GEOLOGY OF THE DOSS-NORTH AREA, MASON AND GILLESPIE COUNTIES, TEXAS

A Thesis

By

THEODORE COUGHRAN

Submitted to the Graduate School of the Agricultural and Mechanical College of Texas in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August, 1959

Major Subject Geology

GEOLOGY OF THE DOSS-NORTH AREA,

MASON AND GILLESPIE COUNTIES, TEXAS

A Thesis

By

THEODORE COUGHRAN

August, 1969

Approved as to style and content by:

Chairman of Committee

Head of Department of Geology and Geophysics

CONTENTS

GEOLOGY OF THE DOSS-NORTH AREA,
MASON AND GILLESPIE COUNTIES, TEXAS

A Thesis

By

THEODORE COUGHRAN

Submitted to the Graduate School of the
Agricultural and Mechanical College of Texas in
partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

August, 1959

Major Subject Geology

GEOLOGY OF THE DOSS-NORTH AREA,

MASON AND GILLESPIE COUNTIES, TEXAS

A Thesis

by

THEODORE COUGHRAN

August, 1959

Approved as to style and content by:

Chairman of Committee

Head of Department of Geology and Geophysics

CONTENTS

Page

ILLUSTRATIONS

A C K N O W L E D G E M E N T S

Sincere appreciation is extended to members of the faculty of the Department of Geology and Geophysics of the Agricultural and Mechanical College of Texas, who gave assistance during the field work and offered constructive criticism in the preparation of this thesis. The writer is indebted to Dr. M. C. Schroeder and Mr. F. E. Smith under whose supervision the field work was done. Dr. Schroeder also helped measure the described section, and offered many helpful suggestions throughout the project. Special thanks are due Mr. C. L. Seward for his constructive criticism and suggestions in the final preparation of this paper.

The cooperation and friendliness of the ranchers of the area are greatly appreciated.

The writer is especially grateful to his wife, Barbara Coughran, for her continual help and encouragement throughout the project.

FRONTISPIECE

NORTHEASTERN PART OF DOSS-NORTH AREA. VIEW TO SOUTH FROM A HILL ON NORTH BORDER OF AREA. RANCH-TO-MARKET ROAD 783 CROSSES COW VALLEY CREEK IN RIGHT CENTER OF PICTURE. FIELDS OF WEATHERED CAP MOUNTAIN LIMESTONE IN FOREGROUND, HILLS OF CAP MOUNTAIN LIMESTONE JUST SOUTH OF COW VALLEY CREEK, AND HILLS OF POINT PEAK SHALE AND BIOHERMS IN DISTANT BACKGROUND.

A B S T R A C T

The Doss-North area is located on the southwest flank of the Llano uplift of central Texas. Rocks exposed in the area are of Upper Cambrian, Lower Ordovician, possible pre-Cretaceous Mesozoic (?), Lower Cretaceous, and Tertiary to Recent ages. All seven members of the two Upper Cambrian formations, the Riley and Wilberns, of the Llano region are represented in this area. The Ordovician system (Ellenburger group) is represented by the Threadgill limestone member. Arkosic conglomerate of possible pre-Cretaceous Mesozoic or Early Cretaceous age occurs in a small outcrop. The Lange's Mill conglomerate, and sandstone, siltstone, and limestone units represent the Cretaceous system; terrace gravel and alluvium represent the Tertiary to Quaternary.

In this area the Cambrian - Ordovician contact is conformable. The contact of the nearly horizontal Cretaceous beds with older rocks is unconformable.

The Paleozoic rocks have a strike of N. 40° to 50° E. and a regional dip of 6°-8° S.E. Three steeply-dipping major faults, downthrown toward the northwest, trend northeast - southwest across the area. Numerous minor faults occur throughout the area, commonly forming small horsts and grabens.

The geologic history of the thesis area, with several small variations, is essentially the same as that of the larger Llano region.

GEOLOGY OF THE DOSS-NORTH AREA, MASON AND GILLESPIE COUNTIES, TEXAS

I N T R O D U C T I O N

LOCATION AND ACCESSIBILITY

Located on the southwest flank of the Llano uplift in central Texas, the Doss-North area is approximately bisected by the Mason-Gillespie County line (Figure 1). The rectangular area contains roughly 18 square miles and is 6 miles long in a north-south direction and 3 miles wide in an east-west direction. The west boundary coincides with longitude 99°10' west. The south boundary lies one mile north of Doss, Texas, for which the area is named. Doss is about 23 miles northwest of Fredericksburg, Texas, by way of U. S. Highway 87 and Farm-to-Market Road 648.

The area is accessible from either Mason or Fredericksburg. Ranch-to-Market Road 783 crosses the eastern half of the area in a north-south direction. The Onion Creek and Lange's Mill roads, both of which are metal-surfaced, join to cross the southern half of the area in an approximate east-west direction. Two improved dirt roads join to cross in an approximate east-west direction the northern half of the area. An improved dirt road roughly coincides with the upper two-thirds of the west boundary. A network of unimproved ranch roads provides access to most parts of the area.

GEOLOGY OF THE DOSS-NORTH AREA,

MASON AND GILLESPIE COUNTIES, TEXAS

INTRODUCTION

LOCATION AND ACCESSIBILITY

Located on the southeast flank of the Llano uplift in central Texas, the Doss-North area is approximately bisected by the Mason-Gillespie County line (Figure 1). The rectangular area comprises roughly 15 square miles and is 5 miles long in a north-south direction and 3 miles wide in an east-west direction. The east boundary coincides with longitude 99°10' west. The north boundary lies one mile north of Doss, Texas, for which the area is named. Doss is about 23 miles northwest of Fredericksburg, Texas, by way of U. S. Highway 87 and Farm-to-Market Road 648.

The area is accessible [illegible] on Fredericksburg. Farm-to-Market Road 783 crosses the eastern half of the area in a north-south direction. [illegible] roads, [illegible], cross the [illegible] half of the area in an approximate east-west direction. Two improved dirt roads join to cross in an approximate east-west direction the southern half of the area. An improved dirt road roughly coincides with the upper two-thirds of the west boundary. A network of unimproved ranch roads provides access to most parts of the area.

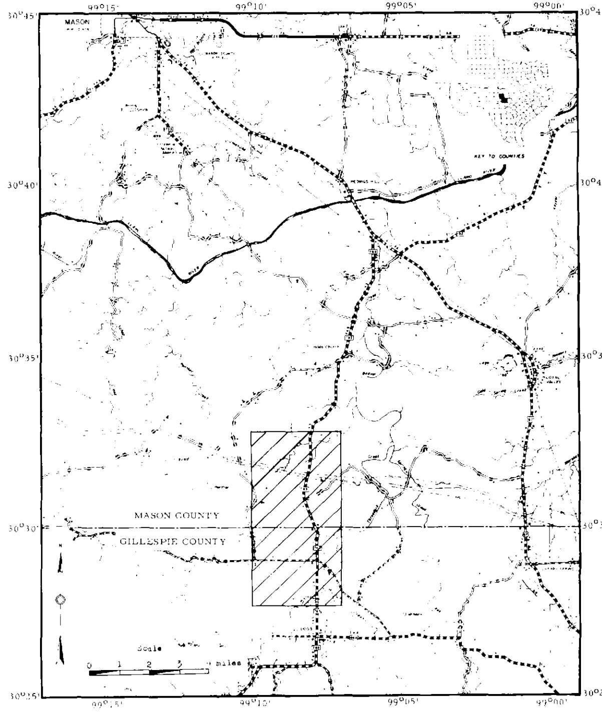


FIGURE 1. LOCATION MAP OF THE DOSS NORTH AREA, MASON AND GILLESPIE COUNTIES, TEXAS

Adapted from Texas State Highway Department highway maps of Mason and Gillespie Counties, Texas.

PLATE II

Figure 1. MASSIVE QUARTZ SANDSTONE BED IN BASE OF CAP MOUNTAIN LIMESTONE
On Cow Valley Creek, 330 yards east of Ranch-to-Market Road 783. Sandstone bed about 25 feet above base of Cap Mountain.

Figure 2. MASSIVE BEDS OF UPPER CAP MOUNTAIN LIMESTONE
On Threadgill Creek, 350 yards west of where Onion Creek joins Threadgill. Note relative size of hammer leaning against bottom ledge.

FIELD TECHNIQUES

The field work was done during the period from June 15, 1958, to August 20, 1958. Mapping was done on acetate overlays of United States Department of Agriculture aerial photographs, series DFZ, numbers 40, 42, 43, 101, 103, and 105, dated November 28, 1955. The scale of the photographs is approximately 1:20,000 or 1 inch equals 1667 feet.

Stratigraphic contacts and faults were located on the ground and plotted on the acetate overlays. Many contacts and faults were first detected by vegetational changes and lineations on the photographs, and then checked by ground observation. The stereoscope was used to help ascertain the stratigraphic-topographic relationships.

Strikes and dips were taken with a Brunton compass. A makeshift Jacob's staff and a Brunton compass were used to measure stratigraphic sections.

Elevations within the thesis area were obtained by the simultaneous use of an aircraft altimeter and an aneroid barometer. Readings from both instruments together were taken at critical points along the main roads, each instrument being used to check the other. A gravity station (alidade elevation) made by Barnes (1952) at Doss, Texas, was used as the base point. All readings were taken between 4:00 and 6:00 A.M. of the same day.

PREVIOUS INVESTIGATIONS

There has been much broad and general study of the geology of the Llano region in the past, with some detailed work done in specific areas. However, except for an overlap on the southeast corner, no detailed geologic study of the thesis area has been published.

Roemer (1846) made the first published observations of the Llano region in an account of his travels with an exploring party of German colonists. He briefly described some Cretaceous deposits and fossils, and also some granites.

B. F. Shumard (1861) confirmed the work of Roemer, and made the first tentative correlation of strata in the Llano area with that of the Potsdam group (Upper Cambrian) of the northern United States. In 1884, Walcott definitely established Shumard's "Potsdam group" as Upper Cambrian.

The results of a systematic geological survey of the Llano area in 1889, made under the auspices of the then newly formed Texas Geological Survey, were reported by individual authors. Comstock (1890) introduced the terms Hickory series, Riley series, and San Saba series for Cambrian and Ordovician strata exposed in the uplift. Tarr (1890) described the topography and drainage pattern of central Texas; and concluded that the principal streams of the region were initially developed on Cretaceous strata during Tertiary time and later superimposed upon Paleozoic rocks.

Paige (1911) named and briefly described the Cap Mountain, Wilberns, and Ellenburger formations, and used the name Hickory sandstone formation in place of Comstock's "Hickory series". Paige (1912), in a comprehensive geologic folio on the Llano and Burnet quadrangles, further described the Hickory sandstone, Cap Mountain, Wilberns, and Ellenburger formations.

Sellards, Adkins, and Plummer (1932) reviewed and discussed the Precambrian, Paleozoic, and Mesozoic stratigraphy and paleogeography of the Llano area. In 1934, Sellards described the major structural features of the Llano region, and mentioned the general northeast-southwest trends of faults.

Bridge (1937) named the Lion Mountain sandstone member of the Cap Mountain formation.

Barnes (1944) made the first mention of the Welge sandstone of the Wilberns formation, and described the stratigraphy of the Cretaceous rocks exposed in Gillespie County.

In a progress report on the stratigraphy of the Ellenburger group of central Texas, Cloud, Barnes, and Bridge (1945) revised the term Ellenburger limestone to Ellenburger group, and restricted it to beds of early Ordovician age. They also proposed the reduction of the Riley series to the rank of a formation which included as members the Hickory sandstone, Cap Mountain limestone, and Lion Mountain sandstone.

Barnes, Dawson, and Parkinson (1947) compiled a reconnaissance type geologic map of the Lange's Mill area which over-

laps the southeast corner of the thesis area in Gillespie County. With the exception of the Welge sandstone, the Wilberns formation was not differentiated into members on this map.

Bridge, Barnes, and Cloud (1947) described and redefined the two formations and eight members of the Upper Cambrian strata of central Texas. This publication has since become a standard reference to these rocks.

Cloud and Barnes (1948) published an extensive report on the Ellenburger group of central Texas. This report also included general descriptions of pre-and post-Ellenburger beds, and description of the geologic structure and history of the Llano region.

In 1950, Plummer's comprehensive description of the Carboniferous rocks of the Llano region was published posthumously. Included in this report was a detailed description of the Lower Cretaceous rocks and fossils of the Llano area.

Barnes, (1952) described the Upper Cambrian, Ordovician, Cretaceous, and Quaternary rocks exposed in the Squaw Creek quadrangle in Gillespie and Mason counties, and prepared a detailed geologic map of that area. The Squaw Creek quadrangle overlaps the southeast corner of the thesis area.

Barnes and Bell (1954) described the stratigraphy of the Cambrian rocks of the Llano area, and included within this description five graphic stratigraphic sections and three detailed measured sections.

Several unpublished theses have been done by graduate students at the Agricultural and Mechanical College of Texas on areas in Mason County generally north of but not overlapping the Doss-North area.

PHYSIOGRAPHY

CLIMATE AND VEGETATION

The Doss-North area lies within the semiarid Llano region. The average rainfall is approximately 22 inches per year, varying from a few inches to over 45 inches a year. Most of the rain usually falls during the winter and spring, leaving the summers hot and dry. The mean average temperature of Mason County is about 64° F., ranging from extremes of 110° F. in the summer to below zero in the winter.

The vegetation of the area belongs to a type adapted to a semiarid environment and thin rocky topsoil. The most prevalent trees are live oak, mesquite, and cedar. Common shrubs include agarita, Mexican persimmon, and catsclaw. Yucca plants and various species of cacti are also common. Grasses such as buffalo, crowfoot, and curly mesquite occur throughout the area.

Since the distribution and relative abundance of vegetation is to a large degree dependent upon the character of rock outcrop and associated soil, vegetation characteristic of unit outcrops will be discussed with stratigraphy.

TOPOGRAPHY

The major part of the Doss-North area lies within the topographic basin of the Llano uplift; however a small southwest portion is within the Edwards Plateau province. Precambrian and some Paleozoic rocks are exposed in the center of the Llano erosional basin, and more resistant Paleozoic and Cretaceous rocks

form the higher surrounding flanks and rim. Long fingers or remnants of the Edwards Plateau extend into the basin from the east, south and west sides. According to Plummer (1950), the maximum and minimum elevations of the Llano area are 2,000+ feet and 650 feet respectively, giving an approximate total relief of 1550 feet.

The maximum elevation of the Doss-North area, estimated to be about 1980 feet, is on a Cretaceous hill in the extreme southwest portion. The lowest elevation, approximately 1495 feet, is where Cow Valley Creek flows out of the northeast corner of the area. Therefore, the total relief of the area is about 485 feet.

In the northern part of the area north of Cow Valley Creek the lowermost beds of the Cap Mountain member form a low, gently sloping terrain. Just south of the creek more resistant beds of the upper part of the Cap Mountain limestone form a steep cuesta.

To the south and southeast of the cuesta formed by Cap Mountain limestone, hills composed of Point Peak shale and capped by bioherms form a high ridge trending southwest. These hills are the highest Paleozoic hills in the area, the highest being approximately 1800 feet in elevation.

The Cap Mountain limestone (repeated by faulting) and the Lion Mountain sandstone exposures in the east central portion of the area just south of the ridge of Point Peak shale and bioherms form a gently sloping, northeast-trending valley. To the form the higher surrounding flanks are [illegible]; long fingers or remnants of the [illegible] Plateau extend into the basin from the east, south and west sides. According to [illegible] ([illegible]), the maximum and minimum elevations of the [illegible] area are [illegible] feet and [illegible] feet respectively, giving an approximate total relief of [illegible] feet.

The maximum elevation of the [illegible]-North area, estimated to be about [illegible] feet, is on a Cretaceous hill in the extreme southwest portion. The lowest elevation, approximately [illegible] feet, is where Cow Valley Creek flows out of the northeast corner of the area. Therefore, the total relief of the area is about [illegible] feet.

In the northern part of the area [illegible] Cow Valley Creek the downcut banks of the Cap [illegible] form a [illegible] gently sloping terrain. Just south of the creek [illegible] resistant beds of the upper part of the Cap Mountain Limestone form a steep [illegible].

To the south and southeast of the area [illegible] formed by Cap Mountain limestone, hills composed of [illegible] are capped by [illegible] form a high ridge trending northwest. These hills are the highest [illegible] hills in the area, the highest being approximately [illegible] feet in elevation.

The [illegible] (capped by [illegible]) and the Lion Mountain [illegible] [illegible] of the [illegible] [illegible] to the east and south of the valley, exposures ranging from Welge sandstone to Ellenburger limestone and basal Cretaceous sand form a rolling terrain, rugged only where it is broken by the deeply entrenched Threadgill and Onion creeks.

In the extreme southwest and western portions, high mesa-like hills of Cretaceous rock extend into the area. Sandstone and siltstone form the steep basal portion of the mesas, and limestone forms the series of flat topographic benches of the upper portion.

DRAINAGE

The entire Llano region is within the watershed of the Colorado River and its tributaries, the San Saba, Llano, and Pedernales Rivers. According to Tarr (1890), these streams were superimposed upon the Paleozoic rocks and have been little modified by Paleozoic structure and rock character.

The Doss-North area is entirely within the Beaver Creek watershed and therefore within the larger Llano River drainage basin. Drainage of the area is generally eastward. Cow Valley Creek drains the northern third of the area, while Threadgill Creek and its tributaries, Hermon and Onion Creeks, drain the southern two-thirds of the area. All but Threadgill Creek are intermittent streams.

Generally the overall drainage pattern of the area is dendritic and without regard to local structure. However, some of the smaller streams such as Cow Valley Creek follow the

existing structure through much of their courses, and are subsequent. Short lengths of some of the larger streams such as Onion and Threadgill creeks are also partially adjusted to local structure.

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

GENERAL STATEMENT

Rocks exposed in the Doss-North area range in age from Cambrian to Recent, and include sandstones, siltstones, limestones, shales, conglomerates, and alluvium. Mississippian and Pennsylvanian strata that are common in other areas of the Llano uplift are absent in the thesis area. The oldest rock cropping out is the uppermost Hickory sandstone. The geologic column for the area is as follows:

- Cenozoic era
  - Quaternary
  - Tertiary (?) terrace gravel
- Mesozoic era
  - Cretaceous system
    - Lower Cretaceous
      - Limestone unit
      - Siltstone unit
      - Sandstone unit
      - Lange's Mill conglomerate
  - Mesozoic (?) arkosic conglomerate
- Paleozoic era
  - Ordovician system
    - Lower Ordovician
      - Ellenburger group
        - Tanyard formation
          - Threadgill member
- Cambrian system
  - Upper Cambrian
    - Wilberns formation
      - San Saba limestone member
      - Point Peak shale member
      - Morgan Creek limestone member
      - Welge sandstone member
    - Riley formation
      - Lion Mountain sandstone member
      - Cap Mountain limestone member
      - Hickory sandstone member

STRATIGRAPHY

GENERAL STATEMENT

Rocks exposed in the [illegible]-South area range in age from Cambrian to Recent, and include sandstones, siltstones, limestones, shales, conglomerates, and alluvium. Mississippian and Pennsylvanian strata that are common in other areas of the Llano uplift are absent in the thesis area. The oldest rock cropping out is the uppermost Hickory sandstone. The geologic column for the area is as follows:

Cenozoic era
  Quaternary
  Tertiary (?) terrace gravel

Mesozoic era
  Cretaceous system
    Lower Cretaceous
      [illegible]
      Siltstone unit
      Sandstone unit
      Lange's Mill conglomerate
  [illegible] (?) arkosic conglomerate

Paleozoic era
  Ordovician system
    Lower Ordovician
      Ellenburger group
        Tanyard formation
          Threadgill member

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

CAMBRIAN SYSTEM

The Cambrian period is represented in central Texas solely by Upper Cambrian strata - the Riley and Wilberns formations. All eight members of the two formations are exposed or partly exposed in the Doss-North area.

Riley Formation

The name Riley was first used as a series name by Comstock (1890) for Cambrian rocks exposed in the Riley Mountains in Llano County. This nomenclature was subsequently rejected by the United States Geological Survey, and in 1945, Cloud, Barnes, and Bridge (p. 154) named and defined the Riley formation to designate part of the same rocks. As defined, the formation includes all of the Cambrian strata in central Texas beneath the Wilberns formation. The formation is divided, from base to top, into Hickory sandstone, the Cap Mountain limestone and the Lion mountain sandstone members.

Hickory sandstone member

The term "Hickory series" was introduced by Comstock (1890) for Cambrian strata exposed near Hickory Creek in Llano County. Paige (1912) changed the name to Hickory sandstone formation. This was subsequently redefined by Cloud, Barnes, and Bridge (1945, p. 154) to Hickory sandstone member of the Riley formation.

CAMBRIAN SYSTEM

The Cambrian period is represented in central Texas solely by Upper Cambrian strata - the Riley and Wilberns formations. All eight members of the two formations are exposed or partly exposed in the Pontotoc area.

Riley Formation

The Riley series was named and described by Comstock (1890) for Cambrian rocks exposed in the Riley Mountains in Llano County. This nomenclature was subsequently rejected by the United States Geological Survey, but in 1945, Cloud, Barnes, and Bridge (p. 154) revised and defined the Riley Formation to designate part of the same strata. As defined, the formation includes all of the Cambrian strata in central Texas beneath the Wilberns Formation. The formation is divided, from base to top, into Hickory sandstone, the Cap Mountain limestone and the Lion Mountain sandstone members.

Hickory sandstone member

The term "Hickory series" was introduced by Comstock (1890) for Cambrian strata exposed near Hickory Creek in Llano County. Paige (1912) changed the name to Hickory sandstone formation. This was subsequently retained by Cloud, Barnes, and Bridge (1945, p. 154) as Hickory sandstone member of the Riley Formation.

As described by Bridge, Barnes, and Cloud (1947), the Hickory sandstone member of the Llano region ranges in thickness from a feather edge to about 415 feet, averaging 360 feet. The extreme upper part of the Hickory sandstone that crops out in the Doss-North area is estimated to be about 20 feet thick. Barnes (1952) measured 364 feet of Hickory sandstone in the Threadgill Creek composite section just east of the thesis area.

The outcrop, in the form of dark-red, residual soil, barely extends into the northern edge of the area. Just north of the area the Hickory crops out as well consolidated rock, and there the gradational contact with the overlying Cap Mountain limestone was placed at a distinct vegetational change at the base of a steep cuesta.

The entire outcrop of the Hickory sandstone is included within gently sloping to flat, cultivated fields.

Cap Mountain limestone member

Definition and thickness

The original Cap Mountain formation named by Paige (1911, p. 23) for Cap Mountain in Llano County was redefined by Cloud, Barnes, and Bridge (1945, p. 154) as the Cap Mountain limestone member of the Riley formation.

According to Bridge, Barnes, and Cloud (1947, p. 113), the Cap Mountain limestone in the Llano region ranges from about 135 to 455 feet thick, with an average thickness of 280 feet. Because of faulting and alluvial cover, a complete section of

As described by Bridge, [illegible] and Cloud (1947), the Hickory sandstone member of the Riley formation ranges in thickness from a feather edge to about 425 feet, averaging 300 feet. The extreme upper part of the Hickory sandstone that crops out in the Rose-[illegible] area is estimated to be about 70 feet thick. Barnes (1959) measured 381 feet of Hickory sandstone in the Threadgill Creek composite section just east of the [illegible] area.

The outcrop is in the form of [illegible] sandy residual soil, [illegible] into the [illegible] of the area. Just north of the area the Hickory crops out as well consolidated rock, and there the contact with the overlying Cap Mountain limestone was placed at a distinct [illegible] change at the base of a [illegible] quartz.

The entire outcrop of the Hickory sandstone is included within gently sloping to flat, cultivated fields.

Cap Mountain limestone member

<u>Definition and reference</u>

The original Cap Mountain [illegible] by Paige (1911, p. 23) for Cap Mountain in Llano County was redefined by Cloud, Barnes, and Bridge (1945, p. 154) as the [illegible] Cap Mountain limestone member of [illegible] formation.

According to Bridge, Barnes, and Cloud (1947, p. 113), the Cap Mountain limestone in the Llano region ranges from about 125 to 450 feet thick, with an average thickness of 280 feet. Because of [illegible] and alluvial cover, a complete section of

Cap Mountain limestone was not exposed in the Doss-North area; however the member was estimated to be about 430 feet thick. Barnes (1952) measured 418 feet of Cap Mountain in the Threadgill Creek composite section, part of which lies within the thesis area.

Lower Boundary

The Hickory - Cap Mountain contact is transitional, with the noncalcareous sandstone of the Hickory grading upward into the alternating impure limestones and calcareous sandstones of the Cap Mountain. A distinct change in vegetation and slope between the two members can usually be seen both in the field and on aerial photographs. The contact occurs at the base of a cuesta of Cap Mountain limestone. Although this type of change was not observed in the thesis area, it was noted just north of the area.

Lithology

The lower beds of the Cap Mountain member are predominantly dark-red, medium-grained, in part highly hematitic, calcareous sandstone, with an increasing amount of brown, arenaceous limestone toward the top. In the northwest part of the area, approximately 25 feet above the base of the member, a massive 3- to 4-foot bed of light-tan, fine- to medium-grained, well-sorted, essentially noncalcareous, quartz sandstone forms a prominent ledge similar to that formed by the Welge sandstone member of the Wilberns formation (Pl. II, fig. 1).

The lower beds grade upward into light brown to olive-gray, fine- to medium-grained, silty, slightly glauconitic limestones. Higher in the section the limestones are fine to medium grained, occasionally silty and sandy, and commonly glauconitic. Thick to massive bedding predominates (Pl. II, fig. 2). Generally the color is medium-gray mottled by browns and yellows.

In the upper part of the member, the limestones become dark greenish-gray and greenish-brown, coarse grained, and highly glauconitic. Except for occasional zones or lenses of trilobite fragments, this interval is generally sparsely fossiliferous. The upper contact with the Lion Mountain sandstone member is transitional.

Topography and Vegetation

The Cap Mountain outcrop forms a prominent cuesta in the north part of the area, with the dip slope toward the southeast. In the northwest portion of the area a partially dissected plateau has been formed from the gentle dip slope of the cuesta.

In the northern part of the area the outcrop is characterized by scrub oak, Spanish dagger, persimmon, and, in places, by extremely thick growths of catsclaw. Thickets of cedar are characteristic of the outcrop in the southeast part of the area.

Lion Mountain sandstone member

Definition and Thickness

The Lion Mountain sandstone member was named by Bridge (1937) for Lion Mountain in northwestern Burnet County, Texas.

The lower unit grades upward into light gray to olive gray, fine- to medium-grained, silty, slightly glauconitic lime-stones. [illegible] the limestones are fine to medium grained, [illegible] and [illegible], and commonly glauconitic. Thin [illegible] (Pl. 11, Fig. 2). Generally the [illegible] and yellow.

In the [illegible] of the [illegible] the [illegible] bottom with [illegible] and highly glauconitic [illegible] the [illegible] is generally [illegible]. The upper contact with the [illegible] sandstone member is transi-tional.

Topography and Distribution

The Dog Mountain member forms a prominent scarp in the north part of the area, with the dip slope toward the northeast. In the northeast portion of the area a partially [illegible] hill has been formed from the gentle dip slope of the basalt.

In the southern part of the area the outcrop is character-ized by scrub oak, [illegible], and, in places, by [illegible] characteristic of the [illegible] part of the area.

[illegible]

Definition and Thickness

The Dog Mountain [illegible] member was named by [illegible] (1937) for [illegible]

Bridge originally defined this sandstone as the top member of the former "Cap Mountain formation". However Cloud, Barnes, and Bridge (1945, p. 154) made the Lion Mountain sandstone the top member of their newly defined Riley formation. They retained the original boundaries of the sandstone.

The Lion Mountain sandstone in the Llano region ranges from about 20 to 69 feet in thickness. In the Doss-North area the member was estimated to be approximately 69 feet thick.

Lower Boundary

The Cap Mountain - Lion Mountain contact is transitional, with the greenish-brown, relatively massive limestones of the Cap Mountain grading upward into the highly glauconitic sandstones, siltstones, and thin-bedded limestones of the Lion Mountain. The contact was placed at the lower edge of the characteristic, sparsely vegetated, topographic bench of the Lion Mountain, which roughly coincides with the first appearance of green, glauconitic, quartz sandstone and siltstone.

Lithology

The Lion Mountain sandstone member is composed chiefly of medium- to coarse-grained, highly glauconitic, commonly calcareous sandstone with minor portions of glauconitic limestones, and lesser amounts of silty shale. The limestones are greenish-gray, cross bedded, coarse grained, and highly fossiliferous. Limestone predominates in the lower part of the member, with the

sandstone becoming more abundant upward and composing the bulk of the upper half of the member.

Much of the limestone is in the form of relatively flat lenses of trilobite fragments and phosphatic brachiopods. The sandstone is composed roughly of equal amounts of glauconite and quartz grains, with a minor amount of calcite. T. D. Daugherty (personal communication, 1959) found that, in about the uppermost foot of Lion Mountain sandstone, the sand and silt grains become coarser and less well sorted than those below.

Blackish-red, hard, siliceous, hematite nodules litter the weathered slopes of the Lion Mountain outcrops (Pl. III). Because these nodules are found only on the surface of the outcrop, they are believed to be a weathering product of the concentrated glauconite. The glauconite apparently weathers relatively easily and the soluble ferrous iron and colloidal silica are dissolved by ground-water. By capillary action and subsequent dehydration the ferrous iron and colloidal silica are concentrated in the soil profile as insoluble ferric oxide (hematite, Fe_2O_3) and quartz respectively. Pettijohn (1952, p. 138) stated that hematite may represent a progressive dehydration and hardening of a gel, analogous to that shown by silica.

The top of the Lion Mountain member is marked by a disconformity.

PLATE III

WEATHERED SLOPE OF LION MOUNTAIN SANDSTONE
LITTERED WITH BLACK HEMATITE NODULES

About 2/3 mile east of Ranch-to-Market Road 783 near center of area. 'Weathered out' lenses of trilobite coquina near right edge of picture.

Topography and Vegetation

The Lion Mountain characteristically forms a relatively narrow, sparsely vegetated, topographic bench between the outcrops of the Cap Mountain limestone and the Welge sandstone.

Vegetation on the outcrop is typically sparse and scattered; on aerial photographs the nearly bare bench is quite distinct.

Wilberns Formation

The Wilberns formation was named by Paige (1911, p. 45) for Wilberns Glen, on Little Llano River, in northeastern Llano County. Barnes (1944, p. 37) very briefly redefined the Wilberns formation and mentioned the four included members - the Welge sandstone, Morgan Creek limestone, Point Peak shale, and San Saba limestone, in ascending order. Finally the Wilberns was more completely described by Bridge, Barnes, and Cloud (1947).

Welge sandstone member

Definition and Thickness

The Welge sandstone member was named by Bridge and Barnes (Barnes, 1944, p. 37) for the Welge land surveys in Gillespie County. According to Bridge, Barnes, and Cloud (1947, p. 115), the Welge sandstone in the Llano region varies in thickness from 9 to 35 feet, with an average thickness of 18 feet. In the type section along Squaw Creek, half a mile north of the Gillespie County

line, the Welge is 23 feet thick. In the Doss-North area the Welge is estimated to be about 23 feet thick.

Lower Boundary

The Lion Mountain sandstone - Welge sandstone contact is disconformable, with the orange-brown, resistant sandstone of the Welge resting on the more unconsolidated sandstone and siltstone of the Lion Mountain member.

Lithology

The Welge member is a yellowish- to orange-brown, massively bedded, fine- to medium-grained, generally nonglauconitic, quartz sandstone. The lowermost foot of section is slightly glauconitic in places. The quartz grains are well sorted and rounded, and many have secondary recomposed faces (Barnes, 1947, p. 114) which glitter in the sunlight. In normal outcrop within the report area the sandstone is somewhat friable; but where it is adjacent to or included within the fault zones it has become well indurated by a hard siliceous cement.

Topography and Vegetation

The outcrop of the Welge forms a prominent ledge or low cuesta between the Morgan Creek and Lion Mountain members. Weathered fragments of the Welge sandstone litter the slope of the Lion Mountain sandstone near the Welge - Lion Mountain contact (Pl. IV).

PLATE IV

Figure 1. LEDGE OF WELGE SANDSTONE RESTING ON LION MOUNTAIN SANDSTONE BENCH
Located 160 feet east of Ranch-to-Market Road 783 just north of pipeline crossing.

Figure 2. DISCONFORMABLE LION MOUNTAIN-WELGE CONTACT (RILEY-WILBERNS CONTACT)
About 2/3 mile east of Ranch-to-Market Road 783 near center of area. Litter on Lion Mountain bench is mostly from overlying Welge sandstone.

The Welge outcrop is marked by dense vegetation which characteristically includes scrub oak and mesquite. This dense growth shows up as a distinctly dark band on aerial photographs.

Morgan Creek limestone member

Definition and Thickness

The Morgan Creek limestone member was named by Bridge (1937) for Morgan Creek in Burnet County, Texas. According to Bridge, Barnes, and Cloud (1947, p. 115) the Morgan Creek member varies in thickness from about 70 feet to about 160 feet, averaging about 120 feet. In the Doss-North area the measured thickness of the member was 138 feet.

Lower Boundary

The Welge sandstone - Morgan Creek limestone contact is gradational, with the yellowish-orange, noncalcareous sandstone of the Welge grading upward into the dark-red or maroon, coarse-grained, sandy limestone of the Morgan Creek. The boundary was placed at the lowermost maroon, arenaceous limestone. A slight topographic change is present - the gentle slope of the cuesta formed by the Welge reverses to the steeper stairstep slope of the Morgan Creek. Also the Welge outcrop is marked by a dense belt of vegetation in contrast to the more sparsely vegetated Morgan Creek outcrop.

Lithology

The lower part of the Morgan Creek consists of maroon, coarse-grained, sandy limestones which grade upward into grayish-pink to greenish-gray, finer-grained, glauconitic limestones. The bedding varies from massive near the base to medium in the upper part of this interval.

The upper half of the member is composed chiefly of dark-gray to greenish-gray, medium-bedded, medium-grained, commonly glauconitic limestones, alternating with thin-bedded, fine-grained, silty limestones, siltstones and silty calcareous shales. Beds of stromatolitic bioherms from 6 inches to 3 feet in diameter occur throughout this upper interval. Some of these stromatolitic limestones are quite persistent, and form ledges that can be traced laterally across the entire outcrop. Near the top of the member, just below the uppermost medium-bedded limestones, there is a silty or shaly zone about 10 feet thick that is much like the overlying Point Peak shale.

Most of the Morgan Creek is highly fossiliferous, with common occurrences of trilobite fragments or "hash" and corneous brachiopods. At most places a characteristic zone containing an abundance of the brachiopod Neorthis texana occurs about 30 feet above the base of the member.

Topography and Vegetation

The Morgan Creek outcrop generally forms a stair-stepped slope between the Welge and Point Peak members. In the central parts

Lithology

The Point Peak shale is composed of grayish-green to light brown, thin-and well-bedded, calcareous shales and siltstones, with subordinate amounts of fine-grained limestones, intraformational limestone conglomerates, and thin-bedded dolomites (Pl. V, fig. 1). Stromatolitic bioherm zones generally occur throughout the lower middle portion of the member, with shale found above, below, and between these zones. The shales and siltstones occur in beds from 1/2 to 6 inches thick, and both are slightly to moderately micaceous. The limestones are usually gray to brown, thin-bedded and commonly glauconitic. The intraformational conglomerates or "edgewise" conglomerates consist of angular, flattened pebbles of variously colored limestones, arranged haphazardly in a silty, calcareous matrix, and occur in beds from 1 inch to 1 foot thick (Pl. V, fig. 2).

The stromatolitic bioherm zones, comprising nearly one-quarter of the Point Peak member, vary both in thickness and in stratigraphic position. Although the thickest zones occur in the lower part of the middle of the member, 1- to 2-foot beds of small bioherms, similar to those in the Morgan Creek limestone, are found locally throughout the Point Peak shale. In the measured section along Threadgill Creek, a bioherm zone about 37 feet thick occurs 73 feet below the Point Peak - San Saba contact (Pl. VI, fig. 1). This stratigraphically low occurrence contrasts markedly to other areas of the Llano uplift, where the top of the bioherms was selected as the Point Peak - San Saba boundary, or where the

[illegible]

The [illegible] shale is composed of [illegible] interbedded [illegible] thin [illegible] well-bedded, calcareous shales and silty stone, with [illegible] content of [illegible] and limestone; interbedded [illegible] limestone [illegible], of [illegible] color (Pl. 7, fig. 2). Stratigraphic [illegible] generally occur throughout the lower middle portion of the section, with [illegible] and [illegible]. The shales are [illegible] in [illegible], and both are [illegible] to [illegible]. The [illegible] are usually [illegible]. The [illegible] conglomerate or [illegible] conglomerate consists of [illegible] pebbles of [illegible] limestone, [illegible] in a [illegible], and [illegible] about [illegible] feet thick (Pl. [illegible], fig. 2).

The [illegible] comprises nearly one-quarter of the [illegible] section, [illegible] in thickness and [illegible] position. Although [illegible] occur in the lower part of the middle of the section [illegible] of small thickness, and [illegible] in the [illegible] limestone, and [illegible] locally throughout the [illegible]. [illegible] about 30 feet thick occurs [illegible] the [illegible] (Pl. [illegible], fig. [illegible]). This [illegible] contrasts markedly in [illegible] areas of [illegible], was [illegible] to [illegible] the selected [illegible] boundary of [illegible].

PLATE V

Figure 1. POINT PEAK THIN-BEDDED SHALE AND SILTSTONE
On north bank of Threadgill Creek about 1/2 mile northeast of C. Heard's house.

Figure 2. WEATHERED BOULDER OF POINT PEAK INTRAFORMATIONAL CONGLOMERATE
In extreme northeast part of area.

Schaak

F10

PLATE VI

Figure 1. POINT PEAK BIOHERM ZONE
On east bank of Threadgill Creek about 1/2 mile northeast of Lange's Mill. Note shale interbedded with bioherms.

Figure 2. "CABBAGE HEAD" STRUCTURE OF POINT PEAK BIOHERMS
In northeast part of the area.

bioherms were included completely within the San Saba limestone. In the northern part of the thesis area generally two or three bioherm zones, each 10 to 20 feet thick, are found in the upper middle part of the Point Peak. Locally any one of these zones may grade laterally into bedded limestone or shale, but usually at least one zone is always present. In the Doss-North area, the bioherm zones 10 or more feet thick were mapped as separate units of the Point Peak member.

The stromatolitic bioherm zones are composed of greenish-gray and mottled, microgranular to sublithographic limestone, which is thought to be algal in origin. Intraformational conglomerate occurs locally between individual bioherms. Concentric or "cabbage head" structures form on the weathered surface of the bioherms (Pl. VI, Fig. 2).

Overall the Point Peak shale is not highly fossiliferous; however brachiopods are locally common throughout the member. A persistent, thick bed of brown limestone containing silicified brachiopods occurs about 45 feet below the top of the shale.

Topography and Vegetation

The outcrop of the Point Peak shale forms a steep to gentle slope between the underlying Morgan Creek limestone and the more resistant bioherm zones. Where two bioherm zones are present, the shale forms a moderate slope between them. The bioherm zones usually cap the high hills of Point Peak shale in the northeast

portion of the area, or form steep ledges on the upper parts of ridges.

The shale outcrop is characterized by mesquite, some live oak, and much persimmon and agarita. A particularly heavy growth of live oak, which appears as a dark band on aerial photographs occurs on the lower part of the bioherms and on the shale immediately below. Locally the bioherms are bare of vegetation, except for some catsclaw and persimmon.

San Saba limestone member

Definition and Thickness

The San Saba limestone member was named by Bridge (Bridge, Barnes, and Cloud, 1947, p. 117) for exposures at and near the Mason - Brady highway bridge over the San Saba River, northwest of Camp San Saba, McCulloch County, Texas. Comstock (1890, p. 301) originally used the term "San Saba Series" for these same beds or for some part of them. According to definition by Bridge, Barnes, and Cloud (1947, p. 117), the member is composed of the "more or less glauconitic limestone" occurring between the underlying Point Peak shale member of the Wilberns formation and the overlying Threadgill member of the Tanyard formation. It is the uppermost member of the Wilberns formation and of the Cambrian system.

The San Saba member is 280 feet thick at the type section and averages about the same throughout the Llano uplift.

In the Doss-North area, the measured thickness of the member is 271 feet.

Lower Boundary

The Point-Peak - San Saba contact is gradational, with the gray-brown clacareous siltstones, shales, and gray- to greenish-brown, fine-grained, slightly glauconitic limestone of the Point Peak grading upward into light-gray to cream, thin-bedded, sub-lithographic limestones of the San Saba. Inasmuch as stromatolitic bioherms do not occur at the top of the Point Peak in this area, the boundary was placed at the bottom of the first beds of hard limestones. The boundary has no topographic expression.

Lithology

The lower third of the San Saba limestone member is composed of light-gray (mottled yellow) to light-cream, generally thin-bedded, sublithographic to fine-grained, nodular limestone. The yellow color of the beds, which is characteristic elsewhere in the Llano region, is not as pronounced in this area. Beds are usually 1/4 to 1 1/2 inches thick, but occasionally are up to 8 inches thick, and are interbedded with thin siltstones and shale. This portion of the member contains thin beds of intraformational conglomerate, thin beds of extremely glauconitic limestone, and coarse-grained, highly fossiliferous, occasionally cross-bedded limestone. The intraformational conglomerates in the lower third of the San Saba are of two types: (1) those lithologically similar

In the Dome-North area, the measured thickness of the member is 291 feet.

Lower boundary

The Tonto-San Saba contact is gradational with the gray-brown [illegible] siltstones, shales, and gray- to greenish-brown, fine-grained, slightly glauconitic limestones of the [illegible] beds grading upward into light-gray to cream, thin-bedded, [illegible] limestones of the San Saba. Inasmuch as [illegible] fossils occur at the top of the [illegible] in this area, the boundary was placed at the bottom of the first beds of [illegible] limestones. The boundary has no topographic expression.

Lithology

The lower third of the San Saba limestone member is composed of light-gray (weathered yellow) to light-cream, generally thin-bedded, [illegible] to fine-grained, nodular limestone. The yellow color of the beds, which is characteristic elsewhere in the Llano region, is not as pronounced in this area. Beds are usually 1/4 to 1 1/2 inches thick, but occasionally are up to 3 inches thick, and are interbedded with thin siltstones and shale. This portion of the member contains thin beds of intraformational conglomerate, thin beds of extremely glauconitic limestone, and coarse-grained, highly fossiliferous, occasionally cross-bedded limestone. The intraformational conglomerates of the lower third of the San Saba of the area [illegible] [illegible] to the Point Peak shale member, and (2) those in which the limestone pebbles are in a limestone matrix and the conglomeritic character is revealed only by weathering. A 5-foot zone of small bioherms occurs near the top of this portion of the member.

The upper two-thirds of the member is composed chiefly of light-gray to greenish-gray and brown, medium- to coarse-grained, thin- to thick-bedded, glauconitic limestones, with occasional interbedded siltstones. This portion of the member is highly fossiliferous and, as in the lower third of the member, contains thin beds of intraformational conglomerate, formed by limestone pebbles in a limestone matrix.

In the northeastern quarter of the area a bioherm zone of considerable thickness (over 15 feet) occurs about 15 feet above the base of the San Saba member. Bridge, Barnes, and Cloud (1947) considered the thick bioherm zone occurring in the Camp San Saba area, McCulloch County, as belonging to the Point Peak member. However in 1954, Barnes and Bell (p. 15, 20) placed the thick bioherm zones of that area within the lowermost portion of the San Saba limestone member. It appears that the occurrence of bioherm zones within the lower part of the San Saba member is fairly common in the western part of the Llano uplift. In the thesis area these bioherms appear to be of the same stromatolitic character as the Point Peak bioherms, except that they are greenish-brown to brown in color and, in places, considerably dolomitized. Although no thick bioherm zones are present in the measured section of San Saba along Threadgill Creek, Barnes (1952) mapped large zones [illegible] Barnes (1952) placed [illegible]

[illegible] of San

color and [illegible] nonclastic constituents. Although no

Point Peak [illegible] brown

[illegible] the same [illegible] as the

[illegible]

[illegible] the lower part [illegible]

[illegible] concordance of [illegible]

[illegible] of the [illegible]

[illegible] in 1956, [illegible] (p. 19, 20) placed the [illegible]

[illegible] County, [illegible] to the Point Peak member.

[illegible] in the [illegible] area,

the base of the San Saba member. [illegible] and [illegible] (1947)

of [illegible] thickness [illegible]

In the [illegible] area a [illegible] zone

[illegible] in a limestone matrix.

thin beds of intraformational conglomerate, [illegible]

[illegible] and, as in the lower part of the member, numerous

interbedded siltstones. [illegible] portion of the member is [illegible]

thin- to thick-bedded, [illegible] limestone [illegible], with occasional

is light-gray to greenish-gray and brown, [illegible]

The upper two-thirds of the member is [illegible]

occurs near the top of this portion of the member.

is [illegible] only [illegible] zone in [illegible]

[illegible] the matrix [illegible] characteristic

to the Point Peak white member, and (2) those in which the lime one

1 3/4 miles farther northeast on strike with this section. Apparently the San Saba bioherm zones grade laterally into other facies as do the Point Peak bioherm zones.

In the measured section in Threadgill Creek, the San Saba as a whole is highly fossiliferous, containing an abundance of trilobites, brachiopods and some gastropods. Small subspherical structures about penny- to pea-sized and called <u>Girvanellas</u> are visible on bedding surfaces of some limestones. Cloud and Barnes (1948, p. 30) refer to these structures as stromatolites and therefore they are of algal origin.

<u>Topography and Vegetation</u>

In the southern half of the area where Onion and Threadgill creeks have cut deeply into the limestone, the San Saba member forms high bluffs (Pl. VII). On the nearly flat hilltops in the northeastern quarter of the area, the weathered surface of the San Saba is littered with thin, platy slabs of limestone.

The San Saba outcrop is usually somewhat sparsely vegetated with live oak, Mexican persimmon, and cedar.

ORDOVICIAN SYSTEM

The Ordovician system is represented in the Llano uplift by rocks of Early and Late Ordovician age. The lower Ordovician rocks of the Ellenburger group, according to Cloud and Barnes (1948), are essentially equivalent to the lower half of the Lower Ordovician of the Ozark uplift in Missouri and Arkansas.

1 1/4 miles further northeast on a trail up this anticline. [illegible] apparently the San Saba biostrome grades laterally into other facies as do the [illegible] biostrome zones.

In the measured section in Threadgill Creek, the [illegible] a abundance of trilobites, brachiopods and some gastropods. Small cylindrical structures [illegible] and called *Girvanella* are visible on [illegible] surfaces of some limestones. Cloud and Barnes (1948, p. 73) refer to these structures as stromatolites and therefore they are of algal origin.

Topography and Vegetation

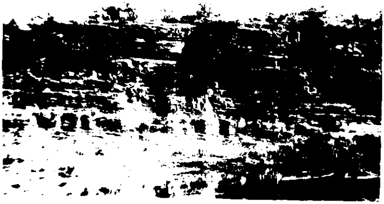
In the southern half of the area where [illegible] and Threadgill creeks have cut deeply into the limestone, the San Saba forms high bluffs (Pl. VIII). On the nearly flat hilltops in the northeastern quarter of the area, the weathered surface of the San Saba is littered with small, platy slabs of limestone.

The San Saba outcrop is usually somewhat sparsely vegetated with live oak, Spanish persimmon, and cedar.

ORDOVICIAN SYSTEM

The Ordovician System is represented in the map area by rocks of Early and Late Ordovician age. The lower divisions of the Ellenburger group, according to Cloud and Barnes (1948), are essentially equivalent to the lower half of the Lower Ordovician of the Ozark uplift in Missouri and Arkansas.

PLATE VII



BLUFF OF SAN SABA LIMESTONE MEMBER

Just downstream from Lange's Mill on the north bank of Threadgill Creek. Barnes (1948, p. 411) reported that the bluff is about 60 feet high and formed by limestones of the lower part of the member.

Ellenburger Group

The "Ellenburger limestone" was named by Paige (1911, p.24) for the Ellenburger Hills in the Burnet quadrangle. Paige considered the included limestones and dolomites to be "Cambro-Ordovician" in age. Cloud, Barnes, and Bridge (1945) revised the term "Ellenburger limestone" to Ellenburger group, which they restricted to beds of early Ordovician age. They also divided the group into three formations, which are, in ascending order, the Tanyard, Gorman, and Honeycut formations. Of these, only the Tanyard formation is present in the Doss-North area.

Tanyard Formation

The Tanyard formation was named for rocks exposed at the Tanyard locality, on the east bank of Buchanan Lake in northwestern Burnet County, Texas. The formation is divided into the Threadgill and Staendebach members, lower and upper respectively. Averaging 585 feet thick, this formation is composed chiefly of limestone and dolomite. Only the Threadgill member is present in the thesis area.

Threadgill member

Definition and Thickness

Originally defined as the "Threadgill limestone" by Bridge and Barnes (Barnes, 1944, p. 37), the Threadgill unit was revised to member status by Cloud, Barnes, and Bridge (1945, p. 143) to include

Ellenburger Group

The "Ellenburger limestone" was named by Paige (1911, p.24) for the Ellenburger Hills in the Burnet quadrangle. Paige consider- ed the Ellenburger limestone and dolomite to be Canadian-Ordovician in age. Cloud, Barnes, and Bridge (1945) raised the term "Ellen- burger limestone" to group status [illegible] [illegible] three formations, which are, in ascending order, the Tanyard, Gor- man, and Honeycut formations. In Mason County only the Tanyard formation is present in the study area.

Tanyard Formation

The Tanyard formation was named for rocks exposed at the Tanyard locality, on the east bank of [illegible] in northwestern Burnet County, Texas. The formation is divided into the Threadgill and [illegible] members, lower and upper, respectively. Averaging 350 feet thick, this formation is composed chiefly of limestone and dolomite. Only the Threadgill member is present in the study area.

Threadgill member

Definition and Thickness

Originally defined as the "Threadgill limestone" by [illegible] (Barnes, 1944, p. 37), the Threadgill [illegible] by Cloud, Barnes and Bridge (1945, p. 153) to include dolomite equivalent to the original limestone. The member was named after exposures on Threadgill and Mormon Creeks, south of Lange's Mill, Gillespie County. These exposures are within the thesis area.

According to Cloud, Barnes, and Bridge (1945, p. 143) the Threadgill member ranges in thickness from 91 feet in the eastern part of the Llano region to 313 feet in the western part. In the type section within the thesis area, the measured thickness of the member is 280 feet (Barnes, 1952).

Lower Boundary

Although the Cambrian - Ordovician contact is disconformable in the eastern part of the Llano uplift (Cloud and Barnes, 1948, p. 31) in the western part the contact appears to be transitional (Pl. VIII, Fig. 1). In the Doss-North area the medium-gray and greenish-gray, granular, intermittently glauconitic limestones of the San Saba member (Wilberns formation) grade upward into the wood-ash gray and buff, nonglauconitic, sublithographic limestones of the Threadgill member (Tanyard formation). The boundary was placed between the last occurrence of glauconite in the San Saba and first appearance of the gastropods Ophileta and Lytospira in the Threadgill. Cloud and Barnes (1948, p. 61) stated that Ophileta and Lytospira first appear at the base of the Lower Ordovician, the Ophileta having a long range within the Lower Ordovician, and Lytospira having a long range within the Ordovician. In this area there are nearly as many fault contacts between the

PLATE VIII

Figure 1. CONFORMABLE CAMBRIAN-ORDOVICIAN CONTACT (TRANSITIONAL SAN SABA-THREADGILL CONTACT)
On west bank of Threadgill Creek about 1/2 mile upstream from Lange's Mill. Contact indicated by white line.

Figure 2. BLUFF OF THREADGILL LIMESTONE MEMBER
On south bank of Threadgill Creek about 200 yards east of Ranch-to-Market Road 783 bridge. Bluff about 30 feet high.

San Saba and Threadgill members as there are sedimentary contacts. The presence of Girvanellas in San Saba limestones in contrast to their apparent absence in the Threadgill limestones was used cautiously to differentiate between the two members. The San Saba - Threadgill contact has no topographic expression.

Lithology

The Threadgill member is predominantly a wood-ash-gray to beige, thin-bedded, almost totally nonglauconitic, sublithographic limestone. Limestone intraformational breccias and conglomerates, and yellowish-brown, dolomitized burrows and trails are common throughout the member. Some fine-grained limestones and siltstones are also present, and dolomite zones occur near the top of the member.

The Threadgill member is considered highly fossiliferous by Barnes (1952). Most of the fossils are readily visible only on the bedding surfaces. Gastropods such as Ophileta and Lytospira predominate, with some brachiopods and trilobites present.

Where covered, the Threadgill member is overlain by either Cretaceous sand and conglomerate, or by Tertiary - Quaternary terrace gravel and alluvium.

Topography and Vegetation

Along the courses of Onion and Threadgill Creeks the Threadgill limestone has formed bluffs 15 to 30 feet high (Pl. VIII, fig. 2). In other parts of the area the member is topographically expressed as an upland flat or as gently rolling hills.

The Tabo and Thurstgill [illegible]. There are intertonguing contacts. [illegible] continue to [illegible] Thurstgill limestones are used arbitrarily to differentiate between the two members. The Tabo - Thurstgill contact [illegible] for mapping convenience.

Lithology

The Thurstgill member is predominantly a [illegible] grey to [illegible], thin-bedded, [illegible] limestone. [illegible] breccias and conglomerates, and yellow-weathering, [illegible] burrows and trails are common throughout the member. Some fine-grained limestones and siltstones are also present, and [illegible] occurs near the top of the member.

The Thurstgill member is considered highly fossiliferous by [illegible] (1958), but [illegible] readily visible [illegible] the bedding surfaces. [illegible] and [illegible] [illegible], with some bryozoans and [illegible] present.

Where exposed, the Thurstgill member is overlain by [illegible] and conglomerate, or by Tertiary - Quaternary [illegible] gravel and alluvium.

Topography and Vegetation

Along the courses of Tabo and Thurstgill Creeks the Thurstgill limestone has formed bluffs 15 to 30 feet high (Pl. VIII, fig. 2). In other parts of the area the member is topographically expressed as a [illegible] flat or gently rolling slope.

Vegetation, which is typically sparse, consists of essentially the same type characteristic of the San Saba limestone: live oak, Mexican persimmon and cedar. The tops of Threadgill limestone bluffs in some places support a thick growth of cedar.

ROCKS OF UNCERTAIN MESOZOIC AGE

Arkosic conglomerate

Definition

In 1954 Grote (p. 30) described an exposure of arkosic conglomerate in the Central Bluff Creek Area. Grote gave the age as questionably Mesozoic. Rogers (1955) described, in detail, arkosic conglomerate from fourteen outcrops located in Mason, Menard, and Kimble counties, and concluded that the conglomerate was of Early Cretaceous age. Woolsey (1958) briefly described arkosic conglomerate in the Squaw Creek - Marshal Creek area, but reached no definite conclusions as to age.

Only one small outcrop of arkosic conglomerate is present in the Doss-North area. This particular rock appears to have been deposited sometime during the Mesozoic era, either as alluvium on the Paleozoic erosion surface before the advance of early Cretaceous seas, or as the lower part of the earliest sand deposited by the encroaching seas.

[illegible]ation, which is typically exposed, consists of essentially the same type characteristic of the [illegible] lime- stone [illegible], [illegible] and others. The type of [illegible] [illegible] limestone [illegible] in some places [illegible] and in growth of [illegible].

ROCKS OF CRETACEOUS AGE

[illegible] conglomerate

Definition

[illegible] conglomerate in the [illegible] area, [illegible] as questionably [illegible]. [illegible] (19[illegible]) described, in detail, although [illegible] in [illegible], [illegible], and [illegible] counties, and [illegible] a conglomerate are of Early Cretaceous age. [illegible] (1951) briefly described several conglomerate in the [illegible] - [illegible] Creek area, but reached no definite conclusion as to age.

Only one small outcrop of [illegible] conglomerate is present in the [illegible] area. This conglomeratic rock appears to have been deposited sometime during the Mesozoic era, either as alluvium on the Paleozoic-erosion surface before the advance of early Cretaceous seas, or as the lower part of the earliest sand deposited by the encroaching seas.

Character

The arkosic conglomerate is composed essentially of poorly sorted, quartz and pink microcline pebbles, cemented by a siliceous, hematitic matrix. The pebbles range from medium sand size to 1/2 inch in diameter. Overall color of the conglomerate ranges from dark maroon to dark gray. As a result of the siliceous cement the conglomerate is a very hard, resistant rock.

The conglomerate crops out in only one locality, where it unconformably overlies the glauconitic sandstone of the Lion Mountain member. Possibly the cement for the conglomerate was derived from the underlying glauconite. The unit is estimated to be about 3 feet thick in this area.

Stratigraphic Relationships

The true stratigraphic position of the arkosic conglomerate is not apparent in the thesis area. The only definitely known stratigraphic relationship is that the conglomerate directly overlies the Lion Mountain sandstone member of the Riley formation.

Rogers (1955, p. 15) reported that in northeast Kimble County undisturbed arkosic conglomerate overlies faulted and folded middle Pennsylvanian rocks, thereby indicating an age at least younger than middle Pennsylvanian and probably post-Pennsylvanian for that particular conglomerate. He also stated (p. 16) that the superposition of Lower Cretaceous beds upon three separate outcrops of arkosic conglomerate precluded the possibility of the conglomerate being younger than Early Cretaceous. For lack of evidence to the

Structure

The sandstone and arkose is composed dominantly of poorly sorted, coarse and [illegible] pebbles, cemented by a siliceous, [illegible] matrix. The pebbles range from medium sand size to 1/2 inch in diameter. Overall color of the conglomerate [illegible] the matrix [illegible] to a very dark, reddened [illegible].

The conglomerate [illegible] locality, seems to [illegible] overlies the [illegible] of the [illegible] Mountain members. Possibly the extent [illegible] the conglomerate was limited [illegible] the [illegible] to be [illegible] in this area.

Stratigraphic Relationships

The true stratigraphic position of the arkosic conglomerate is not apparent in the thesis area. The only definitely known stratigraphic relationship is that the conglomerate directly overlies the [illegible] Mountain volcanic member of the [illegible] formation.

Rogers ([illegible], p. 15) reported that in northwest Middle Georgia undifferentiated conglomerate overlies faulted and folded middle Pennsylvanian rocks, thereby indicating an age at least younger than middle Pennsylvanian and probably post-Pennsylvanian for that particular conglomerate. He also stated (p. 16) that the superposition of lower Cretaceous beds upon three separate outcrops of arkosic conglomerate precluded the possibility of the conglomerate being younger than Early Cretaceous. The lack of evidence on the contrary, the arkosic conglomerate of the thesis area is also considered to have been deposited after Pennsylvanian time.

Inasmuch as outcrops of arkosic conglomerate in other areas of the Llano uplift are directly overlain by Lower Cretaceous rocks and the arkosic conglomerate of the Doss-North area contains no fragments of Cretaceous rocks, the arkosic conglomerate of this area is considered to be not younger than Early Cretaceous. The Lange's Mill conglomerate also does not contain any fragments of Cretaceous rocks but is composed chiefly of pebbles of Paleozoic limestones and is therefore considered to be no younger than Early Cretaceous.

Several physical relations of the arkosic conglomerate are evident in the thesis area. The conglomerate occurs in an intensely faulted, relatively high, flat portion of the area. It is 45 feet higher in elevation than the highest and nearest outcrop of the Lange's Mill conglomerate, and is both higher and lower than outcrops of the Cretaceous sandstone. The arkosic conglomerate and the basal part of the sandstone unit are similar in that they both are composed chiefly of poorly sorted, subangular quartz grains, and are in some degree ferruginous. They are dissimilar in that the arkosic conglomerate contains an appreciable amount of feldspar, is totally noncalcareous, and is highly indurated; whereas the sandstone unit contains no observed feldspar, is calcareous, and is unindurated to slightly indurated.

In the Squaw Creek - Marshall Creek area, about six miles due east of the arkosic outcrop in the thesis area, a similar arkosic conglomerate is exposed. According to Woolsey (1958), this outcrop is surrounded by alluvium, but appears to be in a highly faulted area and stratigraphically between the Paleozoic and lowermost Cretaceous rocks.

In the Doss-North area, two possible stratigraphic positions for the arkosic conglomerate are considered: (1) as a deposit between the Lange's Mill conglomerate and the overlying sandstone unit, either as an alluvial apron or as the basal portion of the sandstone; and therefore younger than the Lange's Mill conglomerate, and (2) as an alluvial deposit upon the pre-Cretaceous erosion surface, and older than the Lange's Mill conglomerate.

There are several indications that the arkosic conglomerate might belong stratigraphically between the Lange's Mill conglomerate and the Cretaceous sandstone unit. The higher elevation of the arkosic conglomerate compared to that of the Lange's Mill conglomerate indicates a possible stratigraphic position above the Lange's Mill unit. Also, the similarity of quartz grains, sorting, and ferruginous nature of the arkosic conglomerate and sandstone unit suggest that the conglomerate is possibly a well-cemented portion of the lower part of the sandstone unit. The total lack of particles of Paleozoic limestones in the arkosic conglomerate is in marked contrast to their con-

spicuous predominance in the Lange's Mill conglomerate. This would imply that deposition of the Lange's Mill conglomerate occurred during the erosion of the Paleozoic limestones, and that the deposition of the arkosic conglomerate occurred only after the Paleozoic rocks had been stripped away to expose Precambrian granite. Possibly the encroaching Early Cretaceous seas first deposited the basal Lange's Mill conglomerate in the lowest areas of the pre-Cretaceous erosion surface and then deposited the sandstone unit. Or perhaps both the Lange's Mill and arkosic conglomerates were alluvial deposits laid down before the advance of the Cretaceous seas: the Lange's Mill conglomerate was first deposited in stream channels and valleys, and after exposure of the Precambrian granite, the arkosic conglomerate was deposited upon a somewhat higher erosion surface. Where the basal portion of the sandstone unit or alluvial arkosic material was deposited in the vicinity of Paleozoic faults or fault zones, it was subsequently cemented into a very hard, siliceous arkosic conglomerate and preserved from later erosion that completely removed the other uncemented material.

Physical relations that could be considered unfavorable to the immediately preceeding interpretation are also present. First, there is evidence suggesting that the arkosic conglomerate is not the basal portion of the Cretaceous sandstone: that the outcrop of arkosic conglomerate is both higher and lower than outcrops of the Cretaceous sandstone implies that it might not be the first

deposit of the advancing Cretaceous seas; and if the conglomerate belongs between the Cretaceous sands, its different lithology is difficult to explain. Also, if there is a relation between the outcrop of arkosic conglomerate and the adjacent faults, remnants of the conglomerate might be expected near faults or fault zones in the vicinity of the single observed outcrop, even if cementation was erratic. There appears to be a total absence of arkosic conglomerate in these portions of the area. Also, no feldspar has been observed by the writer in the lower part of the sandstone unit in the thesis area; however, this may be due to feldspar occurring only locally in the sandstone.

The second stratigraphic position considered for the arkosic conglomerate is that it is older than the Lange's Mill conglomerate. Because of its distribution and extremely poor sorting, it appears that the arkosic conglomerate might possibly have been an alluvial apron deposit. Inasmuch as glauconite contains both silicate and iron, the hard, siliceous and hematitic cement that preserves the arkosic conglomerate from erosion could have been derived from the underlying, highly glauconitic Lion Mountain sandstone. That the outcrop of arkosic conglomerate is at a higher elevation than the Lange's Mill conglomerate and portions of the Cretaceous sandstone unit can be explained by progressive onlap of Cretaceous seas. Also there is the possibility that the Lange's Mill conglomerate is a younger terrace deposit within a valley cut through the arkosic conglomerate and other rocks. Perhaps the arkosic conglomerate was deposited on the pre-Cretaceous surface as

a terrace or an alluvial apron, cemented locally, partially eroded, and finally covered by the encroaching Cretaceous sea. The Lange's Mill conglomerate was possibly deposited in the valleys and channels either as the basal deposit of the advancing seas, or as an alluvial deposit before the sea covered the area. The sandstone unit was deposited next, covering the Lange's Mill conglomerate and all other areas lower than the arkosic unit, and finally overlapping the arkosic conglomerate. Later erosion stripped the sandstone unit from much of the Paleozoic surface, exposing the remnants of the arkosic conglomerate.

The interpretation that the arkosic conglomerate is older than the Lange's Mill conglomerate also has several weak points. If the arkosic conglomerate was deposited before the Lange's Mill conglomerate, then it too should possibly contain fragments of the Paleozoic limestones. However this would depend largely on the climate at that time. The outcrops of similar highly indurated arkosic conglomerates in other areas do not always overlie Lion Mountain sandstone, indicating that the hard siliceous and hematitic cement is not necessarily derived from that unit.

After due consideration the writer's only conclusion is that the arkosic conglomerate is probably of Mesozoic age; even Permian age cannot be precluded. The Doss-North area does not appear to be the critical area for determining the true stratigraphic relations between the arkosic and Lange's Mill conglomerates.

CRETACEOUS SYSTEM

The Cretaceous system is represented in the Llano region by rocks of Early Cretaceous age (Comanche Series), which, except for the northwest side, are distributed around the flanks of the uplift. The contact of the nearly horizontal Cretaceous beds with older rocks is everywhere unconformable.

In describing the Squaw Creek quadrangle, Barnes (1952) recognized the following Cretaceous units:

- Fredericksburg group
  - Edwards limestone
  - Comanche Peak limestone
  - Walnut clay

- Trinity group
  - Shingle Hills formation
    - Glen Rose limestone member
    - Hensell sand member

The above sequence differs from previously recognized nomenclature in that the term Travis Peak formation has been dropped and the term Shingle Hills formation added, to include the Glen Rose limestone and Hensell sand members. In the Doss-North area the Cretaceous units previously recognized by Barnes were not differentiated, but were simply mapped, in ascending order, as the Lange's Mill conglomerate, sandstone, siltstone, and limestone units. The total thickness of Cretaceous rocks in this area is about 330 feet.

CRETACEOUS SYSTEM

The Cretaceous system is represented in the [illegible] region by rocks of Early Cretaceous age (Comanche Series) which, except for the northeast side, are distributed around the flanks of the [illegible]. The contact of the nearly horizontal Cretaceous beds with older rocks is everywhere unconformable.

In describing the Upper Creek quadrangle, Barnes ([illegible]) recognized the following Cretaceous units:

Fredericksburg group
Edwards limestone
Comanche Peak limestone
Walnut clay

Trinity group
Shingle Hills formation
Glen Rose limestone member
Hensell sand member

The above sequence differs from previously recognized nomenclature in that the term Travis Peak formation has been dropped and the term Shingle Hills formation added, to include the Glen Rose limestone and Hensell sand members. In the [illegible] area the Cretaceous units previously recognized by [illegible] were not differentiated, but were simply mapped, in ascending order, as the [illegible] conglomerate, sandstone, siltstone, and limestone units. The total thickness of Cretaceous rocks in this area is about 150 feet.

Lange's Mill conglomerate

Definition and Thickness

The Lange's Mill conglomerate was named by Barnes, Dawson, and Parkinson (1947) for exposures near Lange's Mill in northwestern Gillespie County. Although Barnes dropped the name Lange's Mill in his subsequent publications and referred to this unit merely as basal conglomerate of the Hensell sand, the name has been retained for use in the Doss-North area.

Although Barnes (1952) described this unit as the basal portion of the Hensell sand, there may be some question as to whether the Lange's Mill conglomerate is the basal portion of the sandstone unit. The Lange's Mill conglomerate and the sandstone unit are not exposed together in the thesis area. However soil or "wash" believed to have been derived from the sandstone is in contact with the conglomerate. Only one restricted outcrop of the conglomerate shows any apparent gradation upward. The grain or particle size of the uppermost portion of this outcrop, however, is not nearly as small as the grain size of the lowermost portions of the sandstone unit exposed at other localities. If there were originally gradational strata between the Lange's Mill conglomerate and the sandstone unit, either they are not exposed in the thesis area, or they have been weathered to the pebbly red soil or "wash" that commonly overlies the Lange's Mill conglomerate in this area.

Langa's Hill conglomerate

Definition and Thickness

The Langa's Hill conglomerate was named by Barton, [illegible], and [illegible] (1962) for exposures near Langa's Hill in northwestern [illegible] County. Although Barton dropped the name Langa's Hill in his subsequent publications and referred to this unit merely as basal conglomerate of the Ruxbill sand, the name has been retained for use in the [illegible] area.

Although Barton (1962) described this unit as the basal portion of the Ruxbill sand, there may be some question as to whether the Langa's Hill conglomerate is the basal portion of the sandstone unit. The Langa's Hill conglomerate and the sandstone unit are [illegible] exposed together in the [illegible] area. However, gold in "wash" believed to have been derived from the sandstone is in contact with the conglomerate. Only one northward exposure of the conglomerate shows any apparent gradation upward. The grain [illegible] size of the uppermost portion of this outcrop, however, is [illegible] as much as the gravel size at the lowermost portions of the conglomerate exposed at other localities. If there were originally [illegible] and the sandstone units, either they are not exposed in the [illegible] area, or they have been weathered to the [illegible] "wash" that [illegible] overlies the Langa's Hill conglomerate in this area.

At one outcrop of the Lange's Mill conglomerate (Pl. IX, fig. 2) a reddish-brown, earthy material has filled water-worn potholes in the conglomerate. If this material was the basal part of the sandstone unit, then a disconformity between the conglomerate and sandstone unit would be indicated. Due to the position of the outcrop and nature of the fill material, however, it is believed that this earthy material has been recently washed into the water-worn potholes in the conglomerate.

The possibility that the Lange's Mill conglomerate is post-Cretaceous cannot be absolutely precluded. However the apparent total lack of fragments of Cretaceous limestone and chert in the conglomerate strongly indicates that it is not post-Cretaceous in age. Tertiary or Recent terrace gravel exposed near outcrops of the Lange's Mill conglomerate is composed essentially of Cretaceous limestone particles and chert, particularly Edwards chert.

Barnes (1952) described the conglomerate in the vicinity of Lange's Mill as possibly being 40 feet thick. At other outcrops in the thesis area the conglomerate was estimated to range in thickness from 10 feet to a feather edge.

Lithology

The Lange's Mill conglomerate, wherever observed, unconformably overlies either the San Saba or Threadgill limestones (Pl. IX, fig. 1). The indurated conglomerate is composed chiefly

PLATE IX

Figure 1. UNCONFORMABLE ORDOVICIAN-CRETACEOUS CONTACT
On Onion Creek about 250 yards upstream (west) of Ranch-to-Market Road 783 bridge. Threadgill member overlain by Lange's Mill conglomerate.

Figure 2. LANGE'S MILL CONGLOMERATE
In Drainage ditch on west side of Ranch-to-Market Road 783 just north of Mason-Gillespie County line.

of variously sized and colored limestone pebbles, cobbles, and boulders derived from the Riley, Wilberns, and Threadgill formations and bound together with a carbonate cement. Quartzite, chert, and white, massive quartz pebbles occur occasionally in the conglomerate. The individual pebbles and boulders range in size from very small pebbles to boulders 4 feet in length, and are well-rounded to sharply angular (Pl. IX, fig. 2). Locally the conglomerate is friable near the top and has the appearance of loosely consolidated gravel.

Topography and Vegetation

The Lange's Mill conglomerate is generally found in creek bottoms or adjacent slopes and does not influence the topography.

Vegetation is abundant where the conglomerate has weathered to a pebbly soil, and is characteristically live oak, some cedar and mesquite, and various forms of thick brushes. Very little vegetation is present on the bare exposed surface of the indurated conglomerate.

Sandstone Unit

Definition and Thickness

The Cretaceous sandstone unit mapped in the Doss-North area is probably equivalent to, in whole or in part, the Hensell sand member of Barnes (1952), and possibly to part of the Glen Rose limestone member.

In the thesis area the sandstone unit ranges from a feather edge to an estimated 150 feet thick.

Lower Boundary

Within the Doss-North area the Cretaceous sandstone unit or soil derived from it rests unconformably upon all members of Cambrian age except the Hickory sandstone, and upon the Threadgill member of Ordovician age. Soil derived from the sandstone also rests upon the Lange's Mill conglomerate of Early Cretaceous age. The sand covers over fifty percent of the southern half of the area.

Lithology

The sandstone unit varies widely in color and composition, and is generally poorly sorted. It is a predominantly red to gray, massive, fine- to coarse-grained, unindurated to slightly indurated, calcareous sand (Pl. X). The sand generally grades from red, coarse-grained and ferruginous in the lower portion, to gray and buff, silty in the upper portion. It is also more calcareous in the upper part than the lower.

Topography and Vegetation

In most of the southern half of the area where the sandstone unit is present as cover over Paleozoic rocks, it forms upland flats, gently rolling hills, and flat lowland fields. Where the sand is immediately overlain by the siltstone unit, as in the extreme southwest and eastern portions of the area, it maintains a steep slope.

PLATE X

MASSIVE CRETACEOUS SANDSTONE UNIT

On south bank of an Onion Creek tributary at west border of area. Sand is dull red and medium grained.

Vegetation is usually abundant on the sand outcrop, except for the steep portions at the base of the high Cretaceous hills. There is no particularly characteristic vegetation present on the outcrop; locally it may consist of the trees, shrubs, and grasses found on any member of the Cambrian and Ordovician formations.

Siltstone Unit

Definition and Thickness

The Cretaceous siltstone unit mapped in the thesis area is probably equivalent, in whole or in part, to the Glen Rose limestone member of the Shingle Hills formation, the Walnut clay, and the Comanche Peak limestone; all mapped by Barnes (1952) in the Aquaw Creek aqudrangle, Gillespie and Mason counties, Texas.

In the Doss-North area, the siltstone unit is about 80 feet thick.

Lower Boundary

The siltstone unit occurs only in the Cretaceous hills in the southwestern and extreme western parts of the area. There the contact was placed at the horizon where the silt-sized material first becomes predominant.

Lithology

The siltstone unit is composed of gray- to light-buff, massively bedded and in places nodular, argillaceous, calcareous siltstone and cream- to very light-buff, silty marl.

The unit is abundantly fossiliferous at several horizons. Unidentified gastropods and brachiopods were found in place, and *Exogyra texana* was found on the weathered slope a few feet above the base of the unit.

Topography and Vegetation

The siltstone unit forms the steepest slope of the high Cretaceous hills in the thesis area. Near the top of the unit, well-cemented siltstones form vertical, white cliffs (Pl. XI, fig. 1).

A dense growth of vegetation, predominantly on the northern slopes, is distinctive of the siltstone outcrop, and consists chiefly of Spanish oak. This dense growth shows on aerial photographs as a black band.

Limestone Unit

Definition and Thickness

The Cretaceous limestone unit mapped in the Doss-North area is probably equivalent in part to the lower part of the Edwards limestone.

In this area the limestone unit is about 60 feet thick.

Lower Boundary

The siltstone unit - limestone unit contact is gradational. The contact was placed at the base of the first thin-bedded, hard limestone. About 3 feet above this first limestone, there is a characteristically flat, chert-littered bench.

PLATE XI

Figure 1. CRETACEOUS SILTSTONE BLUFF
(UPPER PORTION OF HILL)
Viewed from east, at dirt road junction at the west border of area about 1 mile north of Mason-Gillespie County line.

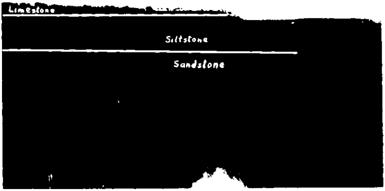


Figure 2. PROFILE OF LIMESTONE-CAPPED CRETACEOUS MESA
Same hill as in Figure 1 viewed from another hill to the south. Contacts of sandstone, siltstone, and limestone units are indicated by white lines.

Lithology

The limestone unit is composed of gray to light-buff, microgranular to medium-grained, soft to hard limestone. Much of the limestone contains black or gray chert nodules. Locally caliche has formed on the weathered surface of some of the softer limestone.

Topography and Vegetation

In the southwestern part of this area the resistant limestone unit forms a more or less flat, commonly chert-littered surface that comprises the upper portion of the steep-sloped Cretaceous hills or mesas (Pl. XI, fig. 2).

Scrubby live oak, cedar, and some Spanish oak form vegetational banding on the various topographic benches.

TERTIARY AND QUATERNARY SYSTEMS

Terrace gravel of Tertiary or Quaternary age and Recent alluvium are present in the Doss-North area.

The terrace gravel or "high gravel" of Barnes (1952) occurs in the extreme southeastern part of the area and is composed essentially of granules, pebbles, cobbles, and caliche. Most of the material was derived from Cretaceous limestone and chert and possibly from the coarser constituents of the Cretaceous sandstone unit. The characteristic Edwards chert content distinguishes the terrace gravel from the more friable portion of the Lange's Mill conglomerate. The gravel is over 10 feet thick in places.

The alluvium is composed of silts, sands, gravels and conglomerates that occur principally along the major streams. Locally this alluvium is at least 10 feet thick, and in the northeastern and southeastern parts of this area some of it is cultivated.

STRUCTURAL GEOLOGY

REGIONAL STRUCTURE

The Llano uplift of central Texas is structurally a large dome in which, according to Sellards (1932, p. 30), the Precambrian basement rocks have been uplifted 5,000 or 6,000 feet. Within the uplift region Precambrian and Paleozoic rocks of pre-Canyon age have been disturbed by an extensive fault system in which the major faults generally trend northeast - southwest. These are normal faults, having steep or vertical dips and often forming extensive graben and horst structures.

Regional folding of Paleozoic rocks has been recognized in the Llano region, and Grote (1954) reported the presence of a gentle fold trending northeast in the Central Bluff Creek area of Mason County. Intense structural deformation occurred during Precambrian time, but the resulting structures were beveled by erosion before Upper Cambrian deposition and are not reflected in Paleozoic or later rocks.

To facilitate the discussion of time of occurrence, the geologic divisions of the Carboniferous strata now recognized in the Llano region (Plummer, 1950, p. 16) are given as follows:

Pennsylvanian system
- Canyon group
- Strawn group
- Smithwick formation
- Marble Falls group

Mississippian system
- Barnett formation
- Chappel formation

According to Sellards (1934, p. 84) the Llano uplift was a positive area as early as mid-Mississippian time. This is indicated by the thinning of the Barnett formation as it approaches the Llano region. Sellards (1934, p. 97) stated that a strong angular unconformity between Bend and post-Bend (post-Smithwick) rocks suggests that the major uplift occurred after Bend time.

The major late Paleozoic faulting, occurring with or immediately following the principal uplift, is dated by Cloud and Barnes (1948, p. 121) as inter-Strawn and pre-Canyon, or as post-Strawn and pre-Canyon in age. This designation is based upon the evidence that the faults cut all pre-Canyon beds of the region while apparently not disturbing Canyon and later beds.

STRUCTURE OF THE DOSS NORTH AREA

General Statement

The principal structural features of the Doss-North area are normal, steeply-dipping faults, which generally trend northeast-southwest and range in throw from a few feet to an estimated 785 feet. The faults essentially control the outcrop pattern. Three major faults, or fault zones, and numerous minor faults disturb all but the Cretaceous and later rocks.

Except in fault zones or small fault blocks, the Paleozoic strata have an average strike of N. $40^{\circ} - 50^{\circ}$ E. and an apparent regional dip of about $6^{\circ} - 8^{\circ}$ S. E. The Cretaceous strata have little or no dip.

The only occurrence of folding in this area is that of minor folding within the Point Peak shale member of the Wilberns formation.

Faulting

Major Faults

Three major faults, trending northeast - southwest, cross or partially cross the Doss-North area: the Monsola fault in the extreme northwestern part, the Law fault in the upper middle part, and the Squaw Creek fault zone in the lower middle part. All major faults are downthrown to the northwest.

The Monsola fault, named by Ammer (1959) crosses the northwest corner of the thesis area and disappears beneath Cretaceous cover immediately west of the area. This fault changes from a strike of N. 70° E. in the northerly adjacent Hilda-Southwest area, and increases in throw from over 200 feet in the former area to an estimated 650 feet in the latter. The fault is downthrown to the northwest, and near the western edge of the area where Cap Mountain limestone is faulted against Morgan Creek and San Saba limestones, a small but sharply defined resequent scarp has formed.

The Law fault extends into the thesis area about 0.8 miles south of the northeast corner. In conjunction with Peterson (1959), this fault was named by the writer for the G. Law land survey. The fault changes from a strike of N. 70° E. at the east border to a strike of N. 45° E. near the west central part of this area, where

The only occurrence of faulting in this area is that [illegible]

[illegible]

formation.

[illegible]

[illegible]

it disappears beneath Cretaceous cover. The Law fault, which has a maximum throw of 785 feet, is the largest fault in the area. Differential erosion has formed an obsequent scarp along the northeast portion of the fault, and here also occur two horsts or blocks of rock surrounded by branches of the main fault. At many places a narrow ridge or dike of hard, silicified Welge-like sandstone occurs along the fault.

The Squaw Creek fault, named by Woolsey (1958), extends into the middle eastern part of the area as a wide zone of faulting. Most of the faults of this zone strike about N. 45° E., but a few strike N. 10° to 15° E. The largest fault has at least 660 feet of throw (Cap Mountain against Ellenburger). One short cross fault (extending obliquely between two parallel faults) less than one half mile long, has an estimated throw of 380 feet. Throws of 300 to 400 feet, steep dips, and horst blocks are common. Normal drag occurs along one fault extending across Threadgill Creek.

The Daffan fault, named by Ammer (1959), lies just west of the extreme northwestern portion of the area and approximately parallels the border (Pl. XIII). Although this fault is not within the thesis area, it influences the structure in the northwest portion, and apparently merges with the Monsola fault just west of the area beneath the Cretaceous cover.

PLATE XII

BRANCH OF SQUAW CREEK FAULT

On Threadgill Creek 1/2 mile northeast of C. Heard's house. Cap Mountain limestone (rock ledges on right side) faulted against Point Peak shale.

Minor Faults

Numerous normal and steeply dipping minor faults occur throughout the thesis area. The strikes of these faults are usually more northerly than those of the major faults, and the average throw is less than 100 feet. The majority of these minor faults are, or appear to be, branches of the major faults. Direction of displacement or downthrow is variable, with the result that small horsts and grabens are common. Faults that extend obliquely between and connect two larger parallel faults are rare, and occur only in the zone between the Daffan and Monsola faults in the northwestern portion of the area, and in the Squaw Creek fault zone in the eastern central portion.

Ridges of highly indurated (nearly quartzitic) Welge-like sandstone often occurs along the faults, and facilitate the tracing of the faults over relatively long distances. Where these dikes occur near faulted Welge sandstone, it is likely that they are actually composed of well-cemented Welge sandstone. However where they occur along faults far removed from any Welge outcrop, their relation to the Welge is uncertain. The sandstone dikes are resistant to weathering because of their hard siliceous cement.

Wherever the resistant Welge sandstone has been displaced, extremely small faults may be easily detected, but displacement within the Cap Mountain limestone is not nearly so obvious, and even the larger faults usually cannot be traced through it for any great distance with much certainty. Faulting contained wholly within

the Cap Mountain limestone was often detected by vegetational lineations, although these also occur along joints in this member. There are no key beds within the Cap Mountain limestone that can be utilized in the detection of faults.

In the extreme northwestern part of the thesis area, much small-scale block faulting has occurred in the V-shaped zone outlined by the apparently merging Daffan and Monsola faults. The faults increase in number and in displacement toward the apex of this zone. An enlarged map of this intensely fractured zone is shown on Plate XIII: the map extends a short distance past the west border of the thesis area so as to include the Daffan fault.

Age and Origin of Faulting

All the Paleozoic strata in the Doss-North area have been cut by faulting, while the overlying Cretaceous strata have been undisturbed. The youngest rock unit cut by faulting is the Threadgill limestone of the Ellenburger group; the faulting in this area can therefore be positively dated as post-Ellenburger and pre-Cretaceous. However, evidence for the Llano region as a whole, as previously discussed under regional structure, indicates the age of faulting as pre-Canyon.

Evidence for cause of faulting in the Llano region is both meager and inconclusive, and any proposed theory of origin is therefore necessarily speculation. However, several facts are evident: (1) general northeast-southwest trend for most major

faults, (2) faults are normal or gravity type, (3) lack of intense folding and thrusting, (4) uplift as the only major deformation for the area - besides faulting, and (5) regional dips on the flanks of the area are not always away from the center of the uplift, and (6) indicated presence of broad folds trending northeast-southwest across the uplift.

It would appear that since Precambrian time intense compression has never occurred throughout the Llano region, and that the faulting was not a result of tension due to relaxation of compressional stresses. The broad folds that trend northeast-southwest could be due to axes of more positive uplift that also trend northeast-southwest. A northeast-southwest fault system would then be expected along those broad folds.

Barnes (1956, p. 9) stated that the faulting of rocks in the Llano uplift was related to the Ouachita orogeny. It is difficult to see any definite relation of this nature unless the actual uplift of the region is related in some way to the orogeny. Differential uplift of the area does provide one possible explanation for the Llano fault system.

Attitude of Beds

The regional dip of the strata in the Doss-North area - 6° to 8° S.E. - is not that which would be expected on the southwest flank of a structural dome. Anomalous regional dips have been reported from other areas flanking the uplift.

Southeast regional dips have been reported throughout a region extending from the thesis area northwestward to a point east of Streeter, Mason County, Texas. West of Streeter dips are generally toward the west. An extension of the Richland Springs axis of relatively higher uplift of basement rock (Grote, 1954, p. 42) through the Streeter area may be the cause of the opposing dips. This axis has the apparent effect of a broad fold trending northeast-southwest. The southeast dip in the thesis area could then be due to position on the southeast flank of a more positive or higher uplift of the basement rock.

Another possible explanation for the southeast dip is that the area from Streeter to the thesis area is part of a large fault block which dips to the southeast. However, the known existence of not one, but a large number of fault blocks within this area would preclude this explanation. Of course all or most of these many fault blocks could be tilted toward the southeast.

Folding

Folding in the Doss-North area is confined to small local folds in the Point Peak shale (Pl. XIV). These folds are a result of the incompetency and relative plasticity of the shale with respect to overlying and underlying beds. Three possible modes of origin are considered: (1) tectonic folding, (2) folding due to overload or differential compaction, and (3) folding related to faulting.

PLATE XIV

Figure 1. RELATIVELY LARGE FOLD IN POINT PEAK SHALE
Roadside exposure on east side of Ranch-to-Market Road 783 near crest of hill, about 0.3 mile south of pipeline crossing. Point Peak bioherms overlying shale in left of picture.

Figure 2. SMALL TIGHT FOLD IN POINT PEAK SHALE
A few feet north of fold shown in Figure 1.

PLATE IV

Figure 7 - HORIZONTAL TRACE ... IN PLATE VIEW

Looking downward at the face of ... about ... mile ... [illegible]

[illegible]

MICROFILMED

Very little, if any, regional compression and tectonic folding have occurred in the Llano region since the end of Pre-cambrian time. However, the regional uplift and consequent doming of the area could have caused possible slippage along beds, resulting in minor folding within the somewhat plastic Point Peak shale.

Overload or compression beneath overlying bioherms could possibly explain the folding in the Point Peak shale. A thick zone of bioherms does overlie the observed folds, and the small folds could have resulted from compaction by the weight of the bioherms. The presence of the bioherms over the flank of one particular fold (Pl. XIV, fig. 1) and the absence of bioherms over the crest indicate compression due to the bioherms. Or perhaps there is a bioherm beneath the crest of this fold and the fold was due merely to differential compaction of the beds above and around the bioherm. The crests of the smaller folds are nearly always pointing vertically upward (Pl. XIV, fig. 2). There are clear-cut examples of differential compaction over and around bioherms in other parts of the Llano region (Cloud and Barnes, 1948, p. 408).

Folding related to faulting is a possibility in the thesis area. The small folds observed in the Point Peak shale were only a few feet from a fault bringing Morgan Creek limestone up against Point Peak shale. One small drag fold is present just at the fault. The folds farther away from the fault could have resulted from stresses set up by the faulting.

It appears to the writer that the evidence favors overload and differential compaction as the cause of most of the minor folding in the Point Peak shale of the Doss-North area.

GEOLOGIC HISTORY

GENERAL STATEMENT

The geologic history of the Doss-North area is a part of the history of the larger area of the Llano region. The over-all regional history of the uplift will be discussed first; then any unusual or anomalous events indicated by the depositional record of the thesis area will be described.

General review of the geologic history or depositional record of the Llano region has been given by Paige (1912), Sellards (1934), Cloud and Barnes (1948), Cheney and Goss (1952), and Barnes (1956).

REGIONAL HISTORY

Precambrian

During Precambrian time a thick sequence of sedimentary rocks similar to those of the later Paleozoic deposition was deposited, deeply buried, and subsequently deformed, intruded, and metamorphosed. Metamorphism of the series resulted in the formation of schist, gneiss and marble. Granite intrusions were common. Uplift followed, and long-continued denudation resulted in an irregular topography of local relief as great as 800 feet (Barnes, 1956, p. 8). It was upon this surface that the Late Cambrian seas advanced.

Cambrian

The absence or Lower and Middle Cambrian rocks in the Llano region suggests that erosion of the Precambrian surface continued until encroachment of the Late Cambrian seas. The oldest Paleozoic deposit, the Hickory sandstone, contains dreikanters in its basal portions. Goolsby (1957) reported that although the lithologic character of the Lower Hickory sandstones suggests they are residual aeolian sediments, the cross-bedding present indicates subaqueous deposition. He also stated that cross-bedding studies suggest that these sandstones were deposited at the mouths of fast, possibly temporary, streams where they entered the quiet sea. The middle and upper portions of the Hickory sandstone were apparently deposited in shallow seas. Cross-bedding, sub-rounded grains, and ripple marks are characteristic.

The Hickory sandstone grades vertically and laterally into Cap Mountain granular limestones, indicating either a rise in sea level and depletion of quartzose detritus, or a decrease in capacity of the streams to carry the detrital load. The lack of an intermediate shale facies suggests that either the rise in sea level was rather rapid, or that there was a deficiency of shale-size material from the source area, allowing the early deposition of carbonates.

The occurrence of glauconite, trilobites, and brachiopods suggests a shallow neritic environment during the deposition

of the Cap Mountain limestone. Barnes (1956, p. 8) reported that northward in the subsurface the Cap Mountain limestone grades laterally into sandstone, indicating a source area in that direction.

The Cap Mountain limestone grades upward into the highly fossiliferous and glauconitic sandstone of the Lion Mountain. Cloud and Barnes (1948, p. 112) suggested that the Lion Mountain sandstone, along with the Welge sandstone, was deposited in a regressive - transgressive zone. The return to predominance of sand in the Lion Mountain member points to an uplift of a quartz-detritus source. Barnes (1956, p. 8) stated that the thinning of the Lion Mountain and Welge sandstones southeastward indicates that the sand source was in the northwest direction. The writer believes that, although rock units may thin away from their source, this is certainly no definite criterion for direction of source; for example, the Karroo sediments in southern Africa become coarser toward their northward source but thicken southward. However, increase in coarseness is a valid indication of direction of source.

Barnes, Dawson, and Parkinson (1947) and Cloud and Barnes (1948, p. 343) refer to the Lion Mountain - Welge contact as disconformable, but do not discuss or give details for such reference. In the discussion of local history the writer gives reasons for designating this contact as a disconformity.

The Welge sandstone represents an environment of agitated or turbulent water that was unfavorable to the formation of glauconite. The Welge is only slightly glauconitic locally in the lowermost part and is totally nonglauconitic upward. The end of Welge time marks the decrease of clastic influx, and a greater transgression of the sea.

A return to an environment somewhat similar to that of Cap Mountain time is implied by the granular Morgan Creek limestone and its included abundance of glauconite and remains of shallow-water marine life. Ripple marks are also present. Near the top of the Morgan Creek limestone, small bioherms make their first appearance in Upper Cambrian rocks, indicating an intermittent shallowing or shoaling of the sea.

At the end of Morgan Creek time, the influx of argillaceous material exceeded carbonate deposition and the Point Peak shale was deposited. A general shallowing of the sea is evidenced by the common occurrence of intraformational conglomerates. Paige (1912, p. 79) stated that intraformational conglomerates along with other features such as mudcracks suggest tidal flat environment. Cloud and Barnes (1948, p. 112) reported that the Point Peak shale gives place to carbonate rocks to the east in the Llano region, indicating warm shoal waters in that direction, far from an effective source of clastics.

During San Saba time, apparent continuation of shoaling in the eastern part of the region is inferred by the lateral

transition of San Saba limestone into Pedernales dolomite eastward (Cloud and Barnes, 1948, p. 112). In the western part of the region, sandy sediments became only intermittently introduced, and the glauconitic and fossiliferous limestones and interbedded siltstones were deposited. Except for brief local shoaling, the rest of the San Saba in the western part of the uplift was deposited in a shallow, relatively calm neritic environment. Barnes (1956, p. 9) reported that in the westernmost portion of the region the San Saba contains thick beds of sand, and the source was probably to the west.

In the western part of the Llano region, sedimentation was apparently continuous across the Cambrian - Ordovician boundary (Pl. VIII, fig. 1). However, Cloud and Barnes (1948, p. 112) reported that the southeastern part of the region became emergent at the end of Cambrian time, with resulting truncation of highest Cambrian strata.

Ordovician

According to Cloud and Barnes (1948, p. 100-105), in Ellenburger time, warm, intermittently turbulent, shallow seas persisted throughout the Llano region, and were probably less than 100 fathoms deep. Land lay to the east and south of the region, and was either distant, worn very low, or separated from the Llano region by a channel. The limestones of the Ellenburger group probably originated as chemically precipitated aragonite

muds in an environment not unlike that found today in the Bahama Bank region. Barnes (1956, p. 9) stated that Lower Ordovician rocks are as much as 1,826 feet thick in the southeastern part of the uplift and as little as 830 feet thick in the northwestern part. This variation in thickness is caused by truncation in the west, representing a marked eastward tilting of the region either before or during the advancement of Devonian seas. That the truncation was pre-Devonian is evidenced, according to Cloud and Barnes (1948, p. 113), by the occurrence of the oldest known Devonian strata in the eastern part of the region, and the youngest in the west where maximum Ellenburger truncation occurred.

Middle Ordovician rocks are not represented in the Llano region. Either these rocks were never deposited or they were completely eroded prior to Late Ordovician deposition. Upper Ordovician rocks recognized in the Llano uplift are preserved mostly in collapsed areas in the Ellenburger. Known Upper Ordovician rocks are not present in the thesis area.

Devonian

Lower, Middle, and probably Upper Devonian rocks are present in the Llano uplift. Most of these occurrences are fillings in solution structures of various sorts (Barnes, Cloud, and Warren, 1947). The marked unconformity between the Devonian and underlying rocks indicates that the Devonian rocks must have been deposited upon an extensively eroded surface.

Rocks of Devonian age are not present in the Doss-North area.

Carboniferous

Marine invasions occurred during Mississippian and Pennsylvanian times, and laid down a series of fossiliferous limestones, shales, and lesser amounts of sand and conglomerate. The high organic content in the darkly colored limestones and shales suggests that the land area during Carboniferous time was possibly low and swampy. Thinning of the Barnett shale (Late Mississippian) as it approaches the Llano region indicates that uplift of the region had begun by that time. Sellards (1934, p. 97) stated that the principal uplift was post-Bend and pre-Canyon in age. Evidence for such dating is that, where the Bend is present, the Ellenburger has retained nearly its full thickness, indicating that the greatest erosion of Ellenburger was of post-Bend age. During Pennsylvanian time the region was highly faulted. Unfaulted Canyon and younger beds overlying older faulted Paleozoic strata date the faulting as pre-Canyon.

Carboniferous strata do not occur in the thesis area.

Permian, Triassic, and Jurassic

Sometime during the Permian, Triassic, and Jurassic periods the Llano region was emergent and was eroded to expose, in some places, the Precambrian rocks. Either sediments were never deposited during most of this time, or they were deposited and

totally removed by subsequent erosion. The arkosic conglomerates present in the region might possibly represent deposition during this time, although, with the present state of knowledge, this is highly speculative.

Cretaceous

At the beginning of Cretaceous time, seas advanced over the eroded Paleozoic surface and possibly deposited basal conglomerate in the valleys and other relatively low areas. By progressive overlap the Cretaceous sands, siltstones, and limestones were deposited on the Paleozoic and Precambrian surface. Plummer (1950, p. 101) stated that starting from near Marble Falls in Burnet County, and extending westward toward the interior of the region, and to topographically higher elevations, younger and stratigraphically higher members of the Lower Cretaceous sequence come in contact with the Ellenburger and older rocks. This clearly indicates that the Llano region was a peninsula, a point, or perhaps an island during Travis Peak (Hensell) and Walnut time, which became smaller and smaller due to progressive overlap, and finally was totally submerged near Edwards time. According to Barnes (1944, p. 37), the Travis Peak sand is the shoreward sandy facies of the Cretaceous system of Texas and, at different places is equivalent to the Glen Rose limestone, Walnut clay, Comanche Peak limestone, and possibly other units.

Post-Cretaceous

Since the final withdrawal of the Cretaceous seas, the Llano region has remained emergent until the present time. Erosion has stripped the Cretaceous rocks from the center of the region, exposing Paleozoic and Precambrian rocks. A large topographic basin has resulted from this extensive erosion. Tertiary or Recent terrace gravels were deposited along the former courses of the streams and rivers of this area. Recent alluvium has also been deposited along the streams and rivers.

LOCAL VARIATIONS

Cap Mountain deposition

In the Doss-North area a massive, fine- to medium-grained, quartz sandstone occurs about 25 feet above the base of the Cap Mountain limestone. The lateral extent of this sandstone is not known, due to faulting and alluvial cover. Bryant (1959, p. 20) reported that a similar massive but very fine-grained sandstone occurs in the lower limonitic part of the Cap Mountain limestone in the Schep-Panther Creek area, about 4 miles northwest of the Doss-North area. He stated that this massive sandstone did not appear to be continuous. If these massive sandstones in the Schep-Panther Creek and the Doss-North area are actually the same unit or occur at the same interval, and the grain size in each area has been correctly ascertained, then an increase in coarseness toward the southeast is indicated. The apparently limited

Since the final withdrawal of the Cretaceous seas, the Mass region has remained emergent until the present time. Erosion has stripped the Cretaceous rocks from the center of the region, exposing Paleozoic and Precambrian rocks. A large topographic basin has resulted from this extensive erosion. Terrace or flood plain gravels were deposited along the former courses of the streams and rivers of this area. Recent alluvium has also been deposited along the rivers and streams.

LOCAL GEOLOGY

[illegible] Deposition

In the Mass-North area a massive, [illegible] quartz sandstone occurs about 40 feet above the base of the Gas Mountain limestone. The lateral extent of this sandstone is not known, due to faulting and alluvial cover. Bryant (1959, p. 60) reported that a similar massive, fine-grained sandstone occurs in the lower Leadville part of the Gas Mountain limestone in the [illegible]-Panther Creek area, about 4 miles northwest of the Mass-North area. He stated that this massive sandstone did not appear to be continuous. If these massive sandstones in the Panther Creek and the Mass-North area are actually the same unit or occur at the same interval, and the grain size in each area has been correctly ascertained, then an increase in coarseness toward the southeast is [illegible]. The apparently limited distribution of the massive sandstone and increase of coarseness toward the southeast suggest a brief reappearance of local sources of quartz material possibly to the southeast in early Cap Mountain time due to either climatic changes or minor tectonic activity in the source area.

Lion Mountain deposition

The combination of alternating limestones and sandstones, trilobite "hash" lenses, and high concentration of glauconite indicates intermittently varying environments during deposition of the Lion Mountain member. However, in that most of the limestone is sandy and most of the sandstone is limy, the variation does not appear to be very great. The glauconite and fossiliferous limestones represent quiet, moderate to shallow neritic water. The "hash" lenses and relatively coarse detritus of the sandstone suggest turbid or agitated conditions.

Cloud (1955) concluded that the formation of glauconite if favored by moderately cool marine waters, moderate to shallow neritic depths, and slightly reducing conditions. High organic content of bottom sediments, lack of continued turbulence, and slow or negative sedimentation also aid in the formation of glauconite. Nearly half of the Lion Mountain sanstone is glauconite.

Inasmuch as the deposition of quartz detritus usually requires turbulent or agitated water, the relatively quiet reducing conditions favorable for glauconite formation occurred only intermittently during Lion Mountain deposition. The presence of

limestones interbedded with the sandstones also suggests varying conditions. The numerous trilobite lenses and "hash" imply that during the deposition of the limestones, organic material or decaying organic matter was plentiful on the sea floor, resulting in reducing conditions.

The nature of the occurrence of glauconite in the Lion Mountain sandstone suggests that the glauconite was concentrated in some manner after its original formation. Concentration might have been brought about by short movement or transportation on the sea floor, aided possibly by subelevation and removal of the finer sediment.

Lion Mountain - Welge contact

Cloud and Barnes (1948, p. 343) refer to the Lion Mountain - Welge contact as a disconformity. This apparently sharp stratigraphic contact can be observed in the Doss-North area. The nature of the contact indicates a possible interruption of deposition, or a rapid change in rate and type of deposition. Although the smooth, even nature of the contact does not suggest an erosion surface, a fairly long time interval may be represented. At the end of Lion Mountain time, a temporary base level of aggradation was probably either reached or closely approached, resulting in nondeposition or very slow deposition.

Point Peak deposition

In the thesis area and in the adjoining Squaw Creek quadrangle, a shallowing and warming of the seas occurred in Point Peak time earlier than in most of the other areas of the Llano region. This is indicated by the early appearance of the thick bioherm zone in this area. The zone or zones vary considerably in stratigraphic position, thickness, and number, suggesting local control of shoaling.

The amount of terrigenous material present in the water appears to be a major factor controlling growth of bioherms: a reduction in the terrigenous supply results in clearer water and in maximum growth ; an increase in supply results in deposition of shale and siltstone. Of course the amount of terrigenous material is itself controlled by various factors such as distance from source area, height of source area, carrying capacity of streams at source area, and marine currents.

Cloud (1952, p. 2146) stated that the filamentous structure of the Upper Cambrian bioherms in central Texas is strongly suggestive of the calcium-precipitating and sediment-binding blue-green algae which do not form large structures below about 30 meters of sea water. Because the very large bioherms in the Camp San Saba area of McCulloch County rest in most places upon intraformational conglomerate, water considerably shallower than 30 meters is indicated for maximum bioherm growth. However, in the Doss-North area the observed bioherms apparently rest upon

shale in most places, and shale deposition does not particularly indicate shallow water conditions.

San Saba deposition

The stratigraphic position of a thick bioherm zone in the lower part of the San Saba limestone of the Doss-North area indicates a general shallowing of seas in that area during early San Saba time. Barnes and Bell (1954) reported the occurrence of thick bioherm zones in the lower portion of the San Saba member in the Camp San Saba and Calf Creek areas in the northwestern part of the Llano uplift. Apparently the water was too deep and cool in the eastern part of the uplift for the formation of bioherms during San Saba deposition.

Arkosic conglomerate deposition

In the Doss-North area, arkosic conglomerate was deposited upon the pre-Cretaceous erosion surface either before or after the Lange's Mill conglomerate. Subsequent erosion removed all but the most indurated parts of the arkosic conglomerate. The microcline content of the conglomerate indicates the source of sediments as uncovered Precambrian igneous rocks. The presence of basal Cretaceous rocks resting directly on Precambrian rocks in this region verifies the fact that Precambrian rocks were exposed sometime during post-Pennsylvanian and pre-Cretaceous time.

ECONOMIC GEOLOGY

Ground-water is the most important geologic resource of the Doss-North area. In the southern portion of the area the main easily available source of water is the Cretaceous sandstone unit (Hensell sand). The Lion Mountain sandstone and possibly the Welge sandstone provide the main water aquifers in the middle part of the area, and the Hickory sandstone provides water in the extreme northern part. The Lange's Mill spring, which is reported to flow 300 gpm, issues from the Lange's Mill conglomerate. At Doss, the town well is reported to be 740 feet deep (Barnes, 1952) and undoubtedly produces water from Paleozoic rocks.

A caliche pit located in the north-central portion of the area has provided large amounts of secondary-road surfacing material.

Soils are used mostly for grazing and limited cultivation of crops. Most of those that are cultivated are derived from basal Cap Mountain limestone, Lion Mountain sandstone and Cretaceous sandstone.

BIBLIOGRAPHY

Ammer, D. R., 1959, Geology of the Hilda-Southwest Area, Mason County, Texas: M.S. Thesis (in preparation), Agricultural and Mechanical College of Texas.

Barnes, V. E., 1941, Cretaceous overlap on the Llano uplift of central Texas: Geol. Soc. America Bull., v. 52, p. 1994-1995.

_______, 1944, Gypsum in the Edwards limestone of central Texas: Texas Univ. Bur. Econ. Geology Bull. 4301, p. 35-46.

_______, 1952, Squaw Creek Quadrangle, Gillespie and Mason Counties, Texas: Texas Univ., Bur. Econ. Geology, Geologic Quadrangle Maps, 1 sheet.

_______, 1956, Lead deposits in the Upper Cambrian of central Texas: Texas Univ., Bur. Econ. Geology, Rept. Inv. no. 26, 68 p.

_______, and Bell, W. C., 1954, Cambrian rocks of central Texas: San Angelo Geol. Soc., Cambrian Field Trip, March 19-20, 139 p.

_______, Cloud, P. E., Jr., and Warren, L. E., 1947, Devonian of central Texas: Geol. Soc. America Bull., v. 58, p. 125-140.

_______, Dawson, R. F., and Parkinson, G. A., 1947, Building Stones of central Texas: Texas Univ., Bur. Econ. Geology Bull. 4246, 198 p.

Bridge, Josiah, 1937, The correlation of the Upper Cambrian sections of Missouri and Texas with the section in the upper Mississippi Valley: U. S. Geol. Survey Prof. Paper 186-L, p. 233-237.

_______, Barnes, V. E., and Cloud, P. E., Jr., 1947, Stratigraphy of the Upper Cambrian, Llano Uplift, Texas: Geol. Soc. America Bull., v. 58, p. 109-124.

Bryant, G. F., 1959, Geology of the Schep-Panther Creek area, Mason County, Texas: M.S. Thesis, Agricultural and Mechanical College of Texas.

Burst, J. F., 1958, "Glauconite" pellets: their mineral nature and applications to stratigraphic interpretations: Am. Assoc. Petroleum Geologists Bull., v. 42, p. 310-327.

Cheney, M. G., 1940, Geology of north-central Texas: Am. Assoc. Petroleum Geologists Bull., v. 24, p. 65-118.

Cheney, M. G., and Goss, L. F., 1952, Tectonics of central Texas: Am. Assoc. Petroleum Geologists Bull., v. 36, no. 12, p. 2237-2265.

Cloud, P. E., Jr., 1952, Facies relationships of organic reefs: Am. Assoc. Petroleum Geologists Bull., v. 36, no. 11, p. 2125-2144.

_______, 1955, Physical limits of glauconite formation: Am. Assoc. Petroleum Geologists Bull., v. 39, p. 484-492.

_______, Barnes, V. E., and Bridge, Josiah, 1945, Stratigraphy of the Ellenburger group of central Texas - a progress report: Texas Univ., Bur. Econ. Geology Bull. 4301, p. 133-161.

Comstock, T. B., 1890, A preliminary report on the geology of the Central Mineral region of Texas: Texas Geol. Survey 1st Ann. Report 1889, p. 235-391.

Daugherty, T. D., 1959, A petrologic and mechanical analysis of the Lion Mountain and Welge sandstones in southern Mason County, Texas: M.S. thesis (in preparation), Agricultural and Mechanical College of Texas.

Deen, A. H., 1931, Cambrian algal reefs of Texas (abst.): Geol. Soc. America Bull., v. 42, p. 368.

Dunbar, C. O., and Rogers, J., 1957, Principles of Stratigraphy: John Wiley and Sons, Inc., New York, 356 p.

Goolsby, J. L., 1957, A study of the Hickory sandstone: M.S. Thesis, Agricultural and Mecahnical College of Texas.

Grote, F. R., 1954, Structural geology of the Central Bluff Area: M.S. Thesis, Agricultural and Mechanical College of Texas.

Paige, Sidney, 1911, Mineral resources of the Llano-Burnet region, Texas, with an account of the Precambrian geology: U. S. Geol. Survey Bull., v. 450, 103 p.

Peterson, D. H., 1959, Geology of the Middle Beaver Creek Area, Mason and Gillespie Counties, Texas: M.S. Thesis (in preparation), Agricultural and Mechanical College of Texas.

Pettijohn, J. J., 1957, Sedimentary Rocks: Harper and Bros., New York, 718 p.

[illegible], and Goss, L. F., 1956, Deposition of [illegible] Central Texas: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 12, p. 2939-2955.

Cloud, P. E., Jr., 1952, Facies relationships of organic reefs: Am. Assoc. Petroleum Geologists Bull., v. 36, no. 11, p. 2125-2149.

______ 1955, Physical limits of glauconite formation: Am. Assoc. Petroleum Geologists Bull., v. 39, p. 484-492.

______, Barnes, V. E., and Bridge, Josiah, 1945, Stratigraphy of the Ellenburger group in central Texas—A progress report: Texas Univ., Pub. 4301, p. 133-161.

Comstock, T. B., [illegible], A preliminary report on the geology of the Central Mineral region of Texas: Texas Geol. Survey 1st Ann. Rept., [illegible].

[illegible], T. C., 1959, A petrologic and [illegible] analysis of the Sloan Mountain and Welge sandstones in southern Mason County, Texas: M.S. thesis (in preparation), Agricultural and Mechanical College of Texas.

Deen, A. [illegible], Cambrian algal reefs of Texas (abs.): Geol. Soc. America Bull., v. 48, p. [illegible].

Dunbar, C. O., and Rodgers, J., 1957, Principles of stratigraphy: John Wiley and Sons, Inc., New York, 356 p.

[illegible], 1957, A study of the Hickory sandstone: M.S. Thesis, Agricultural and Mechanical College of Texas.

[illegible], F. R., 1954, Stratigraphic geology of the Central Bluff Area: M.S. Thesis, Agricultural and Mechanical College of Texas.

Paige, Sidney, 1912, Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology: U.S. Geol. Survey Bull., v. 450, 103 p.

Peterson, D. E., 1959, Geology of the [illegible] Rocks, Mason and Gillespie Counties, Texas: M.S. Thesis (in preparation), Agricultural and Mechanical College of Texas.

Pettijohn, F. J., 1957, Sedimentary rocks: Harper and Brothers, New York, 718 p.

Plummer, F. B., 1950, The carboniferous rocks of the Llano region of central Texas: Texas Univ., Bur. Econ. Geology Bull. 4329, 117 p.

Roemer, Ferdinand, 1846, A sketch of the geology of Texas: Am. Jour. Sci. (2), v. 2, p. 358-365.

Rogers, L. F., Jr., 1955, Arkosic conglomerate beds in Mason, Menard, and Kimble Counties, Texas: M.S. Thesis, Agricultural and Mechanical College of Texas.

Sellards, E. H., 1932, The pre-Paleozoic and Paleozoic systems in Texas, in the Geology of Texas, v. I, Stratigraphy: Texas Univ., Bur. Econ. Geology Bull. 3232, p. 15-238.

_______, and Baker, C. L., 1934, The geology of Texas, v. II, Structural and economic geology: Texas Univ., Bur. Econ. Geology Bull. 3401, 884 p.

Shumard, B. F., 1861, The Primordial Zone of Texas, with descriptions of new fossils: Am. Jour. Sci., (2), v. 32, no. 95, p. 213-221.

Sliger, K. L., 1957, Geology of the Lower James River Area, Mason County, Texas: M.S. Thesis, Agricultural and Mechanical College of Texas.

Tarr, R. S., 1890, Origin of some topographic features of central Texas: Am. Jour. Sci., ser. 3, no. 293, art. 39, p. 306-311.

Woolsey, I. W., 1958, Geology of the Squaw Creek - Marshall Creek Area, Mason County, Texas: M.S. Thesis, Agricultural and Mechanical College of Texas.

A P P E N D I X

MEASURED SECTION

Section of the Wilberns formation measured along the east bank of Threadgill Creek and a small tributary, from a point about 0.3 miles due east of Cyrus Heard's ranch house to a point about 0.6 miles due east of Lange's Mill, Gillespie County, Texas

	Thickness in feet	Feet above base
Wilberns formation		
San Saba limestone member		
25. Limestone: Light brown weathering to yellow mottled surface, thin-bedded, very fine grained to sublithographic, and sparsely glauconitic. Occasionally there are thin beds of intraformational conglomerate; one is at 570.3 to 570.5 feet. The top of this interval marks the contact with the Threadgill limestone; the contact was picked between the last occurrence of glauconite and the first appearance of *Lytospira* and *Ophileta*	17	554-571
24. Limestone: White to light brown, thin-bedded coarsely granular to sublitho-graphic, and very glauconitic to		

Wilberns section

Section of the Wilberns formation exposed along the east bank of Thundergill Creek and small tributary, from a point about 1.3 miles due east of ... house to a point about ... miles due east of ... Hill, Gillespie County, Texas

Thickness in feet — Total above base

Gilmore formation

... limestone member

... limestone: light brown weathering to yellow ... , ... , very fine grained to ... , ... , there are ... beds of ... , ... at 270.3 to 270.4 feet. The top of ... , ... with the ... limestone, ... between the last occurrence of ... and the first occurrence of ... and ...

... limestone, white to light brown, ... , ... , ... and very ...

nonglauconitic. Thin beds of light-gray, sublithographic limestone alternate with light-brown to tannish-white, crystalline, fossiliferous limestones. Some beds are slightly sandy, and others stromatolitic. Some beds are white with fossiliferous "hash". At 525 feet occurs an intraformational conglomerate, and at 547 feet a very glauconitic limestone 47 507-554

23. Limestone: Brown to light tan, crystalline to sublithographic, somewhat glauconitic and occasionally are slightly silty. Beds 1 inch thick form massive layers 6 inches to 3 feet thick. Some beds are "hashy". An undescribed gastropod occurs at 492 feet, and from 492 to 507 feet beds are mostly sublithographic. 38 469-507

22. Limestone and siltstone: Brown to purplish and greensih-gray, medium- to massive-bedded, slightly glauconitic, fossiliferous to nonfossiliferous limestones, and thinner beds of green, glauconitic siltstones. From 442

to 455 feet occur brown, dense, nonfossiliferous limestones and greenish-gray to brown, "hashy", glauconitic limestones; at 445.5 feet to 447 feet, greenish-gray to greenish-tan, cross-bedded, coarsely-crystalline, fossiliferous and very glauconitic limestone; at 459 to 455 feet, green siltstone. From 455 to 459 feet occurs brown, massive, crystalline, very slightly fossiliferous limestone, and from 459 to 460 feet, green, glauconitic siltstone. From 460 to 469 feet, occurs greenish-brown to purplish-gray, finely crystalline, slightly glauconitic limestone with occasional inter-layered beds of green, glauconitic siltstones 27 442-469

21\. Limestone and siltstone: Greenish-gray, fairly thick-bedded, weathering to honey-comb surface, crystalline, fossiliferous, glauconitic limestone and green, glauconitic siltstone. Siltstone occurs mostly from 433 to 441 feet. 15 427-442

20\. Limestone: Whitish-tan, 8 inch beds, crystalline, and quite "hashy" 9 418-427

19. Limestone: Greenish-brown to cream, thin- to thick-bedded, sometimes cross-bedded, fine to coarse, granular, commonly glauconitic. The beds vary considerably in thickness and beds 3 to 4 inches thick sometimes comprise layers 1 foot thick. In places there are extremely glauconitic beds 1 inch thick. Cream-colored, fairly thick "hash" beds commonly show much cross bedding. An intraformational conglomerate 6 inches thick occurs just below 402 feet. From 402 to 408 feet surface of beds shows rather prominent cross-bedding. Above 408 feet there occasionally occur thin beds of coarsely-granular, glauconite "hash" 30 388-418

18. Limestone: Yellowish-green gray to light cream, thin bedded, finely crystalline to sublithographic and slightly glauconitic. Beds generally range from 1/4 to 1 1/4 inches thick, with a few beds ranging up to 6 inches thick. From 356 to 379 feet beds weather to a knobby,

mottled appearance, with silt layers in between limestones. From 378 to 384 feet occur gray, fine-grained to sublithographic beds with small interbedded bioherms. From 384 to 388 feet occur very thin beds of light-tan to light-cream limestone 32 356-388

17. Limestone: Light tan to light cream, beds 2 to 6 inches thick, finely crystalline to sublithographic, and platy. Some of the limestones show cross bedding. 24 332-356

16. Limestone: Grayish-white to buff or cream, thin bedded, hard, solid, and sublithographic. Some thin beds of limestone intraformational conglomerate occur between 312 and 332 feet. A few beds of white, crystalline limestone are present. The contact with the Point Peak shale was placed at the first predominance of hard tan, sublithographic limestone. 32 300-332

Total thickness of San Saba measured 271

Point Peak shale member

15. Limestone and siltstone: Gray-brown, thin-bedded, crystalline limestone with interbedded,

		Thickness (feet)	Depth (feet)
	yellowish-gray siltstone. Some limestone beds are up to 6 inches thick. Limestones predominate in the lower part and siltstones in the upper part.	18	282-300
14.	Limestone, siltstone, and shale: Grayish-brown and yellow-stained, finely crystalline limestones; grayish-brown, micaceous siltstones; and light brownish-gray shale. From 285 feet to 230.5 feet small bioherms occur. From 272 to 273.5 feet and 275 to 277 feet a yellow-stained, slightly glauconitic and "hashy" limestone occurs	55	227-282
13.	Bioherms: A thick zone of olive-gray, mottled light purplish-gray, microgranular to sublithographic, stromatolitic reef limestone. Beds of shale and intraformational conglomerate are woven in and out of the bioherm layers	37	190-227
12.	Limestone, siltstone, and shale: Light grayish-brown, fine-grained limestone, light-tan to light-gray, commonly calcareous siltstones, and light-gray shale. Beds of siltstone and shale are 1/4 to 6 inches thick,		

with occasional beds of limestone 3 to 6 inches thick. A bed of limestone intraformational conglomerate is present from 177 to 177.5 feet. 22 168-190

11. Limestone and siltstone: Light-gray to light-brown, fine-grained limestone, and gray-green calcareous siltstone. The limestones are thinly bedded and argillaceous. An intraformational conglomerate occurs in the middle of this interval. 7.5 160.5-168

10. Limestone, siltstone, and bioherms: Gray to brown, finely-crystalline limestones, gray to light-tan, clacareous siltstones, and beds of small bioherms. The small bioherms, about 6 inches in diameter, occur at 153 to 153.7 feet and 158.5 to 160.5 feet. A 3 inch bed of intraformational conglomerate is present near 158.5 feet. The contact with the Morgan Creek limestone member was picked at the top of the last medium-bedded, glauconitic limestone overlain by a predominance of siltstone 12.5 148-160.5

Total thickness of Point Peak measured . . . 152

with occasional beds of limestone 3 to 5
inches thick; and calcareous intrafor-
mational conglomerate is present from
[illegible]
[illegible] siltstone, laminated limestone and
gray-green dolomitic siltstone. The lime-
stones are thinly bedded and argillaceous.
An intraformational conglomerate occurs in
the middle of this interval 7.5   108.5-116

16. Limestone, siltstone, and biotherms. Gray
to brown, finely-crystalline limestones,
gray to light-tan, calcareous siltstones,
and beds of small biotherms. The small
biotherms, about 2 inches in diameter, occur
at 123 to 129.7 feet and 168.5 to 200.5 feet.
A 3 inch bed of intraformational conglomerate
is present at 138.7 feet. The contact with
the Morgan Creek limestone member was placed
at the top of the last medium-bedded, glauco-
nitic limestone overlain by a predominance
of siltstone . . . . 11.5   [illegible]

Total thickness of Point Peak member . . . 162

Morgan Creek limestone member

9.	Limestone and siltstone: Light-tan to greenish-gray, fine- to medium-grained, generally "hashy", glauconitic, limestones, and grayish-green, micaceous siltstones. Beds of Eoorthis "hash" 1 to 2 inches thick and interbedded with siltstone occur from 142 to 147 feet. A light-tan, medium-bedded, crystalline, "hashy", glauconitic limestone is present at 147 to 148 feet	3	140-148
8.	Limestone and bioherms: Whitish-gray to greenish-gray, brown stained on surface, fine- to medium-grained, occasionally silty, glauconitic limestone, and small bioherms about 1 to 3 feet in diameter. Limestones have a platy appearance on weathered surface. Bioherms occur from 118.5 to 120 feet, 130 to 132 feet, 134 to 135.5 feet and 138.1 to 138.5 feet, and weather as gray, rounded knobs on limestone surface.	33	107-140

7. Limestone and siltstone: Alternating beds of greenish-gray, up to 1 foot thick limestones, and gray siltstones. 10 97-107

6. Limestone and siltstone: Whitish-gray, with yellow stains, medium-bedded, medium- to coarsely crystalline, glauconitic limestone, and greenish-gray, glauconitic siltstones and silty shales. Eoorthis occur at 90 feet. Silty shale intervals form gentle breaks in the slope 35 62-97

5. Limestone: Whitish-gray to gray, fine- to coarse-grained, thinly-bedded limestone. Beds alternate from 1 to 6 inches thick. Weathered limestone gives platy appearance. There is much trilobite "hash" in the highly glauconitic limestone near top. Also near the top there are concentrations of calcite crystals, some 1/4 inch across. Possible Eoorthis fragments from 58 to 60 feet. 16 46-62

4. Limestone: Gray to grayish-white, yellow stains on surface, some thin purplish beds, medium- to coarse-grained, highly glauconitic

and commonly "hashy". The beds of the lower and middle parts of this interval are 2 to 6 inches thick; near the top the beds range up to 1 foot thick. The "hash" is usually made up mostly of trilobite fragments. 16 30-46

3. Limestone. Light purplish-brown, losing purple color upward, sandy, and crystalline. Beds are from 1 to 8 inches thick. Fossil fragments and glauconite are present. The purple color is lost at 27 feet. 13 17-30

2. Limestone: Grayish-purple, sandy, calcite crystals with sand, and beds from 2 inches to 1 foot thick. For a short distance upward the beds become more purplish in color. This is a transition zone. The contact with the Welge sandstone member was picked at the first appearance of calcite in the purplish-brown beds 7 10-17

Total thickness of Morgan Creek measured . . 138

Welge sandstone member

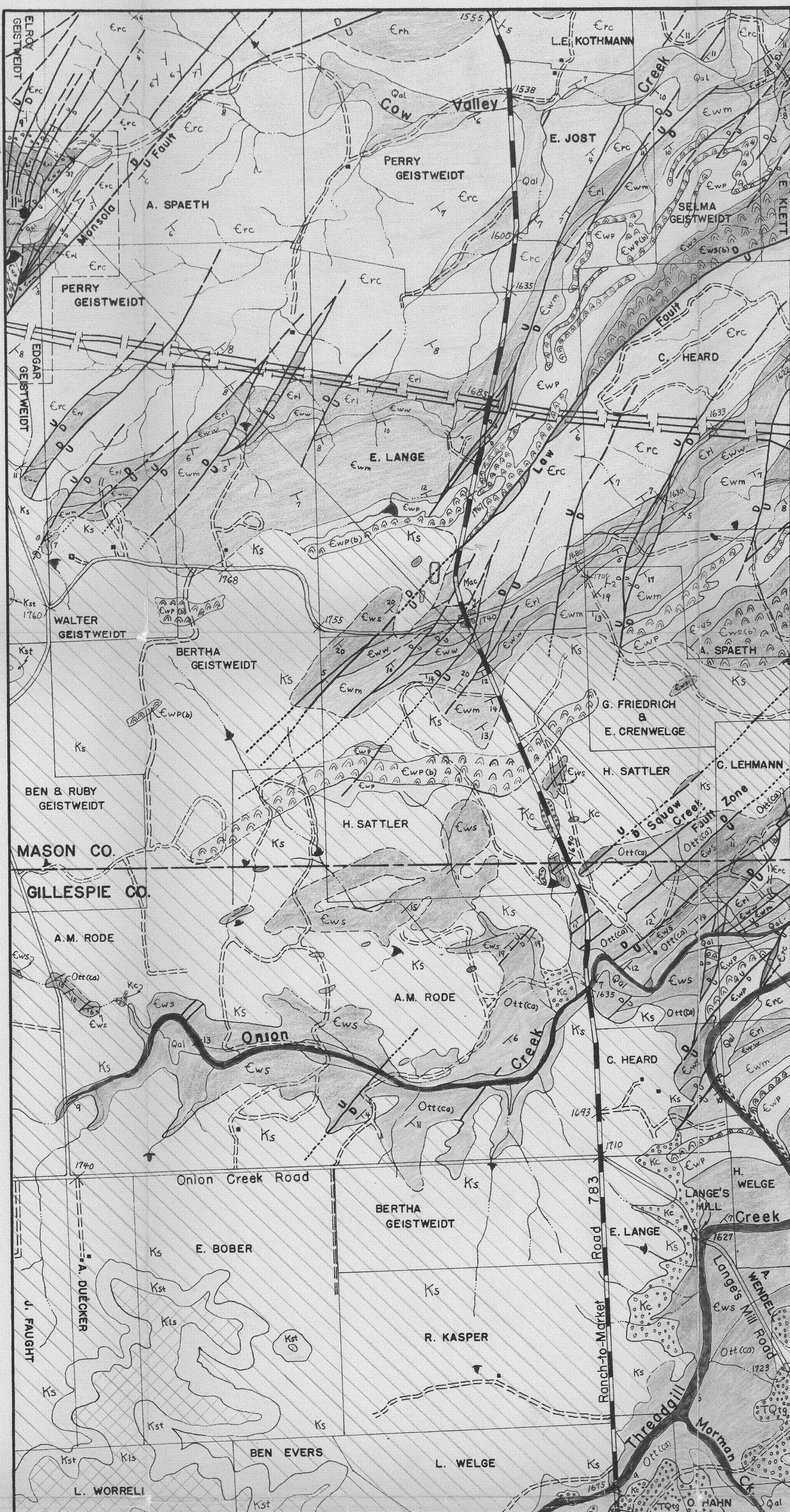
1. Sandstone: Orange to tan, massive and partly cross-bedded, fairly evenly sorted,

and medium-grained. Small ridges form on the weathered surface. The sandstone becomes whitish near the top . . . . <u>10</u> 0-10

(Approximately lower half of Welge faulted out)

Total thickness of Welge measured. . . . . . <u>10</u>

Total thickness of section measured. 580



Base from U.S. Department of Agriculture, Commodity Stabilization Service, aerial photograph, 1955

Geology by T. Coughran 1958

EXPLANATION

CENOZOIC — TERTIARY-QUATERNARY

- Qal — Recent alluvium
- TQtg — Tertiary or Quaternary terrace gravel

UNCONFORMITY

LOWER CRETACEOUS — Trinity and Fredricksberg groups — CRETACEOUS

- Kls — Limestone unit
- Kst — Siltstone unit
- Ks — Sandstone unit
- Kc — Lange's Mill conglomerate

? UNCONFORMITY ?

? MESOZOIC — MESOZOIC ?

- Mac — Arkosic conglomerate

UNCONFORMITY

LOWER ORDOVICIAN — Ellenburger group — TANYARD FORMATION — ORDOVICIAN

- Ott(ca) — Threadgill member (calcite facies)

UPPER CAMBRIAN — CAMBRIAN

WILBERNS FORMATION

- Ꞓws, Ꞓws(b) — San Saba limestone member and bioherm zone (b)
- Ꞓwp, Ꞓwp(b) — Point Peak Shale member and bioherm zone (b)
- Ꞓwm — Morgan Creek limestone member
- Ꞓww — Welge sandstone member

DISCONFORMITY

RILEY FORMATION

- Ꞓrl — Lion Mountain sandstone member
- Ꞓrc — Cap Mountain limestone member
- Ꞓrh — Hickory sandstone member

UNCONFORMITY

PRECAMBRIAN

- pꞒ — Precambrian undifferentiated

Observed and inferred contacts

Known, inferred, and covered faults (U, upthrown side, D, downthrown side)

Strike and dip of beds

Stream

Intermittent stream

Earthen stock tank

Caliche pit

Paved road

Graded, and unimproved ranch roads

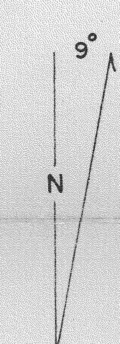
Property lines

Buildings

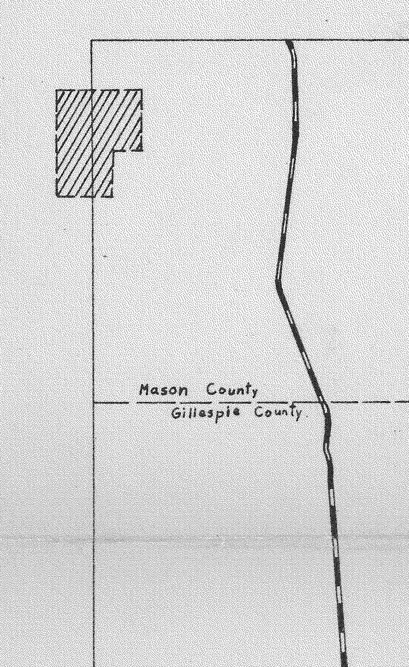
Oil pipe line

Line of described section

Altimeter elevations

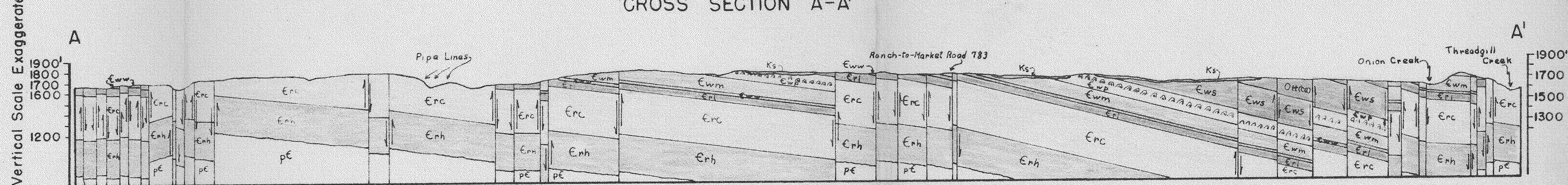


Approximate Mean Declination 1958



Index to enlarged portion of map-Plate XIII

CROSS SECTION A-A'



Cross section elevations are projections of a few scattered altimeter readings

SCALE ABOUT 1/20,000

1/2 1/4 0 1/2 1 2 Miles

2000 1000 0 2000 4000 6000 FEET

GEOLOGIC MAP AND CROSS SECTION OF THE DOSS-NORTH AREA, MASON AND GILLESPIE COUNTIES, TEXAS