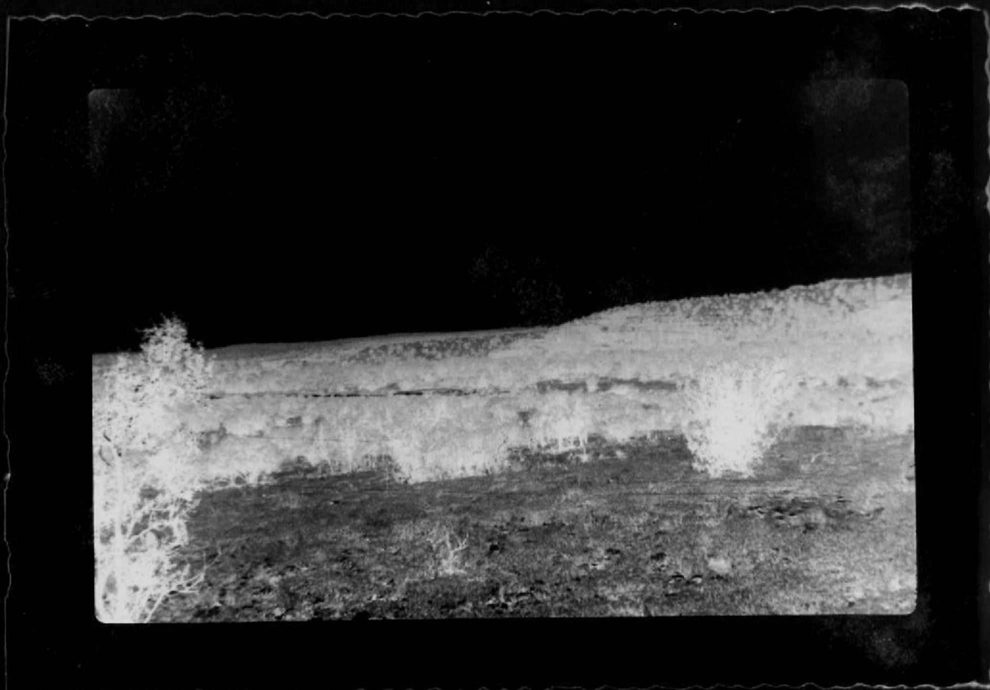


Figure 1
Simons fault topographic break along Llano River

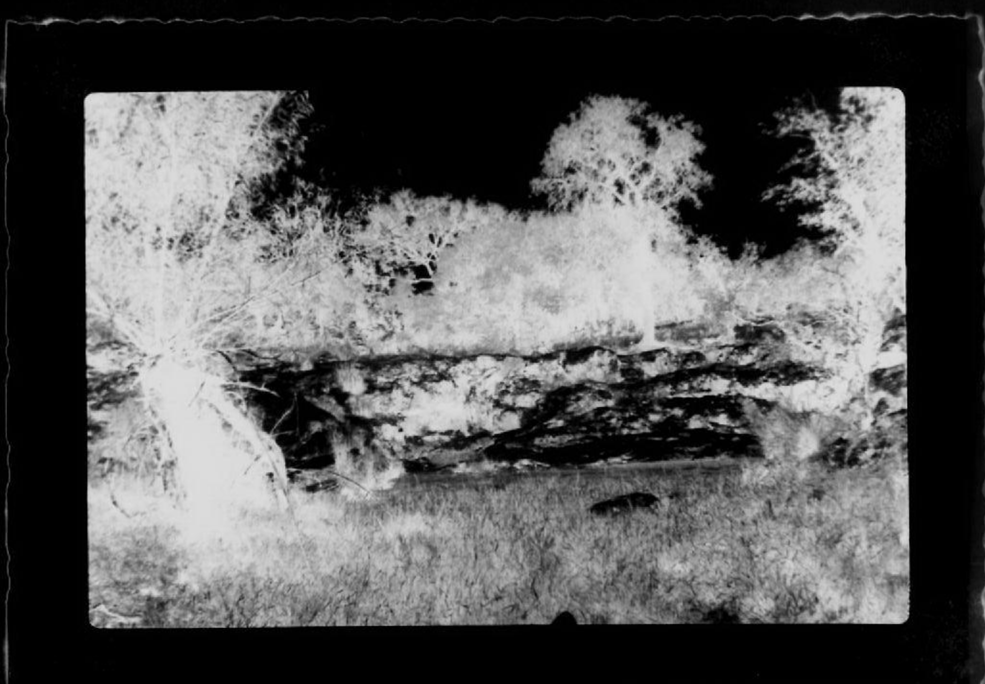


Figure 2
Fault line scarp along Simons fault

this fault is difficult, but the trace is very evident on aerial photographs. From a distance, the vegetational break which marks the trace of the fault stands out clearly as shown in Plate XXVIII.

The Simons fault, which cuts through the southeastern quarter of the area, has a north trend. Its trace is located approximately 200 yards west of Pat Rogers' ranch house and extends south to the Llano River one half mile west of the mouth of James River (Plate XXIX, Figure 1). Slightly north of Rogers' ranch house the fault veers abruptly 30 degrees to the east. It has a throw of 800 feet, with Lower Cap Mountain and upper Hickory beds faulted against upper San Saba and Ellenburger limestones (Plate XXIX, Figure 2). Due west of Pat Rogers' ranch the fault has caused drag dips of 18°.

The Little Mason fault is a smaller fault branching from and forming a parallel fault south of, the Mason fault. This smaller fault has a throw of around 350 feet and brings San Saba beds against Ellenburger limestones. Reverse drag is exibited on the downthrown side of the fault where Ellenburger beds dip into the fault plane. On the upthrown side, San Saba beds show only a slightly diminished regional dip. Other than these dip reversals, the fault is not apparent except on aerial photographs or by very close tracing of key beds up to their termination at the fault.

The major faults have altered the regional dips and strikes quite noticeably, especially along the Mason and Simons faults. Along the Mason fault, the downthrown northwest beds exhibit drag dips of 39° striking parallel to the fault.

This is in the Pennsylvanian Marble Falls limestones which are consistently more distorted by the faulting than the Cambrian and Ordovician beds. Along the Mason fault the Big Saline limestones have a maximum dip of 37° and strike parallel to the fault.

Along many of the faults, dips occur which are opposite to expected dips produced by drag. Cloud and Barnes (1948, p. 119) state that "there is evidence that during faulting, openings may have existed along some of the faults . . . along several of the faults of the Llano region the rocks immediately adjacent to the faults dip in a direction opposite to that of the normally expectable drag. The reason for such 'reversed' drag is not apparent from field observations, but it is conjectured to be caused either by a non-compensatory movement in a direction opposite to the original displacement, or possibly by slumping or pitching of the strata toward openings along the zone of displacement. The 'reversed' drag seems to be mostly associated with the steeper faults."

Along the Simons fault there is strong evidence to support this theory, viz., the Ellenburger beds dip into the fault in a way that is not normal for the downthrown side. Also along the fault are found beds whose strike is completely out of phase with neighboring beds and dipping at high angles, clearly indicating that slumping into some form of depression occurred.

There are, however, places along the faults which exhibit a clean break with little or no apparent distortion of dips or strikes. Along all of the faults these undistorted breaks occur to a limited extent, but invariably grade into typically broken and shattered fault zones which are 150 to 200 yards wide. In these zones beds are greatly distorted. This is especially true along the Mason Fault.

MINOR FAULTS

In the mapped area three types of faults of minor magnitude occur. They are (1) parallel faults, which are prominent in both the north and south portion of the area, (2) cross faults occurring mostly in the northern portion, and (3) one dip fault.

These minor faults range in throw from 10 to 300 feet and usually strike northeast with their displacement controlled by their relation to the major faults. Normally the faults which occur on the downthrown side of a major fault are downthrown to the northwest and those on the upthrown side are downthrown to the southeast. The group of parallel faults located northeast of the Mason fault violate this rule in that they are on the downthrown side, yet are themselves downthrown to the southeast. It is quite logical to assume that this violation is due to partial collapse on the downthrown side of the Mason fault. (Boone, personal communication).

There are very few cross faults which are clearly traceable between the closely spaced parallel faults in the northern portion of the area. They show no definite pattern.

The one dip fault occurs with approximately 100 feet of throw and strikes north in the north central portion of the area. It has caused a

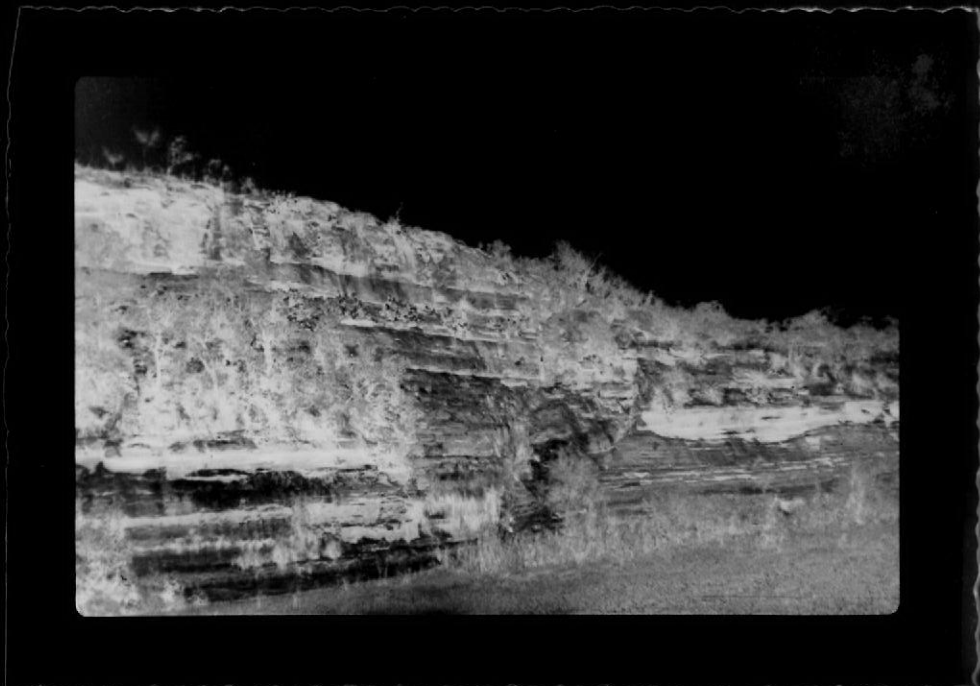


Figure 1
Fault plane exposed along Llano River

Figure 2
Fault plane in Point Peak member along Llano River bank

slight displacement in the Wilberns formation, but other than this and slight strike changes on each side, it is quite inconspicuous. It is traceable only for a short distance until it disappears in San Saba rocks.

In the southern part of the area along the Llano River there are several parallel faults exposed so that the dip is measurable (Plate XXX, Figure 1). One of these faults, exposed in an eight-foot cliff, has a dip of 81° (Plate XXX, Figure 2).

DETECTION OF FAULTING

Detection of a majority of the faults in the mapped area was through investigation of vegetational breaks observed on aerial photographs. Because of the varying nature of the outcropping rock units and their slightly varying flora, any fault with considerable throw becomes evident somewhere along its trace as a vegetational break. Some of the minor faults, which show up clearly both on aerial photographs and in the field when displacing the Riley and lower Wilberns formations, become indistinct and usually impossible to trace after they pass into San Saba or Ellenburger limestones.

All photographic map observations of probable faults were carefully checked in the field for confirmation. Field indications which were used to detect faulting were: (1) abrupt termination of beds along their trend, (2) repetition and omission of strata, (3) variations in the normal strike and dip of beds, and (4) actual observation of the fault break at points denuded by erosion.

AGE OF FAULTING

In the Southwest Mason-Llano River area all faulting is younger than the formations exposed in this area. Along the Mason fault the Smithwick shales have been affected. This indicates that the faulting was definitely during post-Bend times. Cloud and Barnes (1948, p. 121) stated, "in the western part of the Llano uplift, in the vicinity of Calf Creek, unfaulted beds of Canyon age overlap faulted rocks of Ellenburger age. The major late Paleozoic faulting is thus indicated to have taken place before Canyon time."

ORIGIN OF FAULTING

Quoting Cloud and Barnes (1948, p. 118-119), "the rocks of the Llano uplift are thought to have comprised a relatively resistant mass, around the eastern and southern sides of which developed the geosynclinal area (Llanoria geosyncline of Sellards, 1933) containing the Ouachite facies. The faulting in the Llano region probably accompanied the late Paleozoic folding that involved the sediments of the Llanoria geosyncline, movement in the geosynclinal area to the east and to the south placing the Llano area under torque and causing it to fracture. The theoretical tensional couples developed by active compression from east and south would result in fractures aligned dominantly in the northeast quadrant, as faulting in the Llano region is."

A close examination of the overall faulting pattern in the western Llano region and the associated strikes and dips of the affected rocks yields very strong evidence that this particular area is one of some secondary doming. It is possible that a large portion of the faulting in the west Llano region could have actually been a direct result of the secondary doming. (Seward, personal communication). Observations in the Southwest Mason-Llano River area did not yield any conclusive evidence to this effect because of the localized nature of the area.

FOLDING

There is no evidence of folding of any magnitude in the Southwest Mason-Llano River area. Very gently undulations or domal structures of local occurrence are common in the Cambrian formations, especially in the Point Peak shale member of the Wilberns formation. In the upper Point Peak and lower San Saba members these domal features result from differential compaction over large reef structures. These features are well exposed in the bed of the Llano River 0.75 miles upstream from the mouth of the James River.

In the east central portion of the area at the point where the Simons fault veers sharply in strike, upper Wilberns beds have been arched into a highly fractured dome. This dome occurs on the downthrown side of the Simons fault and its west flanks are cut by the Schmidt fault. It is postulated that the strong change in strike along the Simons fault and the dragging effect of the Schmidt fault cause the dome feature to be formed. The crest of the dome has been eroded to expose Point Peak shales surrounded by overlying San Saba limestones.

The collapse structures which occur along or near the Ellenburger-San Saba contact very often give the appearance of small local basins (Plate XVII, Figure 2). Also the ancient sinks or collapse structures of the Ellenburger limestone, which were later filled by Mississippian Chappel limestone and Barnett shale, cause the Chappel to dip into the depressions. Two of these Chappel filled Ellenburger depressions occur in the mapped area. A portion of the smaller one is shown in Plate XVIII, Figure 2.

SUMMARY OF GEOLOGIC HISTORY

The early pre-Cambrian seas of central Texas received a thick series of sediments. These sediments were deeply buried, metamorphosed, and extensively intruded by igneous rocks. The coarse granites indicate that intrusion occurred at considerably depth. A period of folding and erosion bared the pre-Cambrian metamorphics to form a surface of considerable relief. This period of erosion probably represents Lower and Middle Cambrian times.

"The first Paleozoic sea to enter central Texas invaded a region of considerable local relief" (Cloud and Barnes, 1946). The sea reworked sands of eolian origin to form the basal Hickory sandstone member. Over the upper Cambrian sea floor, hills as high as 800 feet remained until they were finally covered by the Cap Mountain member. Through Upper Cambrian time shallow seas persisted. This is indicated in the Southwest Mason-Llano River area by beach sands, shallow water limestone, reef structures, and fossil accumulations.

By middle Riley time, the supply of coarse detritus had been exhausted. Cap Mountain granular limestones, which have a high glauconite content and abundant trilobites, indicate this change. These limestones accumulated in a shallow, cool, neritic environment. A change in land and sea relationship during late Riley and early Wilberns time supplied abundant sand.

Coarser clastic material of the Lion Mountain and Cap Mountain decreases upward into the highly glauconitic, granular Morgan Creek. Duplication of the earlier neritic and cool environment occurred at this time.

The Point Peak shale member indicates an introduction of argillaceous material to the sedimentary sequence. At this time widespread flats, periodically flooded by tides, existed as is indicated by sun-cracked surfaces, shale-pebble conglomerates and thin alternating shale and limestone beds in the upper Wilberns formation (Paige, 1912, p. 79). General shoaling and warming of the sea is indicated by the stromatolitic bioherms of the upper Point Peak member. "The ... presence of a larger island mass to the west ... to the end of Cambrian time, is indicated ..." (Cloud and Barnes, 1946, p. 112). In the Southwest Mason-Llano River area this is suggested by the occurrence of sand in the San Saba member.

There was no break in deposition between Cambrian and Ordovician times. During depostion of the Ellenburger limestone, the area was covered by an intermittently turbulent, warm and shallow sea. "Equilibrium conditions of these ancient waters ... are suggested by the character, persistence, and frequency of penecontemporaneous dolomitization," according to Cloud and Barnes (1946). They further state that the Ellenburger limestones "are commonly, although not generally stromatolitic, indicating an at least partial algal origin and generally a shallow water environment."

The Ellenburger rocks were greatly truncated during a period of non-deposition through Upper Ordovician and Silurian times. Following this truncation, seas again invaded the area and deposited Devonian sediments. Cloud and Barnes (1948, p. 113) stated that "the region was tilted to the east and largely truncated before Devonian time, followed by an east to west Devonian marine invasion. . ." The Devonian rocks found in the Llano region occur in ancient structural sinks, where they were protected from erosion. There are no detectable Devonian strata in the Southwest Mason-Llano River area.

Uplifting of the Llano region during Mississippian time caused the Mississippian beds to thin toward the center of the uplift. In most places the Mississippian rests unconformably on the Ordovician. This unconformity is represented by a coarse breccia or a stratigraphic break.

Widespread truncation and locally complete removal of Barnett were accomplished in pre-Pennsylvanian time (Barnes and Cloud, 1945).

Cloud and Barnes (1946, p. 113) state that "marine invasion occurred at several times during Mississippian and Pennsylvanian time." A return to "low, swamplike conditions" over extensive areas was believed to be indicated by the black shales at the top of the Pennsylvanian (Paige, 1912, p. 80).

Permian, Triassic, and Jurassic times are represented by a long period of erosion. There was probably some uplift accompanying this hiatus. During this long period, erosion removed all Paleozoic sediments from parts of the uplift and exposed pre-Cambrian strata. The Cretaceous seas invaded the area and deposited sediments on pre-Cambrian, Cambrian, Ordovocian, Devonian (?) and Carboniferous beds. The Cretaceous strata have since been eroded from the Southwest Mason-Llano River area to expose the underlying sequence of older rocks.

No indication of Tertiary deposition beyond possible Tertiary alluvium is recorded in the Southwest Mason-Llano River area.

ECONOMIC GEOLOGY

The Southwest Mason-Llano River area is almost void of geologic resources other than abundant ground water and limited quantities of cultivatable soil. Most of the ground water is obtained from the Ellenburger limestone or the Hickory sandstone, although the Lion Mountain and Welge sandstones, as well as fractured granites, frequently serve as aquifers. The Hickory sandstone is one of the most important aquifers in Texas and is a strong asset to ranchers during dry summer months. In the southern part of this area, east of Pat Rogers' ranch house, the Hickory has been penetrated and yields flowing artesian water from six wells. Wherever San Saba limestones crop out in the area, numerous springs occur and further increase the value of the land for ranching.

The Hickory sandstone, Lower Cap Mountain limestone, Lion Mountain sandstone, and Welge sandstone all form slopes of sandy soil that are very favorable for cultivation, but are usually limited in areal extent. Throughout the area, outcrops weather sufficiently to allow an abundant growth of shrubs and grasses which make possible extensive ranching.

The possibility of oil discovery in the area is nil. The reasons were presented by Cloud and Barnes (1948, p. 33), "petroleum will probably not be found by drilling in the Llano region because of the complex faulting of the potential source beds and their present exposure to the atmosphere." It is interesting to note, however, that in drilling for water at various depths in the area, cuttings have been brought to the surface that "had a good smell and showed good 'rainbows'" (personal communication with local water well drillers).

A few of the lower Paleozoic rocks have been used locally for building stone. Many of the old native homes are built from sandstone quarried from upper Hickory and lower Cap Mountain members. Also, the Hickory sandstone as well as weathered pre-Cambrian granites are used extensively as road metal. Most of the purer limestones, especially the Ellenburger, could be crushed and made available for a variety of uses such as road metal or concrete aggregate, but normally such crushing operations are not economically feasible.

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APPENDIX

Marble Falls limestone bedding

Section of Pennsylvanian Marble Falls limestones exposed in bluff north of Mill Springs road at a point 1.55 miles southwest from Kirk Zesch's ranch house along the road.

	Thickness in feet
Marble Falls Group:	
Big Saline Formation:	
1. Limestone; weathered light grey to yellowish tint with mottled black, fresh break black; fine-grained; resistant; hard; platy fracture; ridge forming; no fossils observed.	4.1
2. Limestones weathered dirty grey, fresh break smooth medium dark grey with bands of dark grey; evenly bedded with 1 foot beds; jointed; sub-crystalline; siliceous lens; base marked by 7 inch shale.	6.8
3. Limestone; weathered yellowish to dirty grey, fresh break dark grey; fine-grained to sub-lithographic; well bedded (6 inches to 2 feet); hard; shale partings between beds; weathers rounded; fossiliferous with corals, small brachiopods, one large brachiopod cast, scattered <u>Phanocerous</u> <u>compressium;</u> some lamination in beds; base marked by two parallel	

	Thickness in feet
resistant beds on weathered surface of hill.	17.4
4. Limestone; weathered dirty grey, fresh break smooth grey; crystalline; hard; bedded with 2 foot layers; silty partings; calcite vugs; some reddish coloring on beds; scattered parallel lens of black chert; closely related to overlying unit but distinguished by chert occurrence	3.4
5. Limestone; weathered mostly yellowish grey to faded grey, fresh break banded dark grey in smooth to blotchy grey matrix; bands siliceous; matrix fine-grained to crystalline with lower portion silty; thick-bedded with average of 3 feet; silty partings; chert lens in upper part; fossiliferous with zones of crinoids and scattered brachiopods; lower beds break along obscured cracks containing calcite material.	11.6
6. Shale; brownish-tan; silty; calcareous; thin-bedded; a few thin limestone layers standing out; covered considerably by talus.	11.0
7. Limestone; weathered light dusty yellow, fresh break black; bedded with average of 2 to 3 feet; some silty partings; weathers rounded; calcite present in fractures;	

	Thickness in feet
there is a shredded effect parallel to the bedding with oriented, thin, short stringers; base is disconformable to lower beds.	4.5
. . . disconformity.	
8. Shale; brownish-tan; thin-bedded; contains beds of yellow-weathered limestone that is black on fresh surface; several brachiopods zones in unit.	13.4
9. Limestone; weathered brownish, fresh break black to tan; silty and impure; fine-grained; massive; thin shale break separating it from underlying unit. . . .	2.9
10. Limestone; light grey to buff-grey; medium-hard; silty; fine-grained; weathers to rounded surface; stands out as much lighter than other beds; good traceable unit.	1.8
11. Limestone; weathered yellowish tan-brown with shades of grey, fresh break grey, dark grey and black; fine-grained to sub-lithographic; bedded 1 to 1.5 feet; some silty partings; black zones are lense-like; brachiopod zone two feet from top; weathers to rounded surface; weathering penetrates	

Thickness
in feet

as much as two inches; lower beds are banded and weather to distinctive smooth grey. 10.7

12. Limestone; weathered light grey with fresh break slightly lighter; sub-crystalline, approaches fine-grained; not as hard as the black limestones; massive; chert banding at top with mostly black chert; fossiliferous, crinoidal with some brachiopods at top; weathered surface (vertical) has resistant bands that are irregular and 1 to 2 inches thick; base is shale layer 0.2 feet thick, tan, flaggy, and calcareous. 2.9

13. Limestone; weathered brown with blackish-brown stains, fresh break light tan to grey; impure; sublithographic to crystalline in base 5 inches; bedded (two beds, 1 foot and 8 inches); shale at base and middle; bottom bed crinoidal and crystalline; top of lower bed silicous, forms beginning of cliff exposure below talus covered overlying units. . . 2.4

14. Limestone; consists of two massive beds separated by a fissle shale 5 inches thick. . . . .

Top bed; fresh break light grey with darker

		Thickness in feet
	blotches; sub-crystalline; layer of black chert bands at top and base of bed.	
	Bottom bed; fresh break brown to tan; fine-grained; hard; bottom less pure; contains black mineral and a few rounded pebbles of limestone.	7.0
15.	Shale; tan, bedded shale alternating with grey to brown limestone 8 inches thick; mostly covered by talus; limestone often black but predominently brown.	10.9
16.	Limestone; weathered black with mottled grey, fresh break light grey; massively bedded; grades downward into slightly darker, weathered, more rounded ledge with fresh break dark grey; topped by 6 inches of consistent black chert, another thinner consistent chert layer 4 feet from top.	8.0
17.	Limestone; weathered mottled grey, fresh break light grey to ash colored with black spots of organic origin causing resemblence to wood ashes; fine-grained; bedded; four feet from top is abundant brachiopod zone; seven feet down is a shale parting containing peculiar chert layer.	16.0

		Thickness in feet
18.	Limestone; weathered grey, fresh break brown grading downward into light grey; massive; sub-lithographic to fine-grained; contains large black chert nodules from 2 inches to 1.5 feet in diameter.	5.0
19.	Limestone; weathered smooth grey, fresh break light grey; fine-grained and very smoothly weathered; bedded uniform 2 foot beds; chert nodules and banded chert.	4.6
20.	Limestone; weathered yellowish-tan, fresh break tan-brown; hard; 4 to 8 inch bedding; very fine-grained; weathers to rounded surface; upper portion contains brachiopods; worm-like markings parallel to bedding; siliceous lens at base.	2.2
21.	Limestone; weathered black mottled-grey, fresh break light grey; fine-grained; top bed 1.5 feet thick with lower part platy and fractured; many chert and siliceous lens.	6.1
22.	Limestone; weathered white grey, fresh break white; crystalline; massive; crinoidal; weathers rounded; forms ledge in gully where exposed; no chert.	2.5

		Thickness in feet
23.	Limestone; weathered white grey (very light), fresh break light grey; fine-grained; hard; evenly-bedded; many scattered black chert nodules; forms series of stair steps below overlying massive crinoidal limestone.	8.2
	Total thickness measured.	163.4

Section of the lower Ellenburger limestone, San Saba limestone and upper Point Peak shale exposed in bed of Llano River beginning at top of bluff on south bank 0.79 miles west of the mouth of the James River and extending upstream approximately 4200 feet.

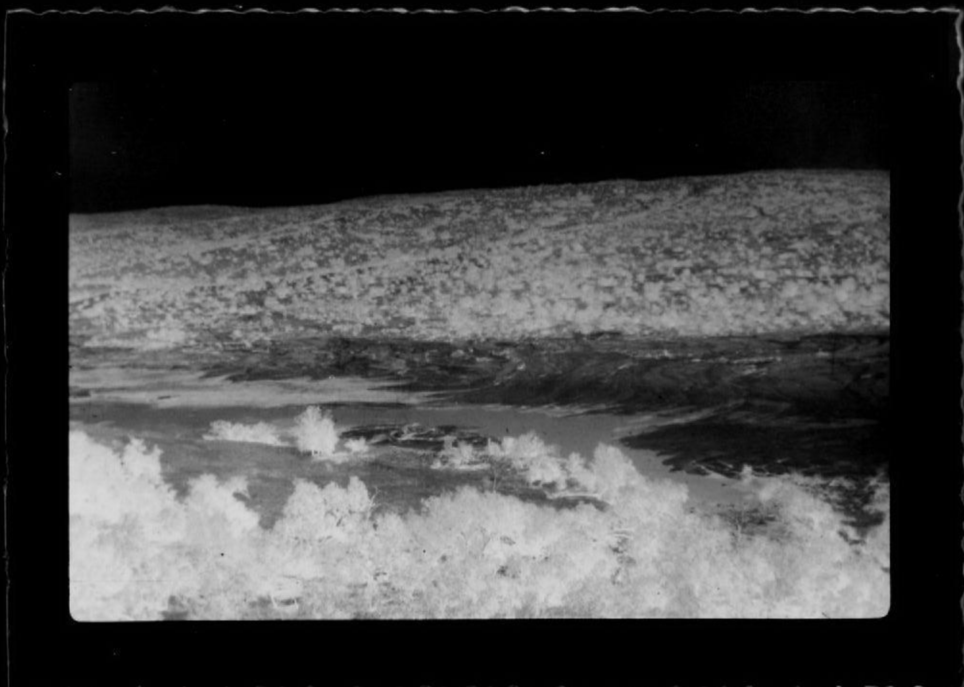
	Thickness in feet
Ellenburger group:	
1. Limestone (partly covered); light grey, tan to very light grey on fresh break; bedding not distinct; medium to finely crystalline; arenaceous; hard; contains calcite; large, smooth, rounded ironstone pebbles and blocky chert weather out over the outcrop.	16.0
2. Limestone; dark to mottled grey; thick-bedded to massive; sub-crystalline to finely crystalline; arenaceous; contains scattered calcite, white chert, and pyrite; slabby limestones often interbedded with thick beds; zone weathers to slumped blocks.	25.7
3. Limestone; light grey to tan; thin-bedded to platy with frequent silty partings; sub-lithographic; slightly arenaceous as a whole, with frequent zones of abundant fine-grained sand occurring; contains scattered calcite, chert, and pyrite; fossiliferous.	27.8

	Thickness in feet
4. Limestone; dark mottled grey, light tan, and pearl grey; thick-bedded; sub-lithographic; hard; contains pockets and stringers of calcite; pockets of pyrite as large as 1 inch diameter; excresences of white chert; fossiliferous; contains scattered silty partings and fine-grained arenaceous beds up to 8 inches thick; weathers to large, prominent ledges and blocks pitted with light brown vugs.	14.4
5. Limestone; light pearl grey weathering to mottled grey and tan; medium to thin-bedded and platy; sub-lithographic; contains small calcite pockets and stringers; white chert occurs as excresences on weathered surface; scattered pockets of pyrite; fossiliferous; bedding planes weather to smooth white surfaces frequently marked by dark grey interlaced snail trails.	25.6
Total measured thickness of Ellenburger limestone. .	109.5

Wilberns formation:

San Saba limestone member:

6. Limestone; light grey and soft tan weathering to



San Saba limestone bedding in Llano River

		Thickness in feet
	mottled grey; thin-bedded to platy with calcareous shale and silt partings; sub-lithographic; contains small pockets of calcite; fossiliferous; bedding planes often marked by snail trails.	36.8
7.	Limestone; light tan and grey weathering to dark and medium grey; massively bedded, but weathers to layers 2 to 3 inches thick; medium to finely crystalline and sub-lithographic; medium-hard. . .	24.7
8.	Limestone; light grey to tan; sub-lithographic; thinly bedded and interbedded with buff tan, calcareous shales; the shales are hard and non-fossiliferous with bedding surfaces frequently suggesting mud cracks; the limestones are flaggy near the top of the unit; unit as a whole weathers easily.	21.8
9.	Limestone; medium to pinkish grey weathering to dark grey; medium-bedded; medium to coarsely crystalline; abundant glauconite; fossiliferous. . . .	4.5
10.	Limestone; mottled light grey and orange-tan weathering to medium grey and yellowish-tan; thin-bedded; sub-lithographic to coarsely crystalline; some beds are	

		Thickness in feet
	silty and contain intraformational conglomerate; hard; infrequent glauconite; fossiliferous.	15.8
11.	Limestone; greenish grey to light tan; thinly bedded to platy with calcareous silty partings; sub-lithographic to coarsely crystalline; very hard; contains pyrite and scattered limonite; glauconitic; glauconite and pyrite are confined to the crystalline beds; fossiliferous with brachiopods and trilobites.	25.2
12.	Limestone; light tan and grey weathering to brownish grey; thinly bedded to platy with calcareous silt and shale partings; coarse to finely crystalline; some sub-lithographic beds containing calcite and glauconite occur in the unit; abundantly glauconitic as a whole; fossiliferous; thickness of some beds varies irregularly.	16.0
13.	Limestone; white to light grey with tints of pink; irregularly thin-bedded to slabby; medium to fine-grained medium hard; contains some interbedded calcareous green shale and zones of intraformational conglomer-	

Thickness
in feet

ate; abundantly fossiliferous with frequent silty, highly glauconitic casts of fossils; contains some limonite and scattered rounded pebbles; weathers to smooth surface. 9.9

14. Limestone; light grey with pink and green tints; trilobite hash with interbedded coarse-grained limestone and green calcareous shale; thinly bedded with cross-bedding apparent in zones containing abundant fossil fragments; glauconitic. 9.6

15. Limestone and shale; grey with tints of blue and green; irregularly thin-bedded to slabby; limestones are medium-grained, glauconitic and silty; shales are non- glauconitic and non-fossiliferous; weathers to rough, pitted surface. 5.4

16. Trilobitic limestone; bluish grey to shades of pink and tan; thinly bedded with prominent cross-bedding; trilobite hash; hard; green grey soft shale occurs as bed partings and fingers within the beds; glauconitic; contains frequent silty fossil casts. 13.6

17. Limestone; mottled grey varying to pinkish and greenish greys; medium bedded with interbedded non-calcar-

		Thickness in feet
	eous, fine, green silt; bedding is rather irregular near base; limestones are fine to coarse-grained; hard; glauconitic; coarser, more fossiliferous beds show large wave marks on bedding surfaces; basal portion strongly resembles unit 13.	11.9
18.	Limestone; greenish grey, orange tan, and pink tinted greys; thin-bedded; cross-bedded; trilobite hash; very hard; contains abundant glauconite and scattered limonite; beds weather to rough, irregular surface. . .	2.5
19.	Limestone; buff tan to greenish-grey; thin-bedded at base, irregularly bedded at top; medium to finely crystalline; arenaceous; silt occurs as pockets and stringers in some beds and as interbedding material; glauconitic throughout; fossiliferous with fossils increasing in abundance toward base.	3.3
20.	Limestone; yellowish-tan to shades of brown and grey; thick-bedded; fine-grained; areaceous, often grading laterally into silty sand; glauconite occurs as scattered specks and often as local concentrated pockets; limonite often occurs in small pockets;	

stringers of calcite are present in some beds; bed surfaces sometimes exhibit large symmetrical ripple marks, and ledge faces often weather to rough, ridged surface. 8.7

21. Limestone; grey-brown to greenish-tan; thinly bedded with silty, calcareous shale partings; coarse-grained medium-hard; glauconite varies in abundance in various beds, particularly in the shale; trilobite fragments and brachiopods are very abundant in lower portion; intraformational conglomerate occurs near the top of the unit; many of the limestone beds thin and pinch out laterally; local variations in dip indicate the proximity of bioherms in the section which are not exposed at the surface outcrop. . . . 11.0

22. Limestone; light grey, tan, and green, weathering to dark greys and tans; medium-bedded; coarse grained, with pockets and stringers of silt; abundant glauconite; scattered limonite; becomes arenaceous toward base; 3-foot zone of silty shale and platy limestone occurs near middle of unit; fossiliferous; beds weather to smooth surfaces. 20.7

23. Limestone; brownish grey to mottled dark grey; med-

	Thickness in feet
ium bedded; medium-grained; arenaceous in part; hard; fossiliferous, trilobite fragments become very abundant in lower portion; silt pocks are found scattered throughout the unit and the central portion is rather arenaceous; glauconite not abundant; a 4 foot, coarse-grained, fossiliferous bed occurs in lower portion; base of unit is marked by a 3 foot zone of green, soft shale which forms a prominent recession in cliff face on river bank. . .	19.7
Total measured thickness of San Saba limestone member.	261.1
Point Peak shale member:	
24. Limestone; light grey to tan; weathering dark grey; thinly bedded limestone interbedded with shale, massive appearance on cliff face; coarse-grained; medium-hard; glauconitic in part; limonitic; trilobites and brachiopods rather abundant throughout; base marked by silty shale, which forms recession in cliff face.	11.8
25. Limestone; light grey to tan with rose colored	

	Thickness in feet
hues; thinly bedded with abundant interbedded silt; fine-grained; glauconitic; fossiliferous; prominent, highly glauconitic shale zone in upper portion; base marked by 13-inch bed of silty shale.	14.0
Total measured thickness of Point Peak shale member	25.8
Total measured thickness of section.	396.4

Section of the upper Point Peak shale exposed on cliff face on north bank of Llano River at sharp bend located approximately 1.83 miles upstream from crossing of the James River Road on the Llano River. Section extends approximately 650 feet upstream.

	Thickness in feet
Wilberns formation	
San Saba limestone member:	
1. Limestone; light grey to tan, weathering to medium grey and brown; medium to thin-bedded; sub-lithographic to fine and medium-grained; hard; sparsely glauconitic; sparsely fossiliferous; forms overhang on cliff above underlying shale and bioherm zones. .	34.0
Point Peak shale member:	
2. Shale; tan to white and green; thin-bedded to platy; silty, grading laterally into platy limestones; calcareous; forms recession in cliff face.	6.0
3. Bioherm zone; grey with tints of blue and tan; sub-lithographic to micro-granular; hard; large blocks have weathered out and dropped into river bed; blocks show reticulated, sub-circular masses; bioherms are bounded laterally by thin-bedded, grey,	

Figure 1
Point Peak bioherm surface

Figure 2
Point Peak bioherm "cabbage heads"

		Thickness in feet
	fine to coarse-grained limestones.	27.5
4.	Shale; greenish-grey to tan; thin-bedded to platy; silty; medium hard; edgewise conglomerate consisting of flat rounded siltstone pebbles is found in several zones; small bioherms occur at top. .	40.3
5.	Limestone; dark grey to mottled greenish-grey and tan; thinly bedded; coarse-grained; medium hard; fossiliferous; lower portion obscured by river deposits.	3.0
	Total measured thickness of Point Peak shale member.	76.8
	Total measured thickness of section.	110.8

Section of Lion Mountain sandstone, Welge sandstone, and Morgan Creek limestone measured along a line running S10°W from a small gulley in the northeast corner of a triangular shaped field. The field is located on the east side of the Mill Springs Road 4.2 miles from the Mason County Court House.

	Thickness in feet
Wilberns formation:	
Morgan Creek limestone member;	
1. Limestone; brown to greyish-brown, fresh break grey with mottled tans and browns; medium bedded but not well exposed; medium to coarse-grained; slightly impure, with silt occurring in pockets; contains glauconite which has a distinctive rich green color; abundant crinoids (?) occur in a 2 foot bed near center of unit; sparsely fossiliferous with trilobites; unit forms edge of basal Point Peak shelf	41.5
2. Limestone; grey with greenish tints, light grey to flesh colored on fresh break; medium to thin-bedded; fine to medium-grained; contains rich-green glauconite; fossiliferous with trilobites and crinoids (?)	44.0
3. <u>Eoorthis texana</u> zone: Limestone; light grey, fresh break very light tan to white with mottled brownish-	

		Thickness in feet
	tan; fine-grained; hard; medium-bedded; glauconitic with intense green color; highly fossiliferous with <u>Eoorthis</u> <u>texana</u> brachiopods, very few trilobites; slightly impure in zones with inclusions of silty material;.	11.2
4.	Limestone; brown to greyish-brown, fresh break grey with mottled tans and browns; medium-bedded; medium to coarse-grained; impure; silty with silt also occurring in pockets; hard; contains calcite vugs and coarsely crystalline stringers; glauconitic; sparsely fossiliferous with trilobites.	21.0
5.	Limestone; reddish-brown, fresh break light brownish-tan with mottled whites; medium-bedded; coarse-grained; arenaceous, with well-rounded, limonite coated grains; contains globules of pyrite; grades upward into slightly impure, less arenaceous beds; glauconitic; contains vugs of calcite; noticeable lighter color at top of unit; beds weather back to slope of hill as rounded ledges.	36.7
	Total measured thickness of Morgan Creek limestone member.	154.4

Thickness in feet

Wilberns and Riley formations:

Welge sandstone member and Lion Mountain sandstone member:

6. Members undifferentiated; mostly covered slope of reddish brown sand forming cultivated field. From float and fragments brought up by auger drill, members are described.

Welge sandstone member: Sandstone; brown tan to light reddish-brown; medium-grained with pockets of coarse grains; rounded to sub-rounded quartz grains; highly ferruginous; float blocks have hemispherical nodules of red-black iron oxide; within sandstone are very hard, hematitic bands and pockets of white sand. .

Lion Mountain sandstone member: Sandstone; deep reddish-brown; medium to coarse-grained, sub-rounded, frosted quartz grains; no lamination; bedding not observable; soft, almost friable; base darker and slightly glauconitic, slightly fossiliferous with brachiopods; basal contact with Cap Mountain obscured. 108.0

Riley formation:

Cap Mountain member:

	Thickness in feet
7. Limestone; fresh break greenish-grey to mottled grey with white and tan streaks, upper middle part almost white; coarse-grained; hard; medium-bedded where visible; contains limonite; highly glauconitic; fossiliferous with trilobites, 2-inch bed of trilobite hash near top; upper beds have small reddish-brown pockets of sand; calcite crystals occur in coarse matrix; unit poorly exposed because of sand wash from overlying Lion Mountain and Welge slope.	17.0
Total measured thickness of section.	301.4

Section of the Welge sandstone and Lion Mountain-Welge contact exposed on south bank of a small creek on Walter Schmidt ranch. Exposure is located approximately 0.8 miles west of Farm Road 1723 crossing of creek which is 1.6 miles from junction of Farm Road 1723 and U. S. Highway 87.

	Thickness in feet
Wilberns formation:	
Morgan Creek limestone member:	
covered slope.	
1. Limestone; brownish-grey, moss covered, fresh break whitish-grey; thin-bedded; very arenaceous; medium to coarse-grained; hard; contains bands of calcite and some fairly large quartz grains, sub-rounded and frosted; weathered surface has multitude of grains protruding where limestone matrix is dissolved; slightly glauconitic; top covered by talus and soil. .	5.0+
Welge sandstone member:	
2. Sandstone; reddish-orange, fresh break light tan with tints of red; poorly bedded; mostly medium to coarse, rounded to sub-rounded grains; grains frosted; argillaceous; poorly cemented; friable; contains scattered brachiopods; thin ironstone laminae at top	3.9

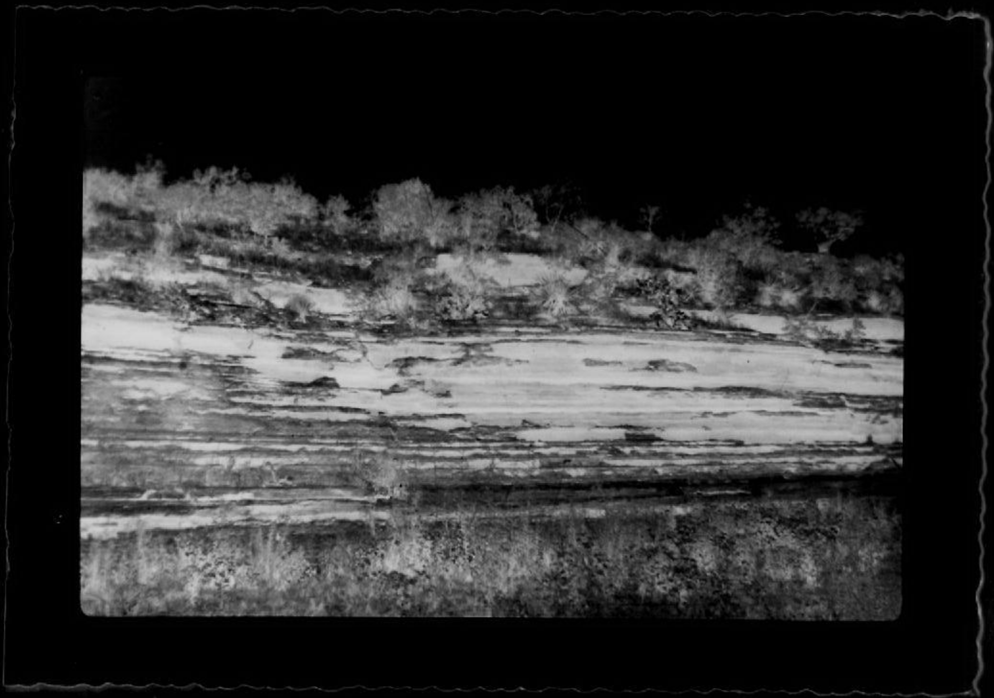
	Thickness in feet
3. Shale; orange-tan; thin-bedded; calcareous; sandy in layers at center (0.4 foot) with medium to coarse, rounded to sub-rounded grains; well cemented and calcareous; shale very soft but sandstone beds hard; some of shale has thin, fibrous structure; unit weathers readily and outcrops are rare.	2.7
4. Sandstone; brownish to reddish-tan, dull red-brown on fresh break to lighter shades of pinkish to reddish-tans; thick-bedded to massive; mostly medium to coarse-grained in base grading upward to mostly fine to medium-grained in upper portions with scattered coarse grains; grains rounded to sub-rounded; grains glitter in sunlight because of recomposed faces; coarse grains show some frosting; small patches of grain size concentration with varying degrees of cementation; seemingly argillaceous cementation; slightly fossiliferous in widely scattered spots; ferruginous; forms rounded bluff on south bank of small gulley.	10.6

	Thickness in feet
Total measured thickness of Welge sandstone member	17.2

Lion Mountain Sandstone member

5.	Sandstone; tannish-white with green bands following cross-bedding; soft; fine-grained with some medium grains, angular grains; smooth cross-bedding; reddish ironstone laminae parallel cross-bedding; fossiliferous with phosphatic brachiopods; this unit and underlying units form a recession under overlying Welge sandstone unit.	1.25
6.	Mudstone; mottled purplish-grey to ochre with shades of green; medium soft; massive; glauconitic; slightly fossiliferous with phosphatic brachiopods; small patches of limonite; limited amount of sub-rounded, coated, frosted, medium to coarse quartz grains; very similar to unit 1.	0.67
7.	Glauconite; green; very sandy; fine to coarse, sub-rounded quartz grains; grains often frosted; fossiliferous with phosphatic brachiopods; non-calcareous; base marked by reddish, hard ironstone stringer 0.1 inch thick.	0.67

	Thickness in feet
8. Mudstone; very similar to unit 3, differing only in the abundance of well distributed round to sub-rounded, coated, frosted, medium to coarse quartz grains. . . .	0.5
Total measured thickness of Lion Mountain sandstone member.	3.09
Total thickness measured.	25.29



Cap Mountain bedding along Llano River bank

Section of the Cap Mountain member of the Riley formation located approximately 100 yards east of "Old Soldiers Crossing" where the James River Road crosses the Llano River and extending two miles downstream along the north bank. Section beginning at the top of the first ledge encountered east of the mouth of a small gulley; bed is covered on outer surface with well cemented recent stream gravels.

Thickness in feet

Riley formation:

Cap Mountain limestone member:

1. Alternating tan limestone and yellowish tan siltstone with interfingered red calcareous sandstone; overall mottled brown-tan with varying degrees of black discoloration and scattered fingers of reddish, calcareous sandstone; the limestones are brown to tan, fresh break is yellowish-grey and brown to mottled grey; hard massive beds; crystalline to coarse-grained; slightly arenaceous; contains calcite pockets and small crystals of calcite; scattered fossil fragments; limonite content varies in abundance; the siltstones are tan, soft; massive to laminated; sandy with fine to medium grains; and weather to recessions on cliff face; silts grade laterally into both sandstones

	Thickness in feet
and limestones. The sandstones are dull red-brown; medium hard; laminated; cross-bedded; medium-grained; contain small hematite globules; sparsely fossiliferous.	31.0
2. Alternating calcareous sandstone and non-calcareous siltstone or mudstone; uniform bedding; 10 feet of middle portion is predominantly siltstone consisting of 1.5-foot beds alternating with 0.5-foot beds of calcareous red sandstone; siltstones are massive; showing little lamination. Red calcareous beds are coarse grained and often fossiliferous; near top of unit wave marks are found and silts become reddish; unit includes scattered intraformational conglomerate and cross-bedding.	70.5
3. Alternating calcareous silts, calcareous sands, and mudstones; overall red-brown on weathered surface; well bedded (2 inches to 1.0 feet) with differential weathering giving concave, ledged cliff face; calcareous sands are fine to medium-grained with scattered coarse pockets and calcite occurences; most beds are	

	Thickness in feet
laminated and infrequently cross-bedded and contain hematite and yellow limonite; silts and mudstones are dirty-brown in color and soft, forming recessions in cliff; one contains distinctive lone stringer of light, red-brown, highly hematitic sand; basal bed is calcareous and highly fossiliferous, containing phosphatic brachiopods; beds range from almost friable to medium-hard; bedding planes often irregular with mud ball effect, often showing good ripple marks; near top silt decreases and calcareous sands become harder.	27.2
4. Interbedded dark-red calcareous sands and light tan to maroon con-calcareous siltstone; bedding from 6 inches to 2 feet thick; sand grains are coated with hematite and streaks of limonite occur throughout sands and silts; sandstones stand out as ledges on cliff face due to differential weathering; noticeable honeycombed weathering on ledge faces; scattered occurrences of phosphatic brachiopods.	6.7
Total Thickness Measured.	135.3

Thickness
in feet

Fault with undetermined throw resulting in repetiton of some of the section

5. Limestone; yellowish-tan to brownish-grey, fresh break medium to brownish-grey; crystalline to impure fine grained with pockets of well cemented silt; very hard; bedding from 7 inches to 1.5 feet; sparsely fossiliferous; scattered glauconite; weathers to honeycombed surfaces; silts are limonitic. 19.7

6. Limestone; dark brown, fresh break mottled grey and light brown; very hard; arenaceous; bedding thick to massive, zones up to 8 feet thick; abundant fragments of phosphatic brachiopods; some cross-bedding within arenaceous layers; patches of silt and highly calcitic silt zones; limestones grade laterally into impure limestones and silts; silts are yellowish-tan with limonitic streaks; portions of unit weathers to honeycombed surfaces. 38.7

7. Limestone; weathers to white calcareous surface, fresh break mottled to dark grey; silty and impure with streaks of rusty-tan silt and coarse, reddish-

	Thickness in feet
sand; medium-grained; medium-bedded; non-fossiliferous.	1.5
. . . Covered Slope.	4.0
Limestone, grades upward into calcareous sand; dark red; arenaceous; massive bedding; top has limonite streaks and flakes, grains in lower portion coated with hematite; grey, calcareous secondary deposits on surface.	14.0
8. Alternating arenaceous limestones and siltstones; limestones are dull red-brown and siltstones buff or tan; soft to medium hard; bedding varies from 0.5 to 1.5 feet with some cross-bedding in ledges; silts are thinly bedded; phosphatic brachiopods and fragments; contains iron in the form of coated grains or limonite streaks; calcite occurs in pockets and as scattered crystals, increasing in abundance toward top.	18.2
Total Thickness Measured.	96.1

Section of upper Hickory sandstone and lower Cap Mountain limestone across the contact between the members located approximately 1330 feet N44.5°W of Alvin Zesch ranch house in small gulley at base of isolated Cap Mountain hill.

	Thickness in feet
Cap Mountain limestone member:	
1. Sandstone and silt; buff-tan to brownish-grey; medium-bedded with some cross-bedding; fine-grained, silty sandstone alternating with fine-grained, arenaceous, thin-bedded limestones; non-fossiliferous, slightly calcareous; contains scattered limonite.	13.7
2. Limestone and silts; reddish to purplish-brown with tan-grey member at base; medium-bedded; well-bedded alternating silts and limestones; fine-grained; arenaceous with rounded grains; ferruginous; limestones are often non-glauconitic, but silts contain glauconite in varying amounts; limestones are hard, but silts are relatively soft; silts weather easily leaving limestones rather prominently exposed.	36.5
3. Calcareous sandstone; maroon-tan, fresh break more maroon to reddish-brown; medium soft at base, hard	

	Thickness in feet
at top; grains rounded and covered with iron film; bedding not too easily observed but fairly even, medium to thin, less than 1 foot; sparsely fossiliferous with phosphatic brachiopods; contains scattered yellowish flakes of limonite; interbedded with, and grading into, calcareous sandstone are fine, tan, soft, silty, often non-calcareous sands; glauconite distributed throughout. This unit usually forms a fairly gentle slope just below the cuesta of overlying unit.	27.8
Total measured thickness of Cap Mountain limestone member.	78.0

Hickory sandstone member:

4. Sandstone; reddish-black to reddish-brown, fresh break is brown to reddish-brown; soft; medium-grained; well rounded quartz grains with iron coating; fossiliferous with phosphatic brachiopods; upper beds are coarse, softer and often calcareous with the grains more sub-rounded; weathers to rounded smooth surfaces, often with a thin coat of high iron content

Hill formed from Hickory sandstone

	Thickness in feet
material that is black with a slight vitreous luster; yields sandy soils that are reddish-brown and loose; top beds of Hickory often show ripple marks; seldom outcrops because of softness, usually forms gentle slope.	39.0
5. Sandstone; reddish-brown to reddish-black, light tan and yellowish-tan to mostly rusty and reddish-browns; medium to coarse, sub-rounded, frosted grains, medium hard; color banding; slightly laminated; fossiliferous with phosphatic brachiopods usually occurring in bands; thin, irregular, hard, well cemented ironstone stringers prominently cut obliquely across laminations; bedding medium to thin; cementation varies; ironstone stringers often weather out to form small, thin, irregular ridges.	8.0+
Total measured thickness of Hickory sandstone member	47.0
Total measured thickness of section.	125.0

The following section constitutes one of the better continuous exposures of middle-lower Hickory in the South Mason-Llano River area and adjacent areas. The section was measured and described by T. P. Polk and W. L. Alexander. Alexander's (1952) lithologic description is included here as a supplement to the other Hickory sandstone sections.

Section of Hickory sandstone measured up isolated hill on Walter Schmidt ranch beginning in draw near tank between ranch house and James River Road, 1.1 miles from junction of James River Road with county road, and 3.2 miles from junction of county road with U. S. Highway 87 opposite Mason County Fairgrounds, southeast of Mason.

Thickness in feet

Riley formation:

Hickory sandstone member:

1. Sandstone and sandstone-conglomerate; conglomerate is brown, weathering to grayish-brown; no distinct beds, slope covered by large slabs and smaller fragments; medium to coarse-grained matrix containing tan, medium-grained, flat pebbles with maximum dimension of 3 inches and coated with iron oxide 1/50-2/50-inch thick; hard, pebbles stand out in relief on weathered surfaces; less conglomerate near top of

	Thickness in feet
unit, slope covered by sandstone slabs and fragments, brown to grayish-brown, having slight greenish tinge; contains black bands of iron oxide, hard, coarse-grained to almost quartzitic; a few scattered fragments of yellowish-brown sandstone on upper portion of slope and top of hill; coarse-grained; fossiliferous, containing white brachiopod shells; yellowish-brown, coarse-grained sandstone ledges in narrow zone near top of hill, parallel ridges on surface resembling ripple marks, 8.5 inches to 1 foot from crest to crest, have smooth coating of reddish-brown iron oxide about 1/4-inch thick; some of the sandstone out in relief on weathered surface.	50.2
2. Sandstone, tan to yellowish-brown, weathering to grayish-brown; thin to thick-bedded, bedding not distinct, slope covered with fragments and slabs, some cross-bedding; fine to coarse-grained, grains rounded and coarser ones concentrated in stringers, similar to basal Hickory; friable to medium-hard, non-fossiliferous.	53.3

		Thickness in feet
3.	Sandstone, tan weathering to gray; glitters on weathered surface or fresh exposure due to presence of many small flakes of white mica; medium-bedded; fine to medium-grained, medium-hard, non-fossiliferous; interbedded with thin silty layers.	13.4
4.	Sandstone, light tan to yellowish-brown weathering to greyish-brown; thin to thick-bedded, few ledges in place, large layers somewhat cross-bedded; fine to coarse-grained, grains rounded clear quartz; soft to friable, non-fossiliferous; interbedded with silty layers, 1/4 - 3/4 - inch thick, easily weathered.	91.9
5.	Sandstone, gray, grass covered slope with sparse vegetation.	91.8
	Total thickness measured.	267.6

Figure 1
Hickory shale overlain by recent stream gravels

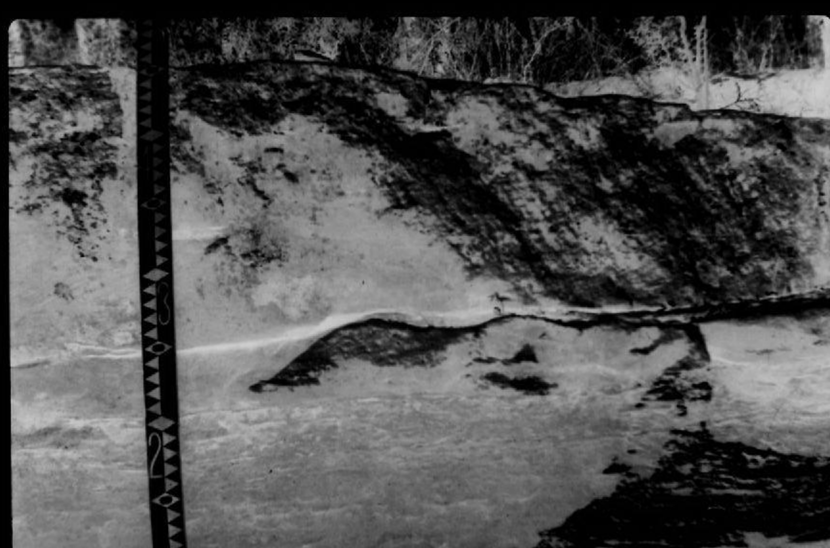


Figure 2
Hickory shale beds and cross-bedded sandstone

Section of the lower middle Hickory sandstone exposed in creek bed approximately 2.4 miles south on James River road from its junction with Farm Road 1723. Section begins in creek bed 170 feet upstream from road crossing and extends approximately 820 feet downstream to small artesian well.

	Thickness in feet
Riley formation:	
Hickory sandstone member:	
1. Sandstone; buff-tan to grey, white to dark tan on fresh break; mostly fine-grained matrix with banded and random occurring coarse and medium grains which are rounded and highly frosted; some laminations; contains irregular, red-brown stringers; unit has thin, uneven bedding as a whole; limonitic, hard nodules around 3 inches in diameter scattered on surface; almost friable; coarse-grained bands are poorly cemented, these coarse grains stand out because of their peculiar random occurrence in fine-grained matrix; a few thin, interbedded, soft, grey shales occur through the unit.	51.3
2. Sandstone; light grey, whitish-grey to buff or yellowish-	

	Thickness in feet
tans on fresh surface; highly cross-bedded; composed of medium to coarse, sub-rounded, frosted, poorly cemented, quartz grains; friable; often stained with limonite; laminated; some ripple marks; scattered elongate ironstone concretionary structures on surface; unit probably represents ancient beach sands; clean sand for most part; probably excellent aquifer.	19.6
3. Silty shale; rusty-tan and whitish-greys to dull maroon; fine to very fine-grained; laminated thin beds (1/16 to 1 inch); interfingered fine-grained, brown to tan sandstone with maroon to whitish, silty shales; medium-soft; sands medium-grained with sub-rounded grains; bedding planes often have small ripple marks; sparsely fossiliferous.	15.9
4. Sandstone; yellowish-tan to white; soft; cross-bedded; medium to fine-grained with bands of coarse grains; coarse grains may occur at random; grains sub-rounded; thin to medium-bedded; limonite stained; joint fillings composed of sand cemented by calcite;	

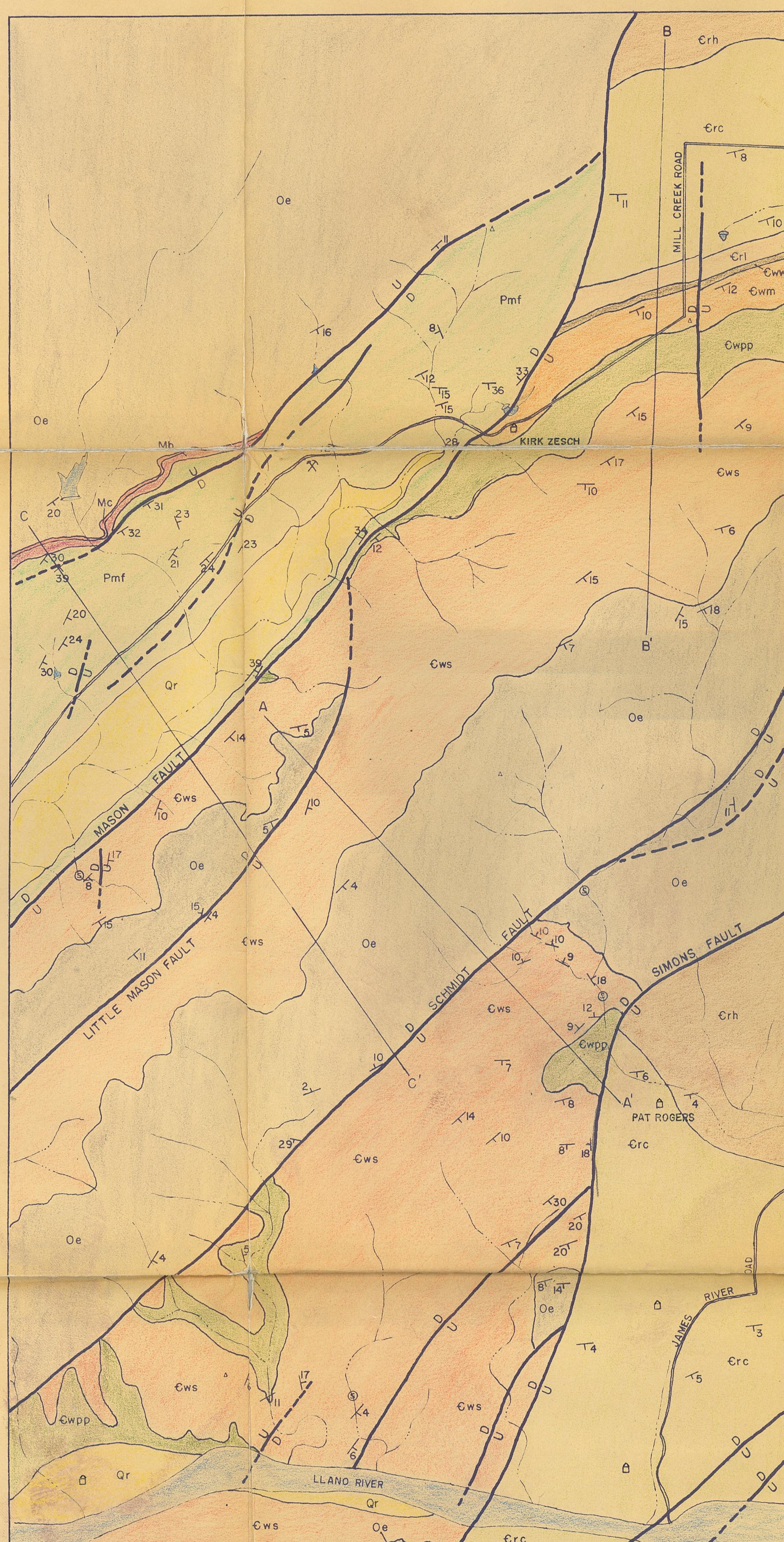
	Thickness in feet
irregular, very thin stringers or bands of red-brown, ferruginous material often cutting across laminations; small ironstone concretions form red-brown coated depressions 2 inches in diameter on weathered surface; ripple marks measuring 2.5 inches from crest to crest occur in unit.	3.0+
Total measured thickness.	89.8

Description of basal Hickory sandstone at pre-Cambrian contact located approximately 1000 feet S20° W from junction of James River Road and Farm Road 1723.

Hickory sandstone member:

1. Sandstone; light buff to yellowish-brown varying to tints of orange and weathering to a dark brown; medium-bedded; coarse-grained, grains sub-rounded to rounded; small sub-angular to sub-rounded pebbles averaging about 1/4 inch in diameter stand out in relief on weathered surface; coarser grains in beds often occur in stringers; fine-grained sandstone fracture fillings frequently stand up in relief on bed surfaces; ventifacts varying in size from about 1/2 inch to two inches are found scattered over surface of pre-Cambrian outcrop; underlying pre-Cambrian granite is pinkish to chalky white and granular textured.

PLATE I



GEOLOGIC COLUMN

QUATERNARY		Qr	Recent Alluvium
PENNSYLVANIAN	Lower Pennsylvanian, Bend Series, Marble Falls Group, Smithwick Formation	Ps	(not exposed in area) Smithwick shale
	Lower Pennsylvanian, Bend Series, Marble Falls Group, Big Saline Formation	Pmf	Limestone members
MISSISSIPPIAN	Lower Mississippian	Mb	Barnett shale
	Lower Mississippian	Mc	Chappel limestone
	UNCONFORMITY		
ORDOVICIAN	Lower Ordovician, Ellenburger Group	Oe	Ellenburger limestone
CAMBRIAN	Upper Cambrian, Wilberns Formation	€ws	San Saba limestone member
		€wpp	Point Peak shale member
		€wm	Morgan Creek limestone member
		€ww	Welge sandstone member
	Upper Cambrian, Riley Formation	€rl	Lion Mountain sandstone member
		€rc	Cap Mountain limestone member
		€rh	Hickory sandstone member

LEGEND

- Normal fault; U, upthrown side; D, downthrown side
- Inferred normal fault
- Observed and inferred contacts
- Strike and dip of strata
- Property line fence
- Intermittent stream
- Flowing stream
- C——C' Structure section line
- Spring
- Windmill
- Road metal quarry
- Stock tank
- Cave
- Ranch buildings
- Graded earth road
- Cattle guard

10°
N

SCALE 1:20,000

0 — 1/2 — 1 — 2 MILES

0 850 1700 3400 5100 6800 8500 10200 FEET

GEOLOGIC MAP OF THE SOUTHWEST MASON-LLANO RIVER AREA, MASON COUNTY, TEXAS

Base from U.S. Department Agriculture, Soil

Conservation Service, aerial photographs, 1948.

Geology by Robert P. Parke

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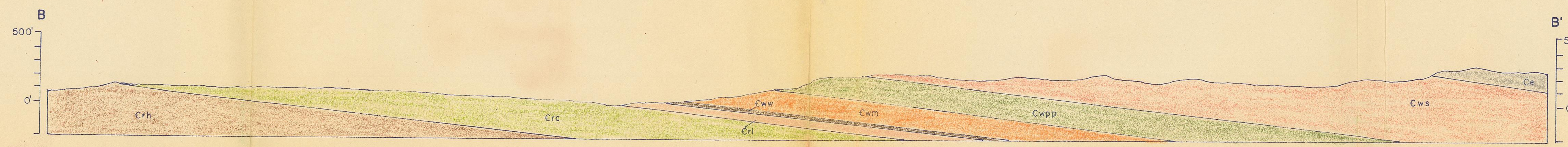
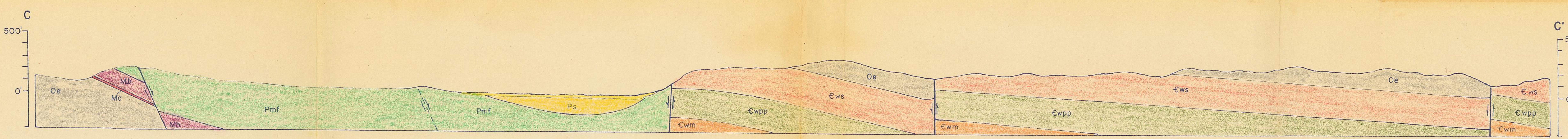
1953 F237 Parke

STRUCTURE SECTIONS

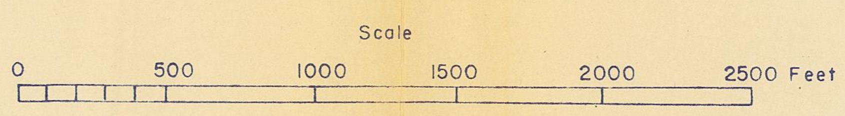
SECTION A - A'



SECTION B - B'



SECTION C - C'



Legend on Plate I