GEOLOGY OF THE HOMER MARTIN RANCH AREA,

MASON COUNTY, TEXAS

A ~~Thesis~~

By

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The writer is indebted to Drs. M. C. Schroeder and K. J. Koenig for assistance in the field. The writer wishes to thank Dr. H. R. Blank for guidance in petrographic studies of the igneous and metamorphic rocks. The suggestions and constructive criticisms of Drs. M. C. Schroeder, H. R. Blank, and P. Dehlinger aided greatly in preparation of the thesis.

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A B S T R A C T

The Homer Martin Ranch area is located nine miles southeast of Mason, Texas on the southwest flank of the Llano uplift. Strata exposed in the area are of Precambrian and Late Cambrian ages.

Precambrian rocks consist of a gneiss unit, a schist unit, and a medium-grained granite. The gneiss unit consists of a fine-grained pink gneiss, a dark gneiss, and an augen gneiss. The schist unit consists of a hornblende schist and a biotite schist. The granite is intrusive into the gneiss unit.

Strata of Late Cambrian age are represented by the Riley and Wilberns formations. The Riley formation consists of three members: the Hickory sandstone member, the Cap Mountain limestone member, and the Lion Mountain sandstone member. The Wilberns formation consists of four members: the Welge sandstone member, the Morgan Creek limestone member, the Point Peak shale member, and the San Saba limestone member.

A broad syncline, plunging gently toward the southeast, is the dominant structural element in the thesis area. Northeast-trending normal faults have broken the syncline in a few places.

During Precambrian time, sedimentary rocks were deeply buried, folded, metamorphosed, and intruded by granite.

The first Paleozoic sediments were deposited on an uneven Precambrian erosion surface by a transgressive sea during Late Cambrian time. A sea regression and another sea transgression also occurred during Late Cambrian time. Younger Paleozoic and Mesozoic rocks which formerly covered the area have been removed by erosion. The folding and faulting probably occurred during regional uplift in Pennsylvanian time.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Homer Martin Ranch area is located approximately nine miles southeast of Mason, Mason County, Texas, on the southwest flank of the Llano uplift. The northwest corner of the thesis area is a right angle bend in the Llano River; the southwest corner is a right angle bend in the east fork of Panther Creek 0.3 of a mile east of the junction of the east and west forks; the northeast corner is the junction of Comanche Creek with the Llano River; and the southeast corner is 1.2 miles northwest of the intersection of Farm Road 648 and Simonville Road along a line drawn from their intersection to the mouth of Comanche Creek. The northern boundary is the Llano River, and the other boundaries are lines connecting the previously mentioned corners (Fig. 1).

The thesis area is readily accessible, except for a few parts. Simonville Road passes through the eastern portion of the area, and several ranch trails branch off from it to various sections of the thesis area.

METHODS OF FIELD AND OFFICE WORK

The field work on this research was done between June 10 and August 9, 1959.

The initial field mapping was done on acetate overlays of U. S. Department of Agriculture aerial photographs with a scale of 1:20,000 or one inch equals approximately 1,667 feet. The essential photographs used were numbers 49, 50, 95, 96, 119 and 120 of series DFZ-1P dated November 28, 1955. Data from the individual photographs were then transferred to an acetate base map of the entire area and finally to the finished map.

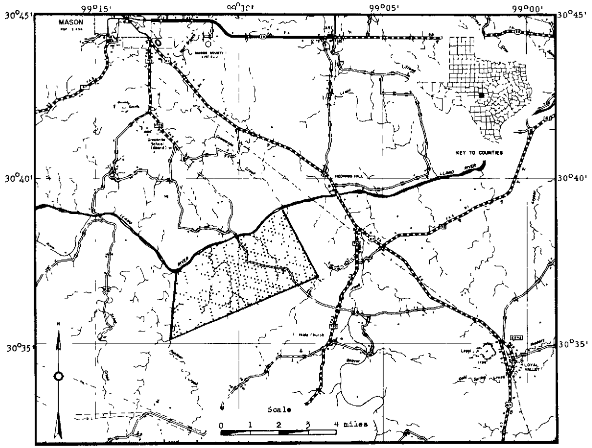


FIGURE 1. LOCATION MAP OF THE HOMER MARTIN RANCH AREA, MASON COUNTY, TEXAS

Adapted from Texas State Highway Department highway map of Mason County, Texas

Faults and formation contacts were traced in the field. As a supplement to field observations, stereoscopic examinations of aerial photographs were used as an aid in locating changes in slope and vegetation changes or lineations that sometimes correspond to formation boundaries or faults.

A Brunton Compass with a pre-set declination of 10 degrees east was used to measure dips and strikes of strata.

The stratigraphic sections (Appendix) were measured with a stadia rod and Brunton Compass. Additional sections were not measured because of poor exposures or faulting.

Horizontal distances used in preparation of structure sections were measured directly from aerial photographs. Elevations for the sections were estimated from stereoscopic examinations of aerial photographs. A few elevations were obtained with an aneroid barometer by Neil Fisher.

REVIEW OF THE LITERATURE

The first recorded geologic observations on the Llano region were made by Ferdinand Roemer (1846 and 1848). He briefly described granite, other crystalline rocks, and strata of Paleozoic and Mesozoic age.

B. F. Shumard (1861) correlated sedimentary strata in Burnet County with the Potsdam sandstone of Late Cambrian age. Shumard also described new species of fossils collected in the Llano region.

G. G. Shumard (1886) briefly described metamorphic and sedimentary rocks occurring between the San Saba River and Fort Mason.

After a brief reconnaissance of the Llano region, Walcott (1884) applied the name Llano group to the metamorphic rocks and correlated them with the Grand Canyon group and referred them to the Lower Cambrian Series. He agreed with B. F. Shumard's correlation of the Upper Cambrian strata with the Potsdam group and assigned a pre-Potsdam age to the granites that intrude the Llano group. Walcott also mentioned strata of Silurian and Carboniferous age.

Hill (1887) reviewed the earlier geologic investigations of the Llano region and other parts of Texas. Later, on the basis of faunal content, Hill (1889) assigned a Carboniferous age to strata exposed near Marble Falls. These strata had previously been designated as Devonian in age.

In 1889, the results of Comstock's field work were published. In his report, Comstock introduced the terms Valley Spring series and Packsaddle series as subdivisions of his Precambrian Systems. He also used the Hickory series, Riley series, Katemcy series, and San Saba series as stratigraphic names. The first three of these series were placed in the Lower, Middle, and Upper Cambrian Series respectively. The San Saba series was assigned to the Upper Silurian Series. The Ordovician System was not mentioned and apparently was not recognized in the United States at that time; hence it is possible that parts of the Silurian System may be equivalent to parts of the present Ordovician System. The name, Katemcy series, has been abandoned, and the definition of the remaining terms have been revised.

Tarr (1890) discussed the drainage of Central Texas and presented evidence that the drainage originated on Cretaceous rocks in Tertiary time and has since been superimposed on Paleozoic rocks.

After extensive field work in the Llano-Burnet Quadrangles in Llano County in 1911 and 1912, Sidney Paige (1912) redefined the sedimentary and metamorphic rock units previously defined by Comstock and classified the granites. He defined the Llano series as consisting of the Valley Spring gneiss and the Packsaddle schist. Paige dropped Comstock's "Hickory series" in favor of Hickory sandstone and named and defined the Wilberns, Cap Mountain, Ellenburger, and Smithwick formations. A geologic map accompanied the report.

The first geologic map of Texas accompanied a review of the geology of Texas by Udden, Baker, and Bose (1916).

Deen (1931) discussed the algal limestone masses that occur in the shale in the upper part of the Wilberns formation in Mason County, Texas, and noted their topographic expression. These limestone masses are prominent ridge formers in the Homer Martin Ranch area.

Dake, Bridge, and Ulrich (1932) presented the results of their study of Upper Cambrian strata and the Ellenburger limestone. Faunal zones within the Ellenburger limestone were correlated with similar zones in Ordovician strata in other states.

Stenzel (1932) redefined the Packsaddle schist and the Valley Spring gneiss and proposed a subdivision of the granites on a structural and lithologic basis.

Sellards, Adkins, and Plummer (1932) reviewed the Precambrian, Cambrian, Ordovician, Mississippian, and Pennsylvanian Systems of the Llano region. A brief discussion of geologic history and regional structure was also presented. In a later report on the structural and economic geology of Texas, Sellards and Baker (1934) dated the time of initial uplift in the region as Mississippian.

In a discussion of Precambrian structural conditions, Stenzel (1934) stated that the Precambrian rocks could be subdivided into three series on a structural basis and that,

"Each series has its own characteristic features ranging from the large scale tectonics down to the minute scale petrographic features."

In a later report, Stenzel (1935) discussed Precambrian unconformities in the Llano region. He reported that there appear to be no stratigraphic breaks in the metamorphic rocks of sedimentary origin, but that if structural and intrusive discordant features are regarded as unconformities, there are several large time breaks in the region.

Bridge and Girty (1936) redescribed some of the Paleozoic fossils from the Llano region which were originally described by Roemer in 1849 and 1852. The localities and stratigraphic horizons from which Roemer collected the fossils were also determined.

Bridge (1937) correlated the Upper Cambrian strata of the Llano region with the Upper Cambrian section in the upper Mississippi Valley. He stated that the Upper Cambrian section of Central Texas is nearly as complete as the upper Mississippi Valley section. He also named the Lion Mountain sandstone member, which was included in the Cap Mountain formation. The Cap Mountain formation was subsequently redefined as a member of the Riley formation.

Lockman (1938) reported three faunal zones in the lower part of the Upper Cambrian System and discussed the relation of the faunal sequence to the stratigraphic units in the Llano region.

Barnes and Parkinson (1939) presented a discussion of the nature and origin of the ventifacts that occur in the basal Hickory sandstone.

Keppel (1940) described the texture, composition, and structure of large granite bodies in the Llano region. To explain the three textural varieties of granite which occur in a concentric arrangement, he proposed an origin of forcible injection into the country rocks.

Cheney (1940) proposed a classification of Pennsylvanian and lower Permian strata of north-central Texas and suggested that the Llano uplift may be a denuded part of the Concho arch.

Bridge and Barnes (1941) divided the Wilberns formation into four members. The members were not named in an abstract of the unpublished manuscript, but were presented orally at a meeting of the Geological Society of America. The present names of the members of the Wilberns formation were published in 1944 in an article by Barnes.

Goldich (1941) presented the results of his study of several granite masses and offered a mechanism to explain their origin.

In 1942, Barnes, Dawson, and Parkinson made a report on building stones in Central Texas. A brief review of the geology and a comprehensive description of rocks at various localities that are suitable for use as building stones were included in the report.

In a report on water resources in Texas, Plummer (1943a) discussed the Hickory sandstone and Ellenburger limestone water reservoirs in the Llano region.

Barnes, Cloud, and Warren (1945) defined rocks of Devonian age in the Llano uplift. Measured sections and faunal lists of the newly defined units were included in the report.

Because of economic interests and the need for a detailed stratigraphic study of the Ellenburger limestone, Cloud, Barnes, and

Bridge (1945) prepared a progress report on their study of the Ellenburger limestone. The strata previously known as the Ellenburger limestone were redefined as the Ellenburger group. The group was divided into three formations: the Tanyard, Gorman, and Honeycut formations. The group was designated as being Early Ordovician in age. In addition, the pre-Wilberns strata (Upper Cambrian) were defined as the Riley formation and divided into three members, namely, from oldest to youngest, the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone.

Bridge, Barnes, and Cloud (1947) described and redefined the two formations and eight members that constitute the Upper Cambrian System in the Llano region.

J. L. Wilson (1949) described the trilobite fauna of the Elvina zone in the basal Wilberns formation.

In a study of weathering of granite domes in the Llano region, Blank (1951a) concluded that exfoliation and granular disintegration are important processes in the development of erosion surfaces on granite masses in Central Texas. During the same year, Blank (1951b) discussed the occurrence of "rock doughnuts", a weathering phenomena observed on weathered surfaces of granite. Their possible origin was also discussed.

Cheney and Goss (1952) discussed the evolution of the Llano uplift.

Barnes, Cloud, and Duncan (1953) reported the discovery of Upper Ordovician rocks in a collapse structure in southern Burnet County. The strata was named the Burnam limestone, but no thickness was given.

In a special report on lead deposits in Upper Cambrian rocks, Barnes (1956) reviewed the geology of the Llano region and reported igneous activity of Carboniferous or later age. The igneous rocks consist of diabase dikes intruded along the Marble Falls fault.

G. J. Wilson (1957) made a detailed geologic study of an area that joins the Homer Martin Ranch area on the north. Bryant (1959) did a similar study of the Schep-Panther Creek area that joins the Homer Martin Ranch area on the west.

After a study of the Hickory sandstone, Goolsby (1957) stated that the Hickory sandstone member of the Riley formation can be subdivided into three mappable units. As a result, he proposed that the member be given formational status.

GEOGRAPHY

CLIMATE

The climate of the Llano region is semi-arid. The average annual precipitation is about 25 inches and is unevenly distributed throughout the year. Rainfall is often torrential and of short duration, resulting in a high percentage of run-off.

The temperature ranges from about -5 degrees F. in winter to slightly above 100 degrees F. in summer. A large variation in temperature is common both in summer and in winter.

VEGETATION

The vegetation in the area is limited to those forms that can endure a semi-arid climate and a thin soil cover.

The sandy soils derived from Precambrian rocks generally support mesquite and varieties of oak, cacti, and scattered grasses. Beebrush and oak are the dominant plants found growing on soils developed from the Hickory sandstone. Catsclaw, mesquite, Spanish dagger, prickly pear, and Mexican persimmon are common on soils derived from Paleozoic limestones. Large pecan and willow trees are present along the Llano River and the lower part of Bast Creek.

INDUSTRY

Within the Homer Martin Ranch area, most of the income is derived from cattle and goat ranching. At the present time, farming is virtually non-existent, but has been done on a small scale in past years.

Hunting leases also furnish a small portion of income within the area.

P H Y S I O G R A P H Y

GEOMORPHOLOGY

The Llano uplift is a structural dome which has been eroded to form a topographic basin, and is one of the major physiographic features of Texas. It is bordered on the northwest, southwest, and southeast by the Edwards Plateau and on the northeast by the Osage Plains. Much of the basin floor consists of Precambrian igneous and metamorphic rocks. Paleozoic and Mesozoic strata are preserved on the flanks of the uplift or on down-dropped fault blocks.

According to Plummer (1943b, p.8), the highest elevation in the Llano region is in excess of 2,200 feet, and the lowest is about 650 feet. Hence, the maximum relief is approximately 1,600 feet.

In the Homer Martin Ranch area, the highest elevations, about 1,775 feet, are on the limestone-capped hills in the south-central and southwestern parts of the area, and the lowest elevation, about 1,450 feet, is along the Llano River. Therefore, the maximum relief in this area is about 325 feet.

The Homer Martin Ranch area can be divided into six geomorphic types; (1) the high cliffs along the Llano River, (2) the cuestas in the northwest and central parts of the area, (3) the relatively flat low-lands of the north-central portion, (4) the relatively low, often rugged, rocky hills in the northeast and east portion, (5) a graben that forms a relatively narrow northeast-trending hill in the southeastern portion, and (6) the high hills in the southwest and central portions that are capped by Point Peak bioherms or San Saba limestone.

The first geomorphic unit is the relatively high, steep cliffs along the Llano River in the northwest part of the area. The cliffs are composed of Hickory sandstone and capped by Cap Mountain limestone. The maximum height of the cliffs is about 75 feet.

Above the cliffs, the surface rises gradually in elevation toward the south in a stair-step arrangement of north or northwest facing cuestas formed by the Cap Mountain limestone.

The flat lowlands of the north-central portion of the area consist of an alluvial flat, a river terrace, and deeply weathered Hickory sandstone. The eastern part of this unit has been under cultivation in the past.

The fourth unit, located in the eastern portion of the thesis area, consists of relatively low, linear, northwest-trending hills of gneiss that are occasionally capped by basal Hickory sandstone. Where bedrock does not crop out, the surface is often littered with quartz and feldspar fragments.

An obsequent fault scarp separates the fourth unit from the fifth unit which is a down-faulted block of Cap Mountain limestone in contact with Precambrian gneiss. This graben forms a rather narrow, flat-topped, northeast-trending hill.

In the southwest and central portions of the area, Paleozoic limestones cap the high hills that form a relatively flat, partially dissected plateau that extends southward beyond the limits of the thesis area. As Cretaceous strata formerly covered much of the Llano uplift, it is possible that this plateau may be a remnant pre-Cretaceous erosion surface.

The river terrace in the north-central portion of the thesis area indicates that the Llano River has been rejuvenated by uplift, possibly during Late Tertiary or Quaternary time. The lowering of the major stream has caused tributaries, such as Bast Creek, to incise their meandering channels.

Though not supported conclusively by field observations, a stereoscopic examination of aerial photographs suggests that at one time the east fork of Bast Creek continued northward to the Llano River rather than making its present right angle turn to where it joins the west fork in the north-central part of the thesis area. Its present course may be the result of stream piracy by the west fork of Bast Creek.

DRAINAGE

The Homer Martin Ranch area is drained by the Llano River and its tributaries. The western portion of the thesis area is drained by tributaries of Panther Creek; the central portion by Bast Creek; and the eastern portion by minor tributaries of the Llano River and Beaver Creek. The streams in the area are intermittent and form a dendritic pattern.

The principal tributary of the Llano River within the thesis area, Bast Creek, heads in the high hills in the southwest and south-central portion of the area. The stream flows over Upper Cambrian rocks northward to the Llano River.

STRATIGRAPHY

GENERAL STATEMENT

Rocks exposed in the Homer Martin Ranch area are of Precambrian and Late Cambrian ages. Alluvium and stream conglomerate of Quaternary age are also exposed.

The stratigraphic column for the Homer Martin Ranch area is as follows:

Quaternary System

- Alluvium and stream conglomerate

Cambrian System

- Wilberns formation
  - San Saba limestone member
  - Point Peak shale member
  - Morgan Creek limestone member
  - Welge sandstone member
- Riley formation
  - Lion Mountain sandstone member
  - Cap Mountain limestone member
  - Hickory sandstone member

Precambrian Rocks

- Igneous rocks
  - Medium-grained granite
- Metamorphic rocks
  - Gneiss unit and schist unit

PRECAMBRIAN ROCKS

Both igneous and metamorphic Precambrian rocks crop out in the Homer Martin Ranch area. These outcrops consist of granite, gneiss, and schist.

Paige (1912, p. 25) regarded the Precambrian rocks of the Llano uplift as Algonkian (Proterozoic) in age. Sellards, Adkins, and Plummer

(1932, p. 31) stated that the metamorphic rocks are considered Precambrian rather than Cambrian because of the angular unconformity and the long time interval between the deposition of these rocks and the deposition of the overlying Upper Cambrian rocks. The rocks were presumed to be Proterozoic because of their degree of metamorphism. Flawn (1956, p. 27) tabulated several radioactive age determinations of rocks in the Llano region and concluded that the batholithic granites have an age of 1,000 million years and are younger than the metasedimentary rocks they intrude.

Metamorphic Rocks

Walcott (1884, p. 431) applied the name Llano group to metamorphic rocks in the Llano region. Comstock (1889) named the Valley Spring gneiss and Packsaddle schist as subdivisions of his Precambrian Systems. In 1912, Paige redefined these two units and presented his interpretation of their origin. He stated that both were metamorphosed sedimentary rocks and that the Valley Spring gneiss was the older of the two. He further stated that the Valley Spring gneiss probably contains material of igneous origin.

Sellards (1932, p. 32) defined the Valley Spring gneiss as a light colored gneiss consisting of feldspathic minerals and quartz, and stated that the gneiss contains schist and grades into schist in such a manner that separation of the two formations is often difficult or impossible. He further stated that the separation of the Valley Spring gneiss from the overlying Packsaddle schist is based on the more massive character of the gneiss and upon its greater content of felsic materials.

As defined by Sellards (1932, p. 33) the Packsaddle schist includes an unmeasured thickness of metamorphosed shales, sandstones and limestones which have been intruded by acidic and basic igneous rocks.

As redefined by Stenzel (1932, p. 143-144), the Valley Spring gneiss is an orthogneiss with concordant contacts intrusive in the Packsaddle schist. According to this interpretation, the Packsaddle schist is the older of the two and is the only metamorphic unit of sedimentary origin in the Llano region.

A gneiss unit and a schist unit crop out in the thesis area. They were not mapped separately because of the limited exposures of the schist unit.

Gneiss Unit

Occurrence and relationships

The gneiss unit crops out in the northeastern part of the area, the best exposures being along the Llano River. The southern boundary of the gneiss outcrop is a fault that brings the gneiss in contact with Upper Cambrian strata. The gneiss also crops out in the southeastern portion of the area. Here the gneiss is deeply weathered, and a large portion of the area underlain by it is under cultivation. Basal Hickory sandstone unconformably overlies the unit at the western edge of its exposure. Although the contact of the Hickory sandstone with the gneiss is obscured by a soil cover in most localities, it can be traced with a fair degree of accuracy.

Three types of gneiss are present in the thesis area: a fine-grained, pink gneiss, a dark gneiss, and an augen gneiss. The dark gneiss and the augen gneiss are concordantly interbanded within the pink gneiss.

PLATE II

Exposure of Precambrian Gneiss

Located on the south bank of the Llano River 0.8 of a mile downstream from the Simonville Road crossing.

The contact of the gneiss with the granite contact is not exposed in the thesis area. However, the strike of the foliation in the gneiss is indicative of a discordant contact between the gneiss and granite. The granite is therefore intrusive into the gneiss and is the younger of the two.

The texture and the mineralogical composition of the pink gneiss are very similar to parts of the Valley Spring gneiss.

On the north bank of the Llano River, G. J. Wilson (1957, p. 28) has described a transition zone between a gneiss unit and granite which are part of the same gneiss and granite exposed in the Homer Martin Ranch area. Wilson applied the term migmatite to the rocks in the transition zone. The present writer could fine no evidence of a transition from gneiss to granite on the south side of the river in the Homer Martin Ranch area. Instead, the fact that the texture and mineral composition of the pink gneiss within 50 feet of the granite appears to be the same as in exposures of the gneiss 0.5 of a mile from the granite suggests that the contact is probably sharp. Therefore, there appears to be differences in the nature of the contact at different places.

Fine-grained pink gneiss

Megascopic description and relationships. The gneiss is massive and the foliation is not well developed. It is usually pink on a fresh surface and weathers to a rusty brown. Minerals identified in hand specimens are pink feldspar, quartz, and biotite. The rock is equigranular, and the average grain size is generally less than 1 mm.

With the exception of exposures along the Llano River, the gneiss is deeply weathered, outcrops being limited to isolated boulders or small knobs on hilltops and to small exposures in gullies.

Microscopic description. A thin section cut perpendicular to the plane of foliation was prepared from a specimen collected on the bank of the Llano River, 0.6 of a mile downstream from the Simonville Road crossing.

The gneiss consists mainly of microcline, quartz, plagioclase (oligoclase), orthoclase, and biotite. Chlorite, muscovite, magnetite, zircon, and apatite are present in lesser amounts.

The predominant feldspar is microcline, followed by plagioclase and orthoclase. The anhedral microcline grains range from 0.45 mm. to 0.90 mm. in diameter. The mineral was easily identified by the "quadrille" pattern formed by albite and pericline twinning.

Anhedral quartz is the second most abundant mineral present. The quartz grains averaged 0.30 mm. in diameter, but much smaller grains occurred as inclusions in feldspar. A positive uniaxial interference figure, a low interference color, and an index of refraction greater than balsam served to identify quartz.

The anhedral to subhedral plagioclase grains were identified as calcic oligoclase by a maximum extinction angle of 12 degrees on an albite twin and an index of refraction greater than balsam. The grain size of the oligoclase varied considerably, the long dimension being 0.075 mm. to 1 mm.

Minor amounts of orthoclase are present in anhedral grains averaging 0.75 mm. in length. A low first order interference color, carlsbad twinning, and an index of refraction below balsam were the main properties used to identify it.

Anhedral grains of brownish- to pale-green biotite showing good cleavage in one direction were relatively abundant. Absorption was greatest parallel to the cleavage, and extinction was parallel to the cleavage.

The close association of chlorite and biotite suggests that the chlorite may be an alteration product of biotite.

The only opaque mineral present was magnetite. The black magnetite grains show little or no alteration and have an average diameter of 0.13 mm.

Scattered grains showing interference colors as great as the second order, parallel extinction, a change in relief when rotated, and having the slower ray parallel to the cleavage were identified as muscovite.

Several small subhedral grains of apatite and zircon were found as inclusions, usually in quartz.

It is estimated that the gneiss is composed of 40 percent feldspar, 35 percent quartz, 15 percent biotite, 4 percent chlorite, 2 percent muscovite, 2 percent magnetite, 1 percent zircon, and 1 percent apatite.

Dark gneiss

Megascopic description and relationships. Scattered exposures of the dark gneiss occur along the Llano River near the contact of the gneiss with the granite. This gneiss occurs in bands up to three feet thick within the pink gneiss.

On a fresh surface, the rock is black with light colored specks. The dark colored minerals weather more easily than the lighter colored minerals so that a weathered surface is grey of various shades.

The foliation is so highly developed that the rock is slightly schistose in places.

The only minerals identifiable in hand specimens are biotite, grey feldspar, and quartz.

Microscopic description. A thin section cut perpendicular to the foliation planes was prepared from a specimen collected on the south bank of the Llano River, 0.6 of a mile downstream from the Simonville Road crossing.

The most abundant minerals found in thin section are plagioclase (andesine), biotite, quartz, and hornblende. Lesser amounts of chlorite, apatite, magnetite, zircon, and microcline are also present.

The plagioclase was identified as andesine because a maximum extinction angle of 17 degrees was measured on an albite twin and an index of refraction greater than balsam was observed. Many of the grains exhibited undulatory extinction as a result of having been bent. The grain size averaged 0.65 mm.

Biotite grains showing a marked alignment were abundant. Many of the grains contained inclusions of zircon surrounded by pleochroic halos.

Quartz was not as abundant in thin section as it appeared to be megascopically. Its average grain size was 0.45 mm.

Hornblende, which was pleochroic in dark green, light green, and greenish brown, was fairly common. The characteristic amphibole cleavage and symmetrical extinction shown in basal sections, inclined extinction in longitudinal sections, and pleochroism were the main criteria used to identify this mineral.

Chlorite occurs as an alteration product of hornblende.

Subhedral to euhedral grains of apatite usually occur as inclusions in quartz. The average grain size was 0.2 mm.; however, longitudinal sections were measured up to 1.5 mm. in length.

Subhedral grains of magnetite are the only opaque grains present.

The estimated mineral composition is 37 percent andesine, 28 percent biotite, 13 percent quartz, 10 percent hornblende, 5 percent chlorite, 3 percent apatite, 3 percent magnetite, 1 percent zircon, and less than 1 percent microcline.

<u>Augen gneiss</u>

<u>Megascopic description and relationships</u>. Outcrops of the augen gneiss occur within the pink gneiss. Because of its susceptibility to weathering, this gneiss can be traced only short distances laterally from the bed of the Llano River, where semi-fresh exposures have been maintained by running water.

The contact between the pink gneiss and the augen gneiss appears to be concordant and sharp.

Megascopically, the augen appear to be pink feldspar; however, color variations in some of them suggest that they may be composed of more than one mineral. The long dimension of the augen is as great as 5 mm.

Quartz and biotite appear to be present in equal amounts.

On fresh surfaces, the gneiss is black with pink spots. The biotite weathers more readily than the augen so that the rock is grey to light-pink on weathered surfaces.

Microscopic description. A thin section cut perpendicular to the foliation was prepared from a specimen collected 0.6 of a mile downstream from the Simonville Road crossing.

The chief minerals found in thin section are plagioclase, biotite, microcline, and quartz, along with lesser amounts of orthoclase (?), chlorite, apatite, zircon, magnetite, pyrite, and hematite.

The very faint albite twinning in the plagioclase grains prevented classification of the feldspar, but it is probably albite or oligoclase.

Elongate grains of biotite showed a marked alignment with the foliation in thin section. Zircon grains surrounded by pleochroic halos were noted in several biotite grains.

As noted previously, the augen appear to be pink feldspar with well defined outlines in hand specimens. In thin section the augen appear to be anhedral microcline grains up to 3 mm. in diameter surrounded by much smaller grains of microcline, myrmekitic intergrowths of quartz and orthoclase (?), and quartz. The exact composition of the augen cannot be determined because of their poorly defined outlines. Twinning in the large microcline grains is very irregular; whereas twinning in the small grains forms the characteristic "quadrille" pattern.

Myrmekitic intergrowths of quartz and orthoclase (?) were fairly common. Quartz was also found in anhedral grains averaging 1 mm. in diameter.

Chlorite is present as an alteration product of biotite.

Subhedral to euhedral apatite grains are present usually as inclusions in quartz.

A few grains of pyrite surrounded or partially surrounded by hematite are present. The pyrite is opaque, has a dark brass color, and shows a faint suggestion of crystal form. The hematite apparently formed by alteration of pyrite.

The estimated mineral composition is plagiocalse 30 percent, biotite 22 percent, microcline 20 percent, quartz 12 percent, orthoclase 5 percent, chlorite 4 percent, apatite 2 percent, zircon 2 percent, magnetite 2 percent, and pyrite and hematite 1 percent.

Topography and vegetation

Along the Llano River, the gneiss forms fairly steep cliffs that extend up to 40 feet above the river. This type of topography changes southward from the river to rather low, linear hills or is gently rolling. In the area of low hills, the gneiss has weathered to a light red, sandy soil covered with scattered quartz and feldspar fragments. In the southeast portion of the thesis area, the gneiss forms a flat area that is under cultivation.

Vegetation on hill tops is usually sparse, mesquite being the dominant form. The vegetation on gentle slopes and low-lying areas is more abundant, with mesquite, catsclaw, and shin oak predominating.

Schist Unit

Occurrence and relationships

Exposures of the schist are very limited in areal extent, and for this reason it was not mapped as a separate unit. However, well defined outcrops are indicated on the accompanying geologic map.

The schist is fairly well exposed along the banks of the Llano River and in a creek bed in the extreme southeast portion of the thesis area.

The schist was never observed in contact with granite, but at most exposures it grades into gneiss both along the strike and perpendicular to it. This together with its limited areal extent makes the schist difficult to separate from the gneiss.

Megascopic description

Two schist types are present in the thesis area: a biotite schist and an apparent hornblende schist.

The biotite schist has a poorly developed schistosity and is friable probably as a result of being badly weathered. Biotite and milky quartz are the only minerals identifiable in hand specimens.

The hornblende schist is greenish-black, very tough, and shows a well developed schistosity. This schist is rather fine-grained, thus making identification of the constituent minerals difficult. The principal dark mineral appears to be hornblende. Streaks of lighter colored minerals parallel the dark bands, but could not be identified.

Microscopic description

Thin sections of the schists were not prepared. Fuller (1957) has examined and described schists that are megascopically similar to those in this thesis area. The schists described by Fuller occur about 5.5 miles northeast from the schists in the northeast part of the Homer Martin Ranch area. The following microscopic description of a hornblende schist is taken from Fuller (1957, p. 33).

Two thin sections cut at right angles to the foliation were prepared from samples collected several hundred feet apart. Fuller found that the minerals in both sections were the same, but that the sections differed in grain size and fabric. One thin section had a mosaic fabric with nearly equidimensional grains. Contacts between adjacent grains were sharp and straight, the average grain diameter being 0.15 mm. The other thin section was inequigranular, with the average grain size being about 0.30 mm. The grains in this section were more elongated and aligned in the direction of elongation.

The minerals found in thin section were (in order of decreasing abundance) hornblende, quartz, orthoclase, magnetite, plagioclase (andesine), apatite, zircon, sphene, and albite (?). Hornblende comprised about 50 percent of the schist. The schist was thus classified as a hornblende schist. Fuller did not examine the biotite schist, but it is believed to be somewhat similar except for the presence of biotite and a decreased amount of hornblende.

Topography and vegetation

The type of topography, soil, or vegetation developed on the schist unit was not observed because of the limited extent of exposures.

Igneous Rocks

General Statement

Precambrian rocks of sedimentary origin in the Llano region have been intruded by granite at several localities. The intrusions vary in age but are all designated as Precambrian.

Stenzel (1932, p. 143-144) stated that the granites are intrusive into gneiss and schists and proposed a subdivision and age relationship on a structural and lithologic basis. His subdivision is as follows (oldest at the bottom):

1. Quartz-porphyry and felsite
2. Sixmile fine-grained granites
3. Oatman Creek grey, medium-grained granites
4. Town Mountain coarse-grained granites

The only igneous rock cropping out in the Homer Martin Ranch area is a medium-grained granite. The texture and mineral composition are similar to that of Town Mountain granites.

Medium-Grained Granite

Occurrence and relationships

The medium-grained granite is exposed at one locality in the bed of the Llano River in the northeastern part of the thesis area. The granite crops out as a steep-sided mass about ten feet high and as low rounded knobs (Plate III).

The contact of the Hickory sandstone and the granite is obscured by alluvium at some localities. Immediately south of the river, the granite forms a hill capped by basal Hickory sandstone. Large angular blocks of Hickory sandstone are slumped so that the contact with the granite is concealed. Just east of the Homer Martin fishing cabin, the contact of Hickory sandstone with the granite is exposed in the east bank of an intermittent stream. At this locality, the granite surface is very irregular and deeply weathered. It is possible that the Hickory sandstone was deposited on this irregular weathered surface without removal of or reworking of the weathered material. However, the arkosic nature of the basal part of the sandstone suggests that the weathered material on the Precambrian surface was at least partially reworked. According to Woolsey (1958, p. 34), the weathered surface on the granite could also be the result of meteoric waters descending through the Hickory sandstone and accumulating on the granite.

Megascopic description

The rock is a phaneritic, equigranular, medium-grained, pink granite. The minerals recognizable in hand specimens are pink feldspar,

PLATE III

Exposure of Medium-grained Granite

Located in the bed of the Llano River 0.7 of a mile downstream from the Simonville Road Crossing.

colorless to cloudy quartz, and black biotite. On a fresh surface the granite is pink with black specks and weathers to a grey or whitish-pink. Biotite is usually not visible on weathered surfaces.

At one locality, intersecting vertical joints were noted in the granite. One set of joints strikes N. 55° W. and the other N. 55° E.

Microscopic description

The essential minerals are microcline, quartz, plagioclase, and biotite. Accessory minerals are magnetite, apatite, zircon, muscovite, sodalite (?), and calcite.

Microcline is the most abundant feldspar present. The anhedral grains range from less than 1 mm. to 7 mm. in diameter, the average being 2.5 mm.

Quartz occurs in anhedral grains ranging from 0.4 mm. to 8 mm. across. Extinction on most grains is sharp.

The plagioclase was identified as oligoclase by a maximum extinction angle of 12 degrees on an albite twin and an index of refraction greater than balsam. A combination of albite and carlsbad twinning was noted on a few grains.

Biotite grains are considerably altered to chlorite. Some of the grains measured 2 mm. parallel to the cleavage.

Most of the magnetite, apatite, and zircon occurred as inclusions in quartz or feldspar.

A few isotropic, anhedral grains showing high relief and an index of refraction below quartz were noted. The optical properties suggest that the grains belong to the sodalite group. Microchemical tests would be required to positively identify them.

A few small irregularly shaped calcite grains with high birefringence were noted.

The estimated mineral composition is microcline 45 percent, quartz 30 percent, oligoclase 10 percent, biotite 10 percent, magnetite, zircon, and apatite 2 percent, muscovite 1 percent, and sodalite (?), and calcite 1 percent.

Topography and vegetation

The granite exposure covers such a small area that no observations could be made concerning the topography or vegetation.

Aplite and Pegmatite Dikes

Along the Llano River, the granite and gneiss have been cut by numerous pegmatite and aplite dikes and quartz veins (Plate IV). The pegmatite dikes are composed of large, pink to red feldspar grains, milky quartz, and an occasional flake of biotite. The aplite dikes appear to be composed predominantly of quartz and feldspar.

The dikes and veins are generally more resistant than the gneiss. The feldspar and quartz fragments that litter weathered surfaces underlain by gneiss were derived from these dikes and veins.

Origin of the Gneisses, Schists, and Granite

The following field relationships and petrographic criteria must be considered in determining the origin of the gneisses, schists, and granite:

(1) The texture and mineral composition of the pink gneiss in exposures within 50 feet of the granite appear to be the same as in exposures 0.5 of a mile from the granite.

PLATE IV

Pegmatite and Aplite Dikes

Pegmatite and aplite dikes cutting Precambrian gneiss, located on the south bank of the Llano River 0.9 of a mile downstream from Simonville Road crossing.

(2) The gneisses may have formed by soaking of granitic magma from the granite batholith partially exposed in this thesis area into sediments or regionally metamorphosed sediments.

(3) The gneisses may have formed by soaking of a granitic magma from a batholith older than any of the presently known Precambrian granite masses into sediments or regionally metamorphosed sediments.

(4) The gneisses and schists were formed by regional metamorphism of sedimentary rocks.

Possible explanations for the origin of the granite are:

(1) It may have formed by granitization in the solid state of pre-existing rocks.

(2) It could have crystallized from an intrusive magma.

The facts that the mineral composition of the pink gneiss is similar to that of the granite and that the schist grades into gneiss suggest that the gneisses, schists, and granite may have formed by granitization, in the solid state, of pre-existing rocks. Granitization, as used here, means the recrystallization in the solid state of pre-existing rocks accompanied by solutions or gases from a magma so that they have the texture and mineral composition of a granite. The granite may represent that portion of the original body of rocks in which recrystallization has gone to completion, and the gneisses and schists may represent those portions where recrystallization has been less complete. Although the above evidence suggests granitization, the following evidence indicates that the gneisses, schists, and granite were not formed by granitization: (1) the uniform texture and mineral composition of the pink gneiss with no apparent transition to granite, and (2) the apparent where there is a transition from gneiss to granite, but that such a process could have formed the entire gneiss unit under discussion does not seem probable because of the apparent absence of a transition zone on the Homer Martin Ranch side of the river.

The writer believes that the gneisses and schists were possibly formed by regional metamorphism of a sequence of shales and sandy shales that might have included interbedded massive arkoses. The gneisses and schists were intruded by the granite after regional metamorphism and were but little changed by the intrusive body. It is possible that the original rocks may have been affected by magma or gases or solutions from an unexposed granite body other than the one now exposed in the thesis area. The pink gneiss was possibly derived from a massively bedded arkose. The presence of hornblende in the dark gneiss suggests that the latter may have been derived from a calcareous shale. The augen in the augen gneiss may be metacrysts resulting from this same regional metamorphism, and may not be directly related to the granite.

The writer has offered the above theories with full realization that none will fully explain the origin of the rocks mentioned. A more detailed petrographic study of a larger area would be required to explain the genesis of the gneisses and schists present in the thesis area. Such a study is beyond the scope of this research.

CAMBRIAN SYSTEM

Sedimentary strata exposed in the Homer Martin Ranch area belong to the Upper Cambrian Series. The Riley formation, composed chiefly of sandstone and limestone, rests unconformably on an irregular Precambrian

PLATE V

Exposure of the Hickory Sandstone

Figure 1. —Exposure of upper Hickory sandstone, located on the south bank of the Llano River 2.5 miles upstream from the Simonville Road crossing.

Figure 2. —Close view of Figure 1.

Topography and vegetation

With the exception of the steep cliffs along the Llano River and an outlier in the northeast portion of the area, the Hickory member normally forms low lying areas.

Bee-brush and various grasses are the predominant vegetation on those parts of the Hickory member that have not been cleared for cultivation. Mesquite, several types of oak, Mexican persimmon, and prickly pear, also grow on soils derived from the Hickory sandstone.

Cap Mountain Limestone Member

Definition and thickness

The Cap Mountain formation was named by Paige (1912, p. 45) for exposures at Cap Mountain in Llano County. It has subsequently been redefined by Cloud, Barnes, and Bridge (1945, p. 154) as the middle member of the Riley formation.

Bridge, Barnes, and Cloud (1947, p. 113) reported that the thickness of the Cap Mountain limestone member ranges from 135 to 445 feet thick, averaging about 280 feet. They attributed the variation in thickness to lateral gradation of the lower beds to sandstone. The writer estimates the thickness of the member in the thesis area to be slightly above the average for the region.

Lithology and relationships

The contact between the Cap Mountain limestone member and the underlying Hickory sandstone member is gradational and is frequently difficult to locate. The change in slope and vegetational change reported by Bridge, Barnes, and Cloud (1947, p. 113) at the contact is apparent on aerial photographs of the thesis area and was used by the present writer. However, this boundary normally does not coincide with the top of a noncalcareous sandstone zone as reported by Bridge, Barnes, and Cloud. At most localities, the present writer placed the contact at the first resistant, calcareous sandstone ledge above the dusky red soil that is characteristic of the upper part of the Hickory sandstone. This contact is marked by the previously mentioned change in vegetation and change in slope. Growths of bee-brush which are characteristic of the Hickory member terminate rather abruptly near the resistant sandstone ledge marking the contact.

The basal portion of the Cap Mountain limestone member consists of a few dark-red, calcareous, thin sandstone beds interbedded with silty, calcareous, pinkish yellow, somewhat friable, fine-grained sandstone beds that weather to a grey-brown. These beds change gradually upward to a harder, thicker-bedded, silty limestone. The silty sandstone is medium grained, tan to grey, and forms resistant ledges. Some of the limestone contains recognizable trilobite and brachiopod remains. Near the middle of the member, the limestone is glauconitic and occurs in beds about one foot thick. Just below the first occurrence of glauconite, the limestone contains small yellow-brown specks that appear to be limonite.

The upper part of the member consists of fine- to medium-grained, glauconitic, light-grey limestone that occurs in beds up to three feet thick. On dip slopes, this part of the member generally occurs in rather large, rectangular slabs. On weathered surfaces, these limestone slabs exhibit a mottled yellow and grey, honey-combed surface. Some of the limestone beds are "hashy" and appear to be of detrital origin. Shale layers up to ten inches thick also occur in this part of the member.

A massively-bedded sandstone lens occurs in the middle of the Cap Mountain member at one locality (Plate VI). The sandstone is white to light yellow, fine grained, nonglauconitic, and essentially noncalcareous. The unit attains an estimated maximum thickness of 15 feet. The sandstone grades both vertically and laterally into limestone. Ammer (1959), Bryant (1959), and Coughran (1959) have also reported the occurrence of sandstone in the Cap Mountain limestone. This sandstone bed has considerable lateral extent in the area mapped by Bryant.

Topography and vegetation

The Cap Mountain limestone member is fairly resistant to weathering and is a prominent ridge former in the thesis area. The member forms cuestas that partially surround the high hills in the central portion of the area.

Vegetation on the dip slopes is generally sparse, with various grasses and mesquite being the most abundant. On scarp slopes, Mexican persimmon and mesquite predominate and minor amounts of Spanish dagger, prickly pear, and catsclaw are also present.

Lion Mountain Sandstone Member

Definition and thickness

The Lion Mountain sandstone was originally named and defined by Bridge (1937, p. 235) as the upper member of the Cap Mountain formation. Later, Cloud, Barnes, and Bridge (1945, p. 154) redefined the Cap Mountain limestone as a member of the Riley formation and retained the name Lion Mountain sandstone as the top member of the Riley formation. According to Bridge, Barnes, and Cloud (1947, p. 114), the Lion Mountain sandstone is 20 feet thick in the type locality at Lion Mountain

PLATE VI

Sandy Facies in Cap Mountain Limestone

Located 1.7 miles southwest of the Homer Martin ranch house.

in the Burnet quadrangle. In the nearby Schep-Panther Creek area, Bryant (1958) measured 51.5 feet of Lion Mountain sandstone. North of the thesis area in the Grossville School area, Fuller (1957) reported a measured thickness of 64.2 feet for the member. The present writer measured 48.9 feet of Lion Mountain sandstone (Appendix).

Lithology and relationships

The contact between the underlying Cap Mountain limestone and the Lion Mountain sandstone is transitional and in places is difficult to locate because of the lack of exposures. The writer preferred to place the boundary above the last outcrop of Cap Mountain limestone and below a somewhat sparsely vegetated bench that is usually easily identified on aerial photographs. At one locality, where the transition zone was fairly well exposed, the boundary was placed at the base of the first glauconitic sandstone.

The lower portion of the Lion Mountain sandstone consists of alternating layers of sandstone, limestone, and siltstone. The sandstone is greenish-brown, thin bedded, fine to medium grained, calcareous, glauconitic, and weathers to a grey brown. The siltstone occurs in beds ½ inch to 1½ inches thick. The limestones are medium grained, thin bedded, glauconitic, and contain some fossil fragments.

White to light-purple, glauconitic limestone lenses composed of "trilobite hash" appear near the middle of the member. The "trilobite hash" consists mainly of fragments of trilobites. The siltstone content decreases and the sandstone becomes less consolidated and more glauconitic upward in the section.

A three foot section of dark-green to purple sand which appears to be nearly 50 percent glauconite occurs near the top of the member.

Numerous hematite nodules, which are characteristically found littering the slopes topographically below the sand bed, can also be found in this bed. The hematite nodules range in color from dark green through maroon to black. It is generally believed that the hematite nodules form by the alteration of glauconite as they may be found in different stages of alteration from glauconite to hematite. This glauconite-rich sand grades into a slightly glauconitic, brown, friable sandstone just below the contact with the Welge sandstone member.

The hematite nodules, fragments of trilobite hash, and a red soil serve as an aid in identifying the Lion Mountain sandstone member. The red soil could be confused with that developed on the Hickory sandstone, but the difference in vegetation growing on the two members would help to differentiate them.

Topography and vegetation

The Lion Mountain sandstone forms a gently sloping bench of varying width at the base of the high hills in the southwest and south-central portion of the thesis area.

Scrub oak and scattered mesquite are the most characteristic forms found existing on soils derived from the Lion Mountain sandstone member.

Wilberns Formation

Definition and Thickness

The Wilberns formation was named by Paige (1912, p. 46) from exposures at Wilberns Glen in Llano County. Paige placed the lower boundary at the top of the present Lion Mountain sandstone member. The formation as now recognized, was redefined by Cloud, Barnes, and Bridge (1945, p. 150) to include all Upper Cambrian strata above the Riley formation.

The Wilberns formation ranges from 540 to 610 feet thick and averages about 360 feet thick according to Bridge, Barnes, and Cloud (1947, p. 114). An entire thickness of the formation is not present in the thesis area, as only the basal portion of the uppermost member is present.

Welge Sandstone Member

Definition and thickness

Barnes (1944, p. 37) named the Welge sandstone member as the basal member of the Wilberns formation but did not describe the member. The first description of the member was given by Bridge, Barnes, and Cloud (1947, p. 114). The type locality is in the Welge land survey between Threadgill and Squaw Creeks in Gillespie County.

The Welge sandstone is 27 feet thick at tho type locality and averages 18 feet throughout the Llano region. A thickness of 17 feet was measured in the Homer Martin Ranch area. Bryant (1958) measured a thickness of 19.8 feet in the Schep-Panther Creek area and Fuller (1957) measured a thickness of 18.2 feet in the Grossville School area.

Lithology and relationships

The contact between the Welge sandstone member of the Wilberns formation and the underlying Lion Mountain sandstone member of the Riley formation is marked by a sharp change from a medium- to coarse-grained, glauconitic sandstone to a medium-grained, nonglauconitic sandstone. Evidence that the contact between the two members is unconformable is generally lacking in the thesis area. However, Woolsey (1958, p. 55)

PLATE VII

Contact between the Lion Mountain Sandstone and the Welge Sandstone

Located 1.2 miles southeast of the Homer Martin ranch house.

reported a thin bed or zone of poorly sorted, glauconitic, calcareous sandstone at the base of the Welge member which may be reworked Lion Mountain sandstone. Also, at some localities within the Llano region the upper portion of the Lion Mountain member was exposed long enough to allow oxidation of its uppermost few inches. There is no doubt that the Welge sandstone overlies the Lion Mountain disconformably.

The Welge member is an excellent stratigraphic marker in the thesis area. The upper and lower boundaries are normally well defined both in the field and on aerial photographs. On aerial photographs, the member is easily identified by a thin band of dense vegetation.

The member consists of thick- to massively-bedded, medium-grained, essentially noncalcareous and nonglauconitic sandstone. The sand grains are rather well rounded and well sorted, and many of the quartz grains show recomposed crystal faces that glitter in sunlight. The lower part of the member is yellow to light tan and weathers to a grey or buff. The upper part of the member is reddish brown and somewhat ferruginous.

<u>Topography and vegetation</u>

The Welge sandstone member forms a prominent ledge that can be traced for long distances above the gently sloping bench of the Lion Mountain sandstone. In some parts of the Llano region, the Welge member does not form ledges. This difference in topographic expression may be due to variations in cementation.

Scrub oak and Mexican persimmon are the predominant types of vegetation which form the narrow, dark band seen on aerial photographs.

Morgan Creek Limestone Member

Definition and thickness

The Morgan Creek limestone member was named by Bridge (Bridge, Barnes, and Cloud, 1947, p. 114) from exposures along Morgan Creek in Burnet County. At the type locality, the member is 110 feet thick and it averages 120 feet thick throughout the Llano region. It is 123 feet thick in the Homer Martin Ranch area. In the Schep-Panther Creek area, Bryant (1958, p. 31) reported a thickness of 126 feet for the Morgan Creek limestone.

Lithology and relationships

The Morgan Creek limestone member is well exposed in the thesis area. Most exposures are on the sides of the high hills in the southwestern and central part of the area and in re-entrants cut by stream erosion.

The transitional contact between the Morgan Creek limestone and the underlying Welge sandstone can be located within narrow limits. The present writer placed the contact at the gradation from brown, noncalcareous sandstone to brownish-purple arenaceous limestone. A change in slope normally occurs at this zone.

Above the basal arenaceous beds, there is a gradational change to a greyish-purple to light-grey, glauconitic, limonitic, fine- to medium-grained limestone in beds 0.5 to 2 feet thick. Some of the beds contain numerous fossil fragments, mostly brachiopods, which give some of the beds a "hashy" appearance. Glauconite is abundant in some beds and scarce in others. Near the middle of the member marly, shaly, or glauconite sand beds alternate with the limestone. Some of the shaly interbeds are so thin that they are only partings between the limestone beds. This part of the member weathers easily and usually forms a gently sloping bench that can be seen on aerial photographs.

The upper part of the member consists chiefly of limestone and minor amounts of siltstone. The limestone is blue-grey to light grey, medium grained, medium-bedded, occasionally silty, glauconitic and weathers to a dark grey. The siltstone is grey or greyish-green, glauconitic and thin bedded.

At a few localities at a position approximately 50 feet above the base of the section, the writer found fragmentary brachiopods believed by him to be Eoorthis texana. This fossil normally occurs 40 to 60 feet above the base of the member throughout the Llano region.

Fossil cystoid columnals were noted in limestone about 60 feet above the base of the member at several localities. The limestone containing the cystoid columnals commonly occurs about 5 to 10 feet above the Eoorthis texana zone.

A zone of small stramatolitic bioherms occurs approximately 10 feet below the top of the member. The bioherms are composed of blue-grey, sublithographic limestone that breaks with a subconchoidal fracture. The individual bioherm is roughly ellipsoidal and ranges from 3 to 8 inches in diameter. The zone is about 4 feet thick and is discontinuous laterally.

Topography and vegetation

The Morgan Creek limestone forms a rather gentle slope in the hilly southwestern and central portion of the thesis area. In most localities there are changes in slope near the base, middle, and top of the unit. Many of the resistant limestone beds form ledges that can be traced easily.

The basal sandy limestones support growths of turkey pear, scrub oak, Mexican persimmon, and catsclaw. Mexican persimmon and scrub oak are predominant on the remainder of the section.

Point Peak Shale Member

Bridge (Bridge, Barnes, and Cloud, 1947) named the Point Peak shale from exposures near Lone Grove in Llano County. It is 270 feet thick at the type locality and averages 160 feet throughout the Llano region. The Point Peak shale is 147 feet thick in the Homer Martin Ranch area. The measured section (Appendix) includes 22 feet of stromatolitic bioherms which are mapped as a separate unit.

Lithology and relationships

The underlying Morgan Creek limestone member is transitional into the Point Peak shale member, and the contact is sometimes arbitrarily chosen. The present writer placed the contact at the first appearance of a thick shale or siltstone sequence that normally occur about 10 feet above the "baby" bioherms in the top of the Morgan Creek limestone. This boundary closely coincides with a change in vegetation and change in slope which is apparent on aerial photographs.

The Point Peak member consists of greenish grey to light purple, calcareous shale interbedded with lesser amounts of white to grey, glauconitic, calcareous siltstones, fine- to medium-grained, thin- to medium-bedded, olive-grey limestone, and six to 12 inch beds of intraformational conglomerate.

Because of lack of resistance to weathering, the shales and siltstones normally alter to caliche. Good exposures of shale and siltstone are limited to gullies where running water has maintained a semi-fresh surface.

The limestone occurs as resistant ledges and as thin stringers and lenses interbedded with shale and siltstone.

The intraformational conglomerates consist of grey, yellow, and tan, flat limestone fragments in a fine-grained limestone matrix. In some of the conglomerates, the pebbles are arranged nearly parallel to the bedding, while in others the pebbles are oriented at varying angles to bedding planes, forming edgewise conglomerates.

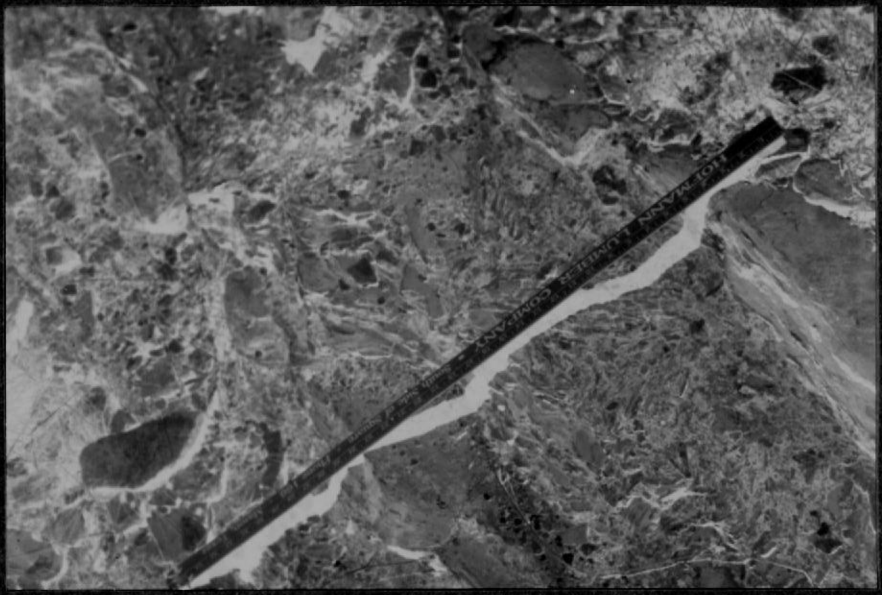
Near the middle of the member, a fairly continuous zone of stromatolitic bioherms occurs. Individual bioherms range up to 3 feet in diameter, and the zone is 5 to 7 feet thick. At one locality, the base of several individual bioherms was imbedded in an intraformational conglomerate. In other places, the bioherms are surrounded by thin-bedded limestone.

Symmetrical ripple marks in limestone in the upper part of the Point Peak shale were noted on one locality (Plate VIII, Figure 1). The ripple marks strike in a northwest direction and measure 10 inches from crest to crest. At the same locality but 5 feet stratigraphically below the above mentioned ripple marks, small ripple marks were also noted in limestone. They had a general northeast trend and measured 2 to 3 inches from crest to crest.

Also at the above locality, chevron-type folds were noted in limestone stringers in shale (Plate VIII). These sharp crested folds are probably due to differential compaction in the enclosing shales.

PLATE VIII

Edgewise Conglomerate in the Point Peak Shale



Located 1.4 miles southeast of the Homer Martin ranch house.

PLATE IX

Exposures of Point Peak Shale

Figure 1. --Symmetrical ripple marks in the Point Peak shale, located 2.1 miles south of the Homer Martin ranch house.

Figure 2. --Compaction folds in limestone stringers in the Point Peak shale, location same as Figure 1.

The bioherm zone at the top of the Point Peak shale was mapped as a separate unit, but is considered to be part of the Point Peak shale member by the writer. The unit ranges from about 20 to 40 feet thick. Individual bioherms range up to 25 feet in diameter and sometimes coalesce to form biostromes. The bioherms are composed of grey, sublithographic limestone and exhibit the typical "cabbage head" structure (Plate X, Figure 1).

Topography and vegetation

Outcrops of the Point Peak shale form gentle slopes immediately above the Morgan Creek limestone and become progressively steeper as the resistant upper bioherm unit is approached.

Vegetation of the shale portion of the Point Peak member is sparse, with mesquite being dominant. Mexican persimmon and oak are the most abundant types on the more thickly vegetated bioherm zone.

San Saba Limestone Member

Definition and thickness

Comstock (1890, p. 566) originally used the name San Saba as a series term for limestone exposed near Camp San Saba in McCulloch County. These beds were referred to as "Post Wilberns" by Dake and Bridge (1932, p. 728). These writers suggested that Comstock's name San Saba may be appropriate for part of these beds. The San Saba member as now recognized was defined by Bridge, Barnes, and Cloud (1947, p. 117) as the uppermost member of the Wilberns formation. The member includes the entire section of limestone overlying the Point Peak shale member and underlying the Tanyard formation of the Ellenburger group (Lower Ordovician).

PLATE X

Point Peak Bioherms

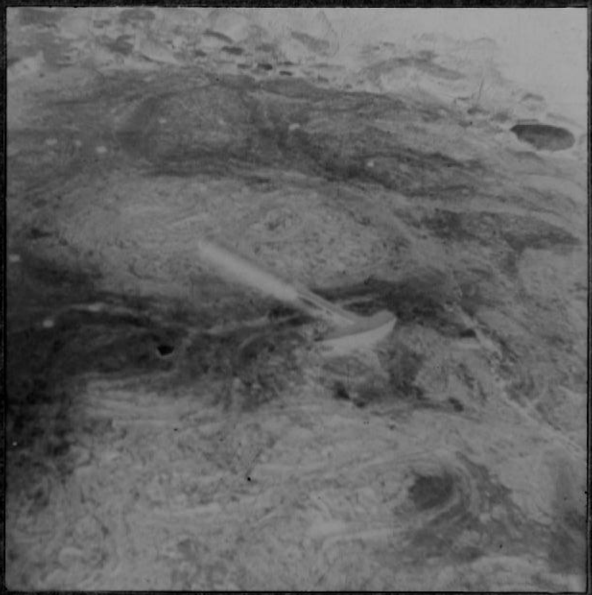


Figure 1. --Point Peak bioherm, showing "cabbage head" structure, located 1.1 miles southeast of the Homer Martin ranch house.

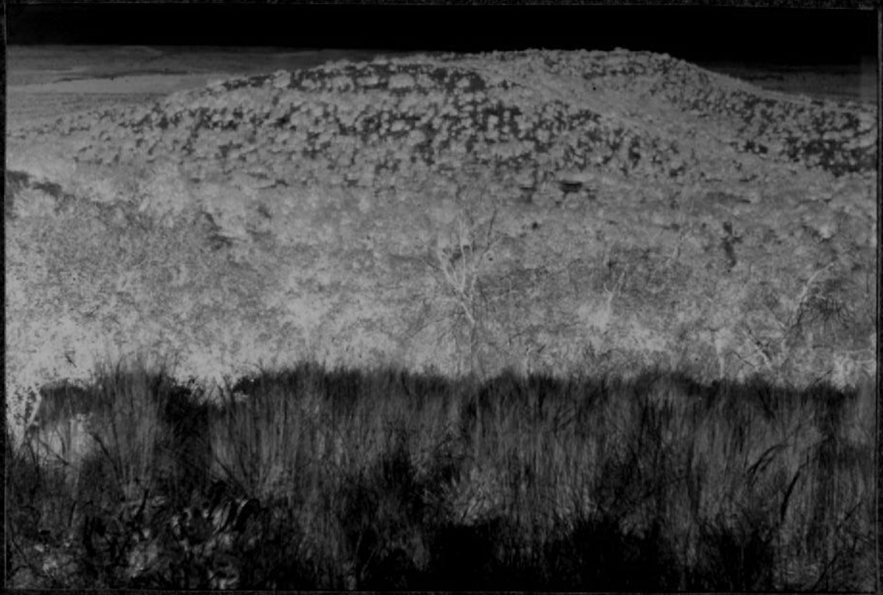


Figure 2. --Hill capped by Point Peak bioherms, location same as Figure 1.

The San Saba member is 280 feet thick at its type section along the Mason-Brady highway just north of the San Saba River. In the Homer Martin Ranch area, only the basal portion of the member is present. The thickness of the portion present is estimated to be about 40 feet.

Lithology and relationships

The lower boundary of the San Saba limestone member is placed at the top of the bioherm zone of the Point Peak shale member. The upper boundary of the member is not present in the thesis area. The identification of the limestone above the bioherms of the Point Peak member as belonging to the San Saba member is based on its lithic character and the abundance of girvanella.

The beds overlying the bioherms of the Point Peak member consist of thin- to medium-bedded, finely crystalline, slightly glauconitic, light-buff limestone which weathers to a mottled grey and yellow. The limestone contains small, irregularly shaped pockets of orange to yellow, glauconitic, fine-grained sand which gives the yellow mottled color.

Upward in the section, the limestone is white to yellow, medium grained, glauconitic, fossiliferous, and weathers to a dark grey. Some of the calcite grains show distinct cleavage surfaces. Brachiopod and trilobite fragments are abundant locally, and the disc shaped, marble sized, body girvanella is very abundant on bedding surfaces.

The San Saba member caps most of the high hills in the southern portion of the thesis area. The limestone weathers to flag-like, tabular masses where it caps the hills and dips at various angles and directions where it overlies the bioherms.

Topography and vegetation

The San Saba limestone member forms a gently rolling surface in the highest portions of the thesis area.

Vegetation is generally sparse, with Mexican persimmon and scrub oak being dominant.

QUATERNARY SYSTEM

The flood plain of the Llano River contains alluvial deposits that were derived from upstream areas and from the thesis area.

The previously mentioned river terrace has a thick alluvial cover with rock fragments scattered over the surface. Alluvium was mapped where there was any doubt as to the idenity of the underlying bedrock.

A coarse caliche conglomerate occurs at several localities along the banks and in the bed of Bast Creek. The conglomerate consists of rock fragments, mostly limestone, of various sizes in a caliche matrix. The fact that the conglomerate occurs in the creek bed and in places several feet above it suggests that it is probably of Recent age.

STRUCTURAL GEOLOGY

GENERAL STATEMENT

The Llano uplift is a structural dome composed of a core of Precambrian igneous and metamorphic rocks surrounded by gently dipping Paleozoic rocks and nearly horizontal Cretaceous rocks. According to Sellards (1932, p. 30), the total amount of uplift is 5,000 or 6,000 feet.

The first period of deformation evident in the region occurred during Precambrian time. During this period, the sedimentary rocks were folded, metamorphosed, and subjected to batholithic intrusions.

A later period of major deformation during Late Paleozoic time resulted in doming of the Llano region. Thinning of the Barnett shale as it approaches the domed region indicates that this uplift may have begun as early as Late Mississippian time. However, Sellards (1934, p. 97) has dated the principal uplift as occurring in post-Bend and pre-Canyon time.

Rocks in the Llano region have been cut by northeast-southwest trending faults. According to Cloud and Barnes (1946) these faults are normal, with dips ranging from 60 to 90 degrees.

Tight folding in Paleozoic strata is absent, except for that described by Cloud and Barnes (1948) and Miller (1957). Broad gentle folds have been described by Grote (1954), Fuller (1957), Wilson (1957), Mounce (1957), Sweet (1957), and Ammer (1959). A broad, gentle syncline is present in the Homer Martin Ranch area. Small folds resulting from differential compaction over bioherms also occur.

PRECAMBRIAN DEFORMATION

General Statement

Stenzel (1934, p. 74) made the following subdivision of Precambrian rocks (No. I being the oldest):

III. Late dike intrusions, comprising the opaline quartz-porphyry and felsites.

II. Batholithic intrusions, comprising the various granites and their aplite and pegmatite dikes.

I. Folded frame metamorphic rocks, comprising the schists, including the marbles and gneisses.

According to Stenzel (1934, p. 74), the rocks of the folded frame are thrown into broad, open folds that trend northwest-southeast and plunge southeast. He further stated that the open folds are disrupted by cross-flexures and zigzag folds.

Local Structure

The lack of good exposures of the gneiss and schist units has made the Precambrian structure in the Homer Martin Ranch area difficult to determine. However, the structure seems to agree with that of the region.

Dip and strike measurements were made on the foliation planes in the gneiss unit where possible. The average strike was found to be about N. 50° W. and dips ranged from 50 to 70 degrees northeast. In the western part of the gneiss exposure, the foliation dips about 50 degrees northeast. The dip steepens to 70 degrees northeast in the central portion, and changes to 60 or 65 degrees northeast in the eastern part of the area. From the dips obtained, an overturned fold is possible, but dip measurements are not sufficient in number to establish a definite pattern. Fisher (1960) has mapped a fold involving Precambrian gneiss and marble in the Hilda-Northwest area. Although the possibility of this fold extending into the Homer Martin Ranch area was investigated, field relationships suggest that such is not the case.

Small drag folds were noted in the schist unit. These tight folds had a general northwest-southeast strike and measured generally less than 2 feet from crest to crest.

All known faults that cut the Precambrian rocks also cut the Paleozoic rocks. No faults within the Precambrian rocks alone were detected.

The strike of the foliation in the gneiss unit is indicative of an intrusive, discordant contact between the granite and gneiss unit.

PALEOZOIC DEFORMATION

General Statement

The main structural elements in the thesis area are a northwest-southeast trending syncline and northeast-southwest trending faults. Several authors who have mapped areas within the Llano region stated that the northeast trending faults control the structure. In the Homer Martin Ranch area, the northwest-southeast trending syncline is the dominant structural feature.

Folding

Dip and strike measurements in the hilly southwestern and central portions of the thesis area indicate the presence of a broad, gentle syncline. Although dip and strike measurements are not at all points indicative of such a structure; the general pattern set by the dip and strike measurements, the elevations of different structural horizons, and the outcrop pattern indicate that the structure is present.

On the east flank of the structure, the strata dip southwest. The few dip measurements made in the thesis area along the west flank show a dip to the east or southeast. In the area adjoining on the west, Bryant (1959) found the beds dipping to the southeast. Some of the beds on the west flank, located southwest of the Homer Martin Ranch area, dip to the northeast, according to Fisher (see Figure 2). Along the blunt nose of the structure, the strata strike either northwest, east-west, or northeast and dip to the south. The pattern of the dip and strike measurements outlines a syncline that plunges to the southeast. The axis of the structure strikes about N. 30° W., as well as can be determined. In determining the structure, dip and strike measurements were made chiefly in the Cap Mountain and Morgan Creek members and to a lesser extent in the Point Peak and San Saba members.

Elevations on the east and west flank and near the axis of the structure show that the amount of down-warping is approximately 270 feet over a horizontal distance of 1.8 miles. Neil Fisher (Personal communication) has measured, with an aneroid barometer, the elevation of the top of the Welge sandstone on the east and west flanks and of the top of the Point Peak member near the axis of the structure, along a line that strikes N. 60° E. in the southern part of the thesis area. It was found that the top of the Welge sandstone is 1,615 feet above sea-level on the east flank and 1,625 feet on the west flank. The top of the Point Peak member is 1,620 feet above sea-level near the axis of the structure. The stratigraphic interval between the top of the Point Peak member and the top of the Welge member is about 270 feet. Because all the known faults within the thesis area strike northeast and do not cross the line of measurement, the above discrepancy in structural elevations must be due to downwarping.

The outcrop pattern also conforms to that which would be expected from a syncline that plunges to the southeast (see Plate I and Figure 2).

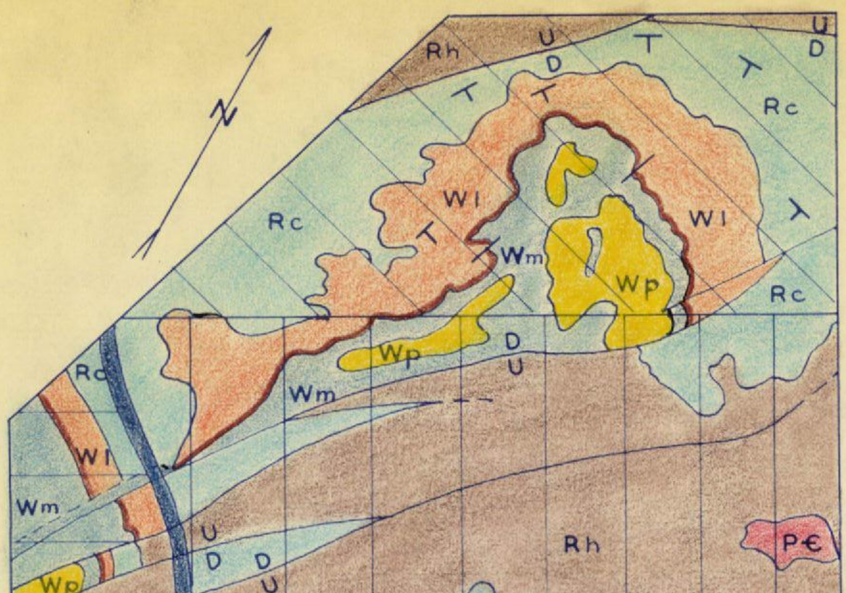
The only other folds noted in Paleozoic strata are the small, sharp-crested folds in limestone stringers in the Point Peak shale. These structures are probably due to differential compacting in the shale.

Faulting

Faults in the Homer Martin Ranch area are normal and have an average strike of N. 65° E. For convenience when referring to different faults, the writer has named two faults which are continuous for a considerable distance. The Bast Creek fault is named from Bast Creek which flows through the central part of the thesis area. The Smith fault is named from the C. H. Smith ranch, which is the only geographic location in the immediate vicinity of the fault. The Holbrook fault was named by Ammer (1959).

The Bast Creek fault extends from west of the thesis area to approximately 1.2 miles south of the Llano River. The fault strikes N. 70° E. for a distance of 1.3 miles from the western boundary of the area and then the fault trace gradually changes to a strike of N. 40° E.,

FIGURE 2



EXPLANATION

Qa
QUATERNARY ALLUVIUM

Ws
SAN SABA LIMESTONE MEMBER

Wp
POINT PEAK SHALE MEMBER

Wm
MORGAN CREEK LIME-STONE MEMBER

Wl
WELGE & LION MOUNTAIN SANDSTONE MEMBERS

Rc
CAP MOUNTAIN LIME-STONE MEMBER

Rh
HICKORY SANDSTONE MEMBER

P€
PRECAMBRIAN UNDIFFERENTIATED

GROSSVILLE SCHOOL AREA (FULLER)

BIG BEND OF THE LLANO RIVER AREA

SCHEP-PANTHER CREEK AREA (BRYANT)

HOMER MARTIN RANCH AREA

HILDA-NORTHWEST AREA-(FISHER)

U
D
NORMAL FAULTS

0 ¼ ½ ¾ 1 MILE
SCALE

GENERALIZED GEOLOGIC MAP OF PART OF THE HOMER MARTIN RANCH AREA AND ADJOINING AREAS, MASON COUNTY, TEXAS.

appearing to die out before reaching Simonville Road. The fault is upthrown to the northwest and has an estimated maximum displacement of 100 feet. Although it was not possible to measure the dip of the fault, it is believed to be nearly vertical. There is no evidence to indicate any horizontal displacement.

Brecciation and tree lineations occur locally along the trace of the fault. The effect of the Bast Creek fault on the dip and strike of the strata was apparent only in a few localities.

Two faults with small displacement branch off the Bast Creek fault and could be traced only short distances.

The Smith fault is located in the southeastern part of the thesis area. Near its western extremity, the fault is upthrown to the south and strikes about N. 80° E. Approximately 0.5 of a mile east of its western end, the fault splits into two branches. The southern branch maintains a strike of N. 80° E. and is upthrown to the south. This branch appears to die out in the Cap Mountain limestone before reaching the Simonville Road.

Northeast of the point where the Smith fault splits, the strike of the northern branch changes gradually to a strike of N. 55° E. This branch of the fault is upthrown to the north. West of the point where the fault splits, the displacement is small, about 50 feet or less. However, the displacement along the northern branch increases to the east and is a maximum of at least 350 feet where the gneiss unit is faulted against Cap Mountain limestone. A prominent obsequent scarp, which is easily seen on aerial photographs, occurs along this same branch at the place where the gneiss unit is against Cap Mountain limestone.

PLATE XI

Trace of the Smith Fault

Looking east from a point 1.3 miles southeast of the Homer Martin ranch house.

The scarp disappears toward the southwest. A downthrown, wedge-shaped block occurs between the north and south branches of the fault.

The Holbrook fault is located 0.8 of a mile south of the Smith fault in the southeastern portion of the thesis area. This fault has a general strike of N. 30° E. and is upthrown to the southeast. The strike of the fault changes from N. 30° E. to N. 70° E. for a short distance and then to the former strike. Basal Hickory sandstone is in contact with Cap Mountain limestone and with upper Hickory sandstone along the trace of the fault. This requires a displacement of 250 to 325 feet. The extent of the fault beyond the eastern boundary of the thesis area is not known. According to Fisher (Personal Communication) the Holbrook fault "cuts off" the synclinal structure in the Hilda-Northwest area which joins the Homer Martin Ranch area to the south. In the central part of the synclinal structure, Hickory sandstone is in contact with San Saba limestone. This indicates that the displacement along the fault increases to the southwest.

The Holbrook fault is difficult to trace where it passes through cultivated fields. In many localities upturned blocks of Hickory sandstone aided in tracing it.

Several unnamed faults are located in the northern part of the thesis area. For the most part, these faults can be traced only short distances and have small displacements. All of them trend northeast-southwest.

Several vegetation lineations which trend northeast-southwest occur in the Cap Mountain limestone and can be seen on aerial photographs. Where these lineations appear entirely within the Cap Mountain member, it is difficult to determine whether they are along faults or joints because of the lithologic similarity of the limestone on both sides of the lineations. Some faults with small displacement that were first noted in the Welge sandstone could be traced to the vegetation lineations in the Cap Mountain and were mapped as faults. Therefore, it is probable that some of the lineations which cannot be traced out of the Cap Mountain outcrop are along faults. Woolsey (1958, p. 84) and Bryant (1959, p. 50) also noted the occurrence of similar vegetation lineations in the Cap Mountain member. Both concluded that they probably are the result of jointing, but that some of them occur along faults.

Detection of Faulting

The criteria used in detecting faults include: (1) repetition or omission of strata, (2) vegetation lineations and offsets in vegetation lineations visible on aerial photographs, (3) offset or abrupt termination of beds, (4) erratic strikes and dips, and (5) brecciated zones.

The above criteria were useful in locating faults, but a close field study was necessary to determine their areal extent.

Age of Deformation

The San Saba limestone is the youngest rock unit involved in the folding and faulting. Thus the faulting and folding are no older than the San Saba limestone.

Cloud and Barnes (1948, p. 120) found evidence that the faulting in the Llano region occurred in post-Strawn and pre-Canyon time.

The faults in the thesis area cut the syncline. This indicates that folding preceded faulting. It is possible that the folding occurred before uplift of the Llano region. But, to the writer it seems more probable that the folding is associated with doming of the region, indicating that the folding may be post-Bend and pre-Canyon in age. Because of lack of evidence, the dating of the formation of the syncline must remain uncertain.

Relation to Adjoining Areas

The fold in the Homer Martin Ranch area is part of a syncline that extends southward into the Hilda-Northwest area and northward into the Big Bend of the Llano River and the Grossville School areas.

The nose of a synclinal structure was mapped by Fuller (1957) in the Grossville School area. A southward continuation of the fold was mapped by Wilson (1957) in the Big Bend of the Llano River area which is adjacent to the Homer Martin Ranch area on the north. In the Big Bend of the Llano River area, the syncline is "cut off" by the Schep Creek fault which is downthrown to the northwest (see Figure 2). South of the Schep Creek fault there is a wide zone of complex faulting that extends to the Llano River. It appears that the "gap" in syncline between the Schep Creek fault and the portion of the structure in the Homer Martin Ranch area is a result of removal by erosion of all but the lowermost Upper Cambrian rocks from a fractured zone in the upthrown fault block. That the zone was highly fractured is evidenced by the complex fault system between the Llano River and the Schep Creek fault.

According to Neil Fisher (Personal Communication), the syncline extends into the Hilda-Northwest area where it is "cut off" by the Holbrook fault. The extent of the structure south of the Holbrook fault is unknown.

Bryant (1959, p. 43) noted that since the Schep-Panther Creek area, which joins the Homer Martin Ranch area on the west, is located on the southwest flank of the Llano uplift, the strata would be expected to dip southwest. However, he (Bryant) found that the regional dip was to the southeast. From this he concluded that the strata occur as tilted, faulted blocks of various sizes. The present writer believes that the southeast dips east of the fault zone in the Schep-Panther Creek area are probably caused by the downwarp in the Homer Martin Ranch area.

Origin of Deformation

Before considering the origin of deformation in the region, consideration must be given to the orientation of the axes of other folds in the region and their relation to trends of faults.

According to Cloud and Barnes (1948, p. 121), the axes of many folds in the Llano region trend northwest-southeast, but alignments in other directions occur.

Grote (1954) has described an anticline that trends north-northeast in the Central Bluff Creek area west of Mason, Texas. The structure plunges to the southwest away from the center of the uplift. According to Grote (1954, p. 40), the major faults are so aligned (northeast-southwest) as to be considered almost parallel to the axis of the anticline.

Sweet (1957) has mapped a north-south trending syncline in the Katemcy-Voca area on the north flank of the Llano uplift. This structure plunges to the north. The faults in Sweet's area do not exactly parallel the axis of syncline, but both limbs have been disrupted by faulting. In the adjoining Camp San Saba-West area, Mounce (1957) has described what appears to be the west limb of a northeast-trending anticline that plunges to the north or northeast. The east limb is a limb of the syncline described by Sweet.

In the Bear Springs area southwest of Mason, Texas, Cloud and Barnes (1948, Plate V) mapped the Honey Creek syncline. This fold strikes northeast and has been disrupted by the Honey Creek fault which parallels the axis of the structure.

A southern extension of the Honey Creek syncline, the Bee Branch Depression, was described by Miller (1957). According to him, the depression is a doubly-plunging syncline that trends nearly east-west. The Honey Creek fault has also disrupted this structure.

As already noted, the syncline in the Homer Martin Ranch area and two adjoining areas to the north trends northwest-southeast and plunges to the southeast. The trend of the major faults is nearly perpendicular to the axis of the fold.

The above mentioned folds show that: (1) the folds in the Llano region trend northwest, north, and northeast, with the exception of the Bee Branch Depression which trends east-west, (2) for the most part, the folds plunge away from the uplift, (3) the major faults strike nearly parallel to the axes of some folds and nearly perpendicular to the axes of others, and (4) the folding antedates the faulting.

Possible explanations for the origin of deformation in the Llano region are: (1) horizontal compression, (2) differential compaction, and (3) differential uplift. Grote (1954) has previously suggested horizontal compression, compaction and settling, and basement uplift.

If horizontal compression were responsible for folding in the Llano region, the folds should have similar trends, and it seems likely that reverse as well as normal faults should have occurred.

The absence of thick shale sequences in the sedimentary section seems to indicate that the large folds in the region were not caused by differential compaction.

Because the basement rocks in the Llano region have been uplifted some 6,000 feet, it seems probable that some differential uplift may have occurred which could have produced the folds. Since the folding antedates faulting, the rocks may have first yielded to the deforming stresses by folding; and as uplift of the region progressed, the folding was followed by faulting.

G E O L O G I C   H I S T O R Y

Because the complete geologic section of the Llano region is not present in the Homer Martin Ranch area, the following summary of geologic history from Precambrian to Late Cambrian time is derived mainly from data within the thesis area and augmented by data from other parts of the region and from other writers. The geologic history from the Ordovician to Recent is chiefly from Cloud and Barnes (1948).

The gneisses and schists in the thesis area probably represent an unknown thickness of sandstone and shale which were deeply buried, intensely folded, metamorphosed, and intruded by granitic magma during the unknown expanse of Precambrian time. The coarse texture of the granite gives evidence that the magma cooled slowly at great depths.

Subsequent to emplacement of the granite, the region was uplifted and subjected to a long interval of erosion. During this period of erosion, folds in the metamorphic rocks were truncated and granite bodies were partially uncovered. The absence of Lower and Middle Cambrian rocks indicates that this erosional interval, which probably began in Late Precambrian time, lasted until the invasion by the Late Cambrian Sea.

This Late Cambrian Sea advanced over truncated folds and exposed granite and deposited the Hickory sandstone. The initial transgression incorporated ventifacts and other residual material in the basal conglomerate. As Goolsby (1957, p. 78) has noted, the poor sorting and the composition of the basal conglomerates indicate that the initial transgression of the sea was rapid and that the basal deposits probably were derived from the underlying Precambrian rocks. Bridge, Barnes, and

Cloud (1947, p. 113) stated that the Hickory sandstone was deposited on a rugged terrain of at least 800 feet of relief. Goolsby (1957, p. 79) believed that, although relief did exist, the lithologic similarity of lower Hickory sediments across the Llano uplift indicates that the areas of high relief were confined to several local areas.

That the seas remained shallow during deposition of the lower and middle Hickory is indicated by cross-bedding in the lower part of the member and symmetrical ripple marks and intraformational conglomerates in the middle part of the member. The decrease in grain size and the better sorting in the middle Hickory suggest by the time of its deposition that the relief in the source area had been reduced.

The occurrence of cross-bedding and some phosphatic brachiopods in the upper Hickory indicates that the sea was still shallow. The increase in grain size in the upper Hickory suggests renewal of supply. This could have been caused by a slight uplift in the source area, or by an increase in rainfall in the source area.

The dark-brown to red sandstone of the upper Hickory in addition to having a hematite cement that coats the quartz grains, contains some oolites of hematite. The origin of the iron oxide is a controversial subject. Since the source of these sediments was probably Precambrian igneous and metamorphic rocks, streams entering the sea could have contained iron in solution which could have been precipitated as iron oxide by oxidation and incorporated in the sediments during deposition.

It is also possible that the iron oxide may have been formed by oxidation of glauconite. However, this method would not explain the oolites.

A third method which could possibly explain the origin of the iron oxide is that it was precipitated in the pore spaces of the rock by circulating ground water after consolidation of the sandstone. If such were the case, the source of the iron could have been either within or outside the sandstone. However, the presence of oolites suggests that this method of deposition does not satisfactorily explain the origin of all the iron oxide.

Although the actual origin of the iron oxide is unknown, it seems more probable to the writer that the iron was precipitated from solution during deposition of the sandstone. Alling (1947) believed that the iron oxides in the Clinton iron ores had a similar origin.

A gradual decrease in the supply of sand and a gradual increase in carbonate deposition is represented by the transitional contact between the Hickory sandstone and the Cap Mountain limestone. This change in deposition indicates a continued transgression of the sea and a decrease in relief or continuation of low relief of the source area.

Glauconite in the Cap Mountain limestone is indicative of deposition in under slightly reducing conditions in marine waters of normal salinity and moderate depths.

As noted previously, the occurrence of the massive, fine-grained sandstone in the Cap Mountain member has been reported to the west, southwest, and south of the thesis area, but has not been reported to the north or east. Coughran (1959, p. 80) has reported a fine- to medium-grained sandstone in the Cap Mountain member south of the Homer Martin Ranch area. If the sandstone reported by Coughran is at the same stratigraphic level as the one in the thesis area, the increase in grain size to the south suggests that the source area may have been a local uplift, possibly to the south instead of the west. However, this could also be the result of a climatic change causing increased rainfall in the source area.

A gradual uplift of the Llano region is indicated by the lithology of the Lion Mountain member. The transition from carbonate deposition in the Cap Mountain member to predominantly sand deposition in the Lion Mountain indicates that the latter is a regressive deposit. The increase in grain size of quartz toward the top of the Lion Mountain is also indicative of a regressive deposit (T. D. Daugherty, Personal Communication). The character of the Lion Mountain sediments suggests deposition in a littoral zone. The presence of trilobites and glauconite indicates a quiet water environment. But the trilobite remains are fragmental and have been deposited in lenses. Much of the glauconite sand is cross-bedded and probably has been redeposited. The transportation of both the trilobite fragments and the glauconite could have been caused by storms that caused local disturbances in the quiet environment or by tidal currents in channels on the shallow sea bottom.

The sharp contact between the Lion Mountain and Welge sandstones marks an interval of emergent conditions. The interval of exposure to subaerial erosion was long enough to account for some of the variation in thickness of the Lion Mountain member, but the increase in elevation above sea level was not sufficient to cause extensive erosion.

Deposition of the Welge sandstone represents a renewed sea transgression in the Llano region. The purity, the well rounded and well sorted quartz grains, and the thin but constant thickness of the Welge sandstone are indicative of deposition on a stable shelf.

The transition from deposition of sands of the Welge member to the sandy limestones and then to the crystalline limestones of the Morgan Creek member represents a transgressive sequence similar to that represented by the Hickory and Cap Mountain members. According to Krumbein and Sloss (1956, p. 359), such a transgressive sequence is also characteristic of deposition on a stable shelf. The limestones and the abundance of fossils above the lower arenaceous limestones indicate deposition in warm, moderately clear waters of moderate depths. The alternating limestone and marly beds near the middle and top of the member suggest slight fluctuations of sea level. The small bioherms near the top of the member are suggestive of deposition in clear, shallow, warm water.

The Point Peak sediments represent a shallowing of the sea and an influx of argillaceous material. The intraformational conglomerates appear to be tidal flat deposits that were desiccated and cracked due to exposure to the atmosphere and then were transported short distances and deposited in a limy matrix. Other indications of a shallow water environment during deposition of the Point Peak shale are the occurrence of bioherms at several stratigraphic levels and ripple marks on surfaces of some of the limestone beds.

The glauconitic, fine grained limestones of the San Saba member suggest a slight subsidence. Intraformational conglomerates, sandy facies, and bioherms reported in this member from other parts of the Llano region indicate that shallow water conditions prevailed throughout its deposition in the western part of the region.

Sedimentation was continuous from Late Cambrian into Early Ordovician time. Cloud and Barnes (1946, p. 112-113) described the sedimentation and ecology of the region during deposition of Ellenburger sediments as similar to the conditions on the present Bahama Banks off the coast of Florida.

The history of the region during Middle and Late Ordovician and Silurian time is not certainly known. The absence of deposits of these ages suggests that the region was emergent. According to Cloud and Barnes (1946, p. 113), the longest period of Paleozoic emergence occurred before Devonian time. During this emergent period, a considerable thickness of Ellenburger sediments was removed by subaerial erosion.

Devonian sediments preserved in widely isolated collapse structures in the Ellenburger limestone described by Cloud and Barnes (1946, p. 110) indicate that Devonian seas covered the Llano region.

Following deposition of Devonian sediments, the Llano region was again exposed to erosion. During this time, most of the Devonian strata were eroded from the region. As a result, sediments of Mississippian age were deposited on Ordovician as well as on Devonian strata. Thinning of the Barnet shale as it approaches the Llano region suggests the beginning of the uplift as a positive structural element in the Mississippian period. However, the principal uplift occurred in the Pennsylvanian period before Canyon time, probably during the Strawn epoch.

Strata younger than Canyon in age have been broken by faults throughout the Llano region. Hence, the most recent faulting in the region occurred during Strawn time.

There is no record of sedimentation in the Llano region during the Premian, Triassic, or Jurassic periods. It is probable that the region was emergent and subjected to a long period of erosion, during which it was denuded to a peneplane before submergence and deposition of Cretaceous sediments. The accordant summit levels in the high hills of the southern part of the Homer Martin Ranch area may represent remnants of the pre-Cretaceous peneplane. But as noted previously, the age of such a surface in the Homer Martin Ranch area cannot be proven because of the absence of Cretaceous strata.

Following submergence and the deposition of Cretaceous strata, the region has been emergent and is undergoing subaerial erosion at the present time.

As the drainage in the Llano region originated on Cretaceous strata and has been superimposed on the underlying Paleozoic strata, the Llano River terrace and the Bast Creek meanders entrenched in bed-rock indicate rejuvenation by post-Cretaceous uplift.

Deposition at the present time is limited to stream valleys.

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A P P E N D I X

Section 1

Section of Welge sandstone, Morgan Creek limestone, and Point Peak shale, located 1.0 mile southeast of the Homer Martin ranch house and south of Simonville road.

	Thickness in feet
Wilberns formation	
Point Peak shale member	
20. Bioherm, light to dark grey, composed of sub-lithographic limestone, weathers light rusty-brown, breaks with subconchoidal fracture. Individual bioherms attain diameters as great as 25 to 30 feet.	22.0
19. Covered slope, underlain by caliche and covered with scattered fragments of intraformational conglomerate, siltstone, and fine-grained limestone. The caliche is probably altered shale and siltstone.	13.3
18. Limestone. Same as unit 16.	0.9
17. Covered slope, underlain by caliche and covered by an abundance of vegetation.	6.4
16. Limestone, grey to buff, weathers dark brown with rusty mottled spots on surface, medium to coarse grained, glauconitic, limonitic, numerous fossil fragments visible	1.6

		Thickness in feet
15.	Covered slope. At 35.2 to 38.2 there is a fine-grained limestone and intraformational conglomerate. The limestone is light grey, glauconitic and very tough. The conglomerate consists of flat pebbles of limestone in a limestone matrix. Much of the covered area is probably underlain by shale.	54.6
14.	Bioherms, light to olive-grey, very hard, sublithographic limestone that breaks with subconchoidal fracture. Bioherms range in diameter from 0.6 feet to 3 feet. Bioherms are surrounded by fine- to medium-grained, glauconitic limestone.	4.6
13.	Intraformational conglomerate, blue-grey, consists of flat limestone pebbles in a fine-grained limestone matrix.	0.8
12.	Covered slope, underlain by caliche, covered by float of limestone, intraformational conglomerate, and small bioherms. Limestone at 5.2, same as unit 11.	31.4
11.	Limestone, olive-grey with yellow-brown specks, weathers dark grey to buff, glauconitic.	2.2

	Thickness in feet
10. Covered slope. Slope covered with caliche, small bioherms, and limestone float. The base of this unit is the approximate contact between the Point Peak shale and the Morgan Creek limestone. This corresponds closely to the change in vegetation and in slope seen on aerial photographs.	9.6
Total Point Peak member measured.	147.4
Morgan Creek limestone member	
9. Limestone, grey to light, rusty yellow, weathers olive to dark grey, medium grained, glauconitic, medium bedded.	5.6
8. Bioherms, blue-grey, hard, sublithographic limestone that breaks with subconchoidal fracture. Surrounded by medium-grained, glauconitic limestone.	4.0
7. Limestone, blue-grey, weathers grey with rusty mottled spots on surface, medium to coarse grained, glauconitic, limonitic, fossil fragments visible (brachiopod fragments are the only identifiable fossils), medium bedded, forms protruding ledges.	25.0

Thickness
in feet

6. Covered slope. This unit forms a bench or change in slope that can easily be seen on aerial photographs. The stratigraphic position of this unit conforms closely to that of shaly or marly beds seen at other localities. At 15 to 15.5 feet, there is a white to grey, coarse grained, fossiliferous limestone. From 22.5 to 25.5, there is a soft, white, speckled green, thin-bedded, glauconitic, limestone. 35.0

5. Limestone, greyish purple to light grey, weathers blue-grey to dark grey with light orange mottled spots on surface, glauconitic, limonitic, thin to medium bedded. Numerous cystoid columnals and other fossil fragments are apparent. Doorthis texanus at 5 feet and continues to covered slope above. 10.0

4. Limestone, speckled green, white and light purple, weathers light to dark grey, glauconitic, limonitic, occurs in beds 0.5 feet to 2 feet thick, some bedding indistinct. Brachiopod fragments at 26 feet. 30.0

3. Limestone, reddish brown, weathers buff to light tan, arenaceous, quartz grains better rounded and less abundant than in unit 2. . . . . 7.4

	Thickness in feet
2. Limestone, brownish-purple, weathers yellowish brown, sand content may be 50 percent. Secondary silica appears to have been deposited in crystallographic continuity on quartz grains. This unit is badly weathered in places.	6.0
Total Morgan Creek member measured	123.0
Welge sandstone member	
1. Sandstone, tan to light-greyish brown, medium-grained, well sorted, non-calcareous, non-glauconitic. Contact with underlying coarse-grained sandstone sharp. Thin soil cover near middle of section. Upper part of section forms a prominent ridge.	17.2
Total Welge member measured.	17.2
Total thickness measured.	287.6

Section 2

Section of Lion Mountain sandstone member measured in creek bed 0.3 of a mile north of the Homer Martin hunting cabin.

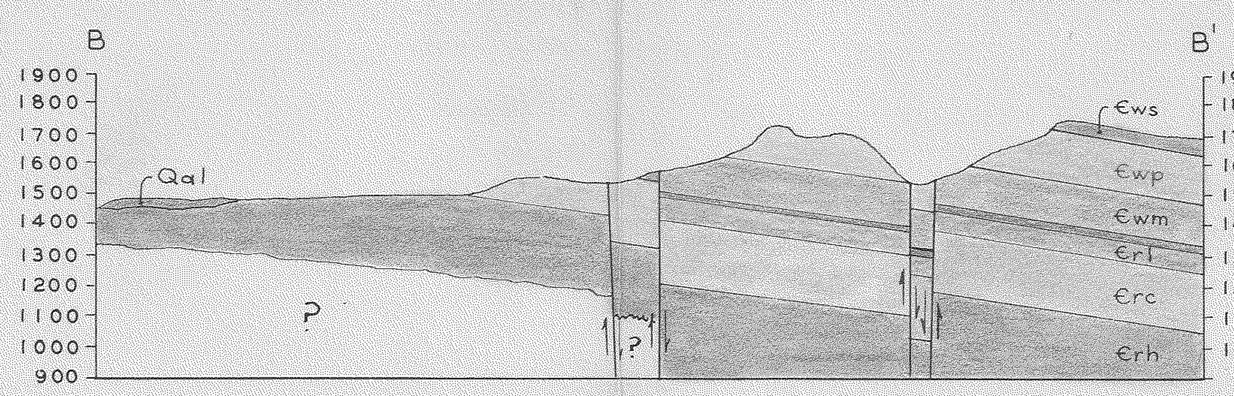
	Thickness in feet
Riley formation	
Lion Mountain sandstone member	
13. Sandstone, medium- to coarse-grained, somewhat friable, yellow-brown, bedding indistinct. Contact with overlying Welge member is sharp. . . .	3.0
12. Greensand, medium grained, bedding indistinct, appears to be 50-60 percent glauconite, green to purple to nearly black.	3.0
11. Limestone, composed almost entirely of trilobite fragments, glauconitic.	0.8
10. Covered slope. Surface is littered with hematite nodules.	6.0
9. Covered slope. Hematite nodules litter surface. Occasional outcrops of a fine-grained, yellowish orange, glauconitic sandstone. Trilobite hash at 29.9 and 31.7 feet above base of section.	25.6
8. Limestone, mostly "trilobite hash".	0.5
7. Sandstone, brown, calcareous, glauconitic	1.4
6. Same as unit 4.	0.4

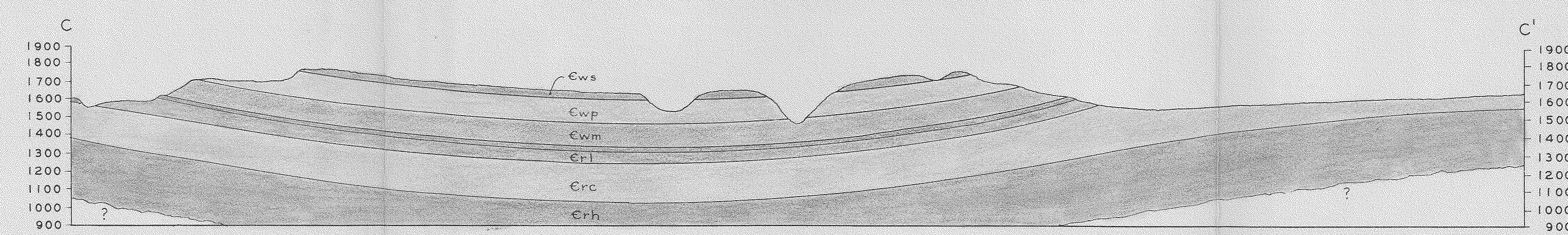
		Thickness in feet
5.	Limestone, white to whitish purple, composed of fossil hash.	0.6
4.	Sandstone and siltstone, sandstone same as unit 3 in thin beds 0.3 feet thick, interbedded with siltstone 0.2 feet thick. Siltstone is sandy, orange-yellow and weathers buff to nearly orange, glauconitic, calcareous	6.0
3.	Sandstone, greenish purple, weathering grey, fine grained, fresh surface glitters in sunlight, glauconitic, bedding indistinct.	0.4
2.	Limestone, white, speckled rusty brown and green, medium grained, sandy, glauconitic, very tough.	0.8
1.	Sandstone, greenish grey, weathers greenish brown, fine grained, glauconitic, calcareous. . . .	0.4

PLATE I

GEOLOGIC MAP OF THE HOMER MARTIN RANCH AREA, MASON COUNTY, TEXAS

STRUCTURE SECTIONS





Vertical Scale { 3.3 x horizontal scale; datum = approximate sea level

topography and dips of faults estimated

EXPLANATION

GEOLOGIC COLUMN

QUATERNARY — RECENT
- Qrs — River sand
- Qal — Alluvium

CAMBRIAN — UPPER CAMBRIAN

WILBERNS FORMATION
- €ws — San Saba limestone member
- €wpb / €wpp — Point Peak shale member, Bioherm zone on top
- €wm — Morgan Creek limestone member
- €ww — Welge sandstone member

RILEY FORMATION
- €rl — Lion Mountain sandstone member
- €rc — Cap Mountain limestone member
- €rh — Hickory sandstone member

UNCONFORMITY

PRECAMBRIAN
- P€mg — Medium-grained granite
- P€gn, P€sc — Gneiss and Schist

SYMBOLS

- Normal fault
- Inferred normal fault
- Observed and inferred contact
- Strike and dip of Strata and foliation
- Stream
- Intermittent stream
- A—A' Structure section line
- TS + Thin section locality
- Measured section
- Property line fence
- Unimproved earth road
- Stock tank
- Windmill
- House
- N 10° Approximate mean declination

Base Map from U. S. Department of Agriculture, Soil Conservation Service, aerial photographs, 1955

Horizontal Scale: 1/20,000

0 — 0.5 — 1 — 2 MILES