GEOLOGY OF THE SALT CREEK AREA, MASON COUNTY, TEXAS

A Thesis

By

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ABSTRACT

The Salt Creek area is located in the southernmost part of Mason County, Texas and lies on the southwestern flank of the Llano Uplift, a structural dome in central Texas. The surface rocks represent six of the seven members of the Riley and Wilberns formations of Late Cambrian age, the basal portion of the Ellenburger group of Early Ordovician age, and limestone and sandstone of Early Cretaceous age.

The Riley formation, which averages 680 feet in thickness, is divided from bottom to top into the Hickory sandstone member, the Cap Mountain limestone member, and the Lion Mountain sandstone member. The Hickory sandstone member is not exposed in the thesis area, but good outcrops of the Cap Mountain and Lion Mountain members were mapped and described. All four members of the Wilberns formation crop out in the Salt Creek area and attain an average total thickness of approximately 580 feet. In ascending order these members are the Welge sandstone, the Morgan Creek limestone, the Point Peak shale, and the San Saba limestone.

The uppermost beds of the San Saba limestone member grade into the basal beds of the overlying Ellenburger group. The Ellenburger group consists predominantly of limestone with local occurrences of dolomite.

With the exception of Quaternary and Tertiary stream deposits, rocks of Early Cretaceous age are the youngest strata exposed in the research area. From the base upward these rocks grade from sand and silt to clay to limestone.

The Paleozoic rocks cropping out in the Salt Creek area strike approximately N 40° E with an average dip of 4° SE, exposing successively younger rocks in a southeast direction. The homoclinal attitude of these rocks is interrupted by many steeply dipping normal faults, most of which strike in a general northeast-southwest direction and exhibit relatively small vertical displacements of the order of 1 to 10 feet. The youngest rocks affected by these faults belong to the Ellenburger group of Early Ordovician age, and as the Cretaceous strata are not faulted, the faulting may be dated as being of pre-Cretaceous and post-Ordovician age. Local folding is suspected to be the cause of the southeast dip of the sedimentary strata and the northeast-southwest trend of the faults in the Salt Creek area.

Pre-Cretaceous peneplanation is indicated by a low-relief surface in the southern half of the thesis area which is comprised of outcrops of Paleozoic rocks of varying lithology and resistance to weathering and erosion. The facts that fault line scarps are uncommon, that meander patterns of streams are not affected by structural features, and that specific lithologic units do not always have the same topographic expression, may be interpreted as evidence that the pre-Cretaceous peneplane has been exposed to erosion during relatively recent time.

No profitable ore deposits and no accumulations of hydrocarbons have been discovered in the area at the present time. The most important natural resource is ground water, which is available for all domestic and agricultural demands.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude to Mr. S. A. Lynch, head of the Department of Geology and Geophysics at the Agricultural and Mechanical College of Texas, who assisted in the selection of the field problem. Thanks are also due Mr. Clay L. Seward, Dr. M. C. Schroeder, and Dr. Peter Dehlinger, all from the aforementioned department. Mr. Seward, chairman of the author's thesis committee, assisted in resolving some of the field problems and contributed most generously of his time in discussing the organization and presentation of the information contained in this paper. Dr. Schroeder supervised the field work upon which this thesis is based, and the writer is indebted for his guidance and constructive criticism throughout the preparation of this paper. Dr. Dehlinger discussed the structural features of the thesis area with the author and made helpful suggestions regarding the writing of this thesis.

The writer is also very grateful to many property owners and to the citizens of Mason County, Texas, who were unfailingly helpful and friendly.

Mapping equipment used in the field was the property of the Agricultural and Mechanical College of Texas.

GEOLOGY OF THE SALT CREEK AREA,

MASON COUNTY, TEXAS

INTRODUCTION

LOCATION

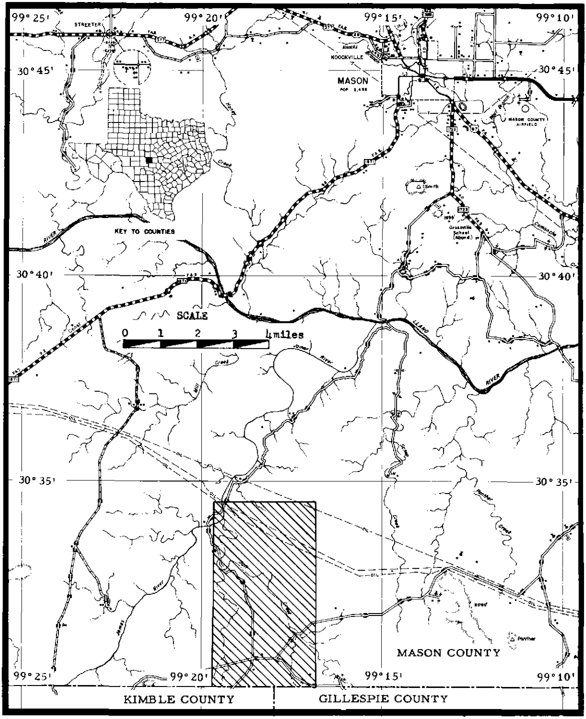
The Salt Creek area is named for Salt Creek, locally called Salt Branch, which is a tributary of the James River in southern Mason County, Texas. The area is approximately 19 square miles in extent and is bounded by latitudes 30°30' and 30°34' North and by longitudes 99°17' and 99°19.5' West. The center of the area is approximately 14 air-miles south-southwest of the city of Mason, Texas. The southern boundary of the area coincides with the southern boundary of Mason County (Fig. 1).

ACCESSIBILITY

The Salt Creek area is traversed from north to south and from east to west by unpaved but graded county roads.

The road furnishing access from the north, or from Mason, Texas, is the James River road. It is impossible to reach the thesis area by way of this road when the Llano and James Rivers are at flood stage, as there are two fords and one low-water bridge along this road to the north of the area.

Access to the Salt Creek area may be gained from the east by way of the Hey Ranch road which turns off Farm Road 783 at the Hilda church. This is a graded county road and is usually passable except immediately after very hard rains.



Modified from Texas State Highway Department Map
of Mason County, Texas, revised to January 1, 1958.

FIGURE 1

LOCATION MAP OF THE SALT CREEK AREA,

MASON COUNTY, TEXAS

The Salt Branch road turns off Farm Road 783 at the settlement of Doss, enters the southeast corner of the thesis area, and merges with the Hey Ranch road approximately one mile from the eastern boundary of the thesis area. This is the best road of the three mentioned, but due to the additional distance which must be traveled, it is not recommended for access from Mason except in times of extremely adverse weather conditions.

Numerous ranch roads traverse the interior of the Salt Creek area. Those which may be traveled by automobile are shown on the geologic map (Pl. XIII) included with this paper.

METHODS OF FIELD WORK

The field work was accomplished between June 2 and September 10, 1958. The mapping was done on acetate covering on aerial photographs obtained from the United States Department of Agriculture. Photographs 156, and 155 of series DFZ-3P were used in the preparation of the geologic map. The scale of these photographs is 1:20,000.

Formation and member contacts and structural features were located by interpreting the relationships of rocks observed in the field and by stereoscopic study of the aerial photographs. The author wishes to call attention to the fact that none of the geological features were mapped on the basis of stereoscopic interpretation alone. In all cases the stereoscopic investigation supplemented actual observations made in the field.

The dips and strikes of the bedded rocks were determined in the field with the use of a Brunton compass. Each dip and strike shown on the geologic map represents the average of several readings taken in that immediate vicinity.

As topographic control was not available, the relative relief shown by the geologic cross sections on the geologic map was estimated from stereoscopic study of the aerial photographs and from field observations.

REVIEW OF PREVIOUS WORK PERTINENT TO THIS RESEARCH PROJECT

Dr. Ferdinand Roemer (1846) was responsible for the first publication describing the geology of Central Texas. This paper was concerned with the area bordering the Central Mineral Region on the south. The first report on the stratigraphy and paleontology of the Paleozoic rocks in this area was also published by Roemer in 1849. This latter paper included the first geologic map of Texas, which was very inaccurate due to the reconnaissance nature of the surveys made by Roemer.

B. F. Shumard (1861) presented the first description of the stratigraphy and paleontology of the Potsdam group (Upper Cambrian) in Texas.

The Texas Geological Survey published a brief discussion of the mineral resources and the general geology of the Llano region by S. B. Buckley (1874). In this paper Buckley stated his belief that not all of the granites in the Llano region were of Precambrian age. He also stated that the metamorphic rocks are older than the granites with which they are associated.

C. D. Walcott (1884) determined the Potsdam group to be of Late Cambrian age, named the metamorphic rocks in the Llano region, and proposed that the igneous intrusions were of pre-Potsdam age.

In 1887 R. T. Hill summarized and discussed previous geologic studies made in Texas. In this paper Hill suggested there were two periods of tectonic activity, one of which occurred immediately following the deposition of the Llano series and the other at the close of the Paleozoic Era.

The Geological and Mineralogical Survey of Texas was created in 1889. Under the direction of T. B. Comstock this organization conducted the first systematic geological survey of the Llano region. During the course of this survey, Comstock (1890) introduced several new names such as the Hickory series, Riley series, San Saba series, Packsaddle schist, and Valley Springs gneiss.

In 1890 R. S. Tarr discussed the geomorphology of the Central Mineral Region. He stated his belief that the present drainage system in this area originated during Tertiary time and subsequently has been superimposed on the Paleozoic rocks and structures.

Sidney Paige (1911) revised some of the previous work done in the Llano region and named the Wilberns, Cap Mountain, and Ellenburger formations. Included in this paper was a discussion and description of

Precambrian geological features. The United States Geological Survey published a geologic folio of the Llano and Burnet quadrangles by Paige (1912).

In 1916 the Texas Bureau of Economic Geology published a geologic map of Texas which was the most accurate map up to this time.

Sellards, Adkins, and Plummer published a comprehensive report on the stratigraphy of Texas in 1932. This paper included a discussion of the Paleozoic systems and the regional structure in the Llano region.

Paleozoic deformation and structural relationships in the Llano region were discussed in a paper published in 1934 by Sellards and Baker.

Paleozoic fossils originally described by Roemer (1852) were redescribed by Bridge and Girty (1937). This latter paper accurately described the stratigraphic zones in which the fossils occur.

Barnes and Parkinson (1939) published a paper which discussed the origin and distribution of the ventifacts which occur in the base of the Hickory sandstone. These authors concluded that an arid climate and aeolian erosion prevailed during early Hickory time.

In 1940 Plummer briefly discussed the regional and local structure of the Central Mineral Region.

A report on the Ellenburger rocks was published by Cloud, Barnes, and Bridge in 1945. These authors elevated the Ellenburger formation to group status, defined the boundaries of the group, and restricted it to rocks of Ordovician age. They also divided the group, from bottom to top, into the Tanyard, Gorman, and Honeycutt formations.

Bridge, Barnes, and Cloud (1947) redefined and described members of the Riley and Wilberns formations in the Central Mineral Region. The stratigraphic relationships and sedimentary environments of the different members were also discussed.

Cloud and Barnes (1948) published a detailed report on the Ellenburger group in central Texas. These authors discussed the regional correlation of the Ellenburger group, the genesis of the lithic constituents, the paleontologic features, and described many measured sections. Many references were made to the paper published in 1945 by Cloud, Barnes, and Bridge.

The Pennsylvanian and Mississippian rocks in the Llano region were discussed in a detailed report by Plummer in 1950. Descriptions of measured sections and detailed geologic maps accompanied discussions of stratigraphy and paleontology in this report.

The San Angelo Geological Society's Guidebook (1954) for a Cambrian field trip in the Llano area contains a description by Barnes and Bell of the units comprising the Upper Cambrian strata. Several measured sections are included in this paper.

The northern portion of the Salt Creek area overlaps part of an area mapped by Dannemiller (1957). The present author is in general agreement with Dannemiller regarding the outcrop patterns and structural features. In a few cases, however, some of the member contacts and some of the faults as mapped by Dannemiller are slightly modified in this paper.

G E O G R A P H Y

And

P H Y S I C A L   F E A T U R E S

CLIMATE

Information obtained from the Mason County Chamber of Commerce indicates that the mean annual rainfall in Mason County, Texas is 22.5 inches. Precipitation may vary as much as 15 inches from year to year however, and is irregularly distributed throughout the seasons. Due to the light rainfall, this general area is classified as semi-arid.

The average annual temperature is approximately 70° F. The daytime winter temperature from November to April ranges from 20° F to 70° F. The daytime summer temperature ranges from 80° F to 110° F. Severe freezes are common during the winter months.

VEGETATION

The Salt Creek area in Mason County, Texas supports a vegetative cover that is characteristic of semi-arid regions with a thin, poorly developed soil. The trees consist of mesquite, scrub oak, post oak, live oak, cedar, and a few willows, sycamores, and elms. The predominant grasses are curly mesquite, buffalo, needle, and crowfoot. Various shrubs and cacti such as prickly pear, catsclaw, tasajillo, Mexican persimmon, agarita, and yucca are widely distributed throughout the area.

Topography, lithology, and structure affect the type and concentration of vegetative cover. The hills and slopes in the research area generally support a sparse growth of mesquite, scrub oak, cedar, yucca, needle grass, and curly mesquite grass. The stream valleys support a relatively dense growth of vegetation characterized by willows, sycamores, elms, various oaks, catsclaw, and high buffalo grass. The surface traces of faults commonly result in an alignment of relatively dense vegetation which is not affected by topography nor bedding planes of the outcropping strata. These lineations of vegetation are probably due to better soil development on the fractured rocks and to the entrapment of surface water in the fractures.

GEOMORPHOLOGY

The Salt Creek area in Mason County, Texas is located on the southwestern flank of the Llano Uplift, a structural dome which has been reduced to a topographic basin by erosional processes. Rocks cropping out within the basin range in age from Precambrian to Recent. The basin is bounded on the east and south by a high, distinct rim of relatively flat-lying Cretaceous rocks.

The topography in the northern half of the Salt Creek area is represented by high bluffs, steep slopes, and many high hills. The high bluffs occurring along the James River and Salt Creek, in all instances, are capped by the bioherm zone which is stratigraphically located above or in the upper Point Peak shale. Traveling eastward and southeastward from where the James River crosses the area, many hills with steep slopes are encountered. These hills are capped by either the bioherm zone or by the San Saba limestone. In this portion of the research area, many deep gulleys or arroyos have been formed by surface drainage into the James River.

In the extreme southern part of the area, the Cretaceous rocks form a plateau which is capped by what is probably the Edwards limestone. This Cretaceous plateau abruptly rises approximately 250 feet above the Ellenburger surface and is topographically the highest part of the research area.

The lowest part of the area is formed by the bed of the James River. Maximum relief within the area is estimated to be on the order of 500 feet and was caused primarily by the drainage system of the James River. In the thesis area, Salt Creek, an intermittent stream which flows in a northwesterly direction, is the major tributary of the James River. Hey Creek, also an intermittent stream, joins Salt Creek approximately 1.5 miles south of the James River.

The relatively recent uplift of the area, which has resulted in the removal of a large part of the Cretaceous cover, is indicated by the rejuvenated nature of the streams. The incised meander patterns of the James River, Salt Creek, and Hey Creek are not affected by the many faults which they cross.

The alluvium which is located 2.6 miles from the southern boundary and 0.5 miles from the western boundary of the thesis area, represents a "meander cutoff" of Hey Creek. This channel, which has been abandoned only very recently, may be interpreted as evidence that the area is still being uplifted.

In the southern and eastern parts of the Salt Creek area, pre-Cretaceous peneplanation is evidenced by a low-relief erosion surface which consists of rocks of varying resistance to weathering. In the southern half of the Salt Creek area, exposures of the siltstone-sandstone facies of the San Saba limestone member crop out at the same elevation as does the Ellenburger limestone. In the eastern part of the area, the Point Peak shale also outcrops at approximately the same elevation as the Ellenburger limestone.

Although many faults were observed in the Cambrian and Ordovician rocks, fault line scarps are practically nonexistent. This fact also indicates that the Cambrian and Ordovician rocks were at one time peneplaned, and it also suggests that this peneplane was exposed again to erosional processes during relatively recent geologic time. Since removal of the Cretaceous cover, the erosional and weathering processes have not had sufficient time to produce topographic features which are influenced by varying lithologies.

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

General Statement

Rocks cropping out in the Salt Creek area range in age from Cambrian to Recent. The Paleozoic era is represented by rocks of the Cambrian and Ordovician Systems. The Paleozoic sediments are overlain by those of Cretaceous age. The stratigraphic column in the area is as follows:

CENOZOIC ERA

- Quaternary
  - Recent alluvium
- Tertiary conglomerate

MESOZOIC ERA

- Cretaceous System
  - Commanche Series

PALEOZOIC ERA

- Ordovician System
  - Lower Ordovician
    - Ellenburger group
- Cambrian System
  - Upper Cambrian
    - Wilberns formation
      - San Saba limestone member

Point Peak shale member

Morgan Creek limestone member

Welge sandstone member

Riley formation

Lion Mountain sandstone member

Cap Mountain limestone member

Hickory sandstone member

PALEOZOIC ERA

CAMBRIAN SYSTEM

The Riley formation, originally called the Riley series, was named for the Riley Mountains of Llano County by T. B. Comstock (1890, p. 286-289) and consisted of rocks now included in the Hickory sandstone and Cap Mountain limestone members. Comstock also proposed the name Hickory series for the Paleozoic strata underlying his Riley series. Sidney Paige (1912, p. 42) used the term Hickory sandstone rather than Hickory series and proposed the name Cap Mountain formation for the limestone beds overlying the Hickory sandstone. The Lion Mountain sandstone was described as a member of the Cap Mountain formation by Bridge (1937, p. 235). The Riley series was redesignated as the Riley formation by Cloud, Barnes, and Bridge (1945, p. 154) and includes the following three members in descending order:

3) Lion Mountain sandstone

2) Cap Mountain limestone

1) Hickory sandstone

The Riley formation, as described by Cloud, Barnes, and Bridge (1945, p. 154), may vary from 780 to 200 feet in thickness due to the irregular Precambrian surface upon which it was deposited. The average thickness, however, is estimated to be 680 feet.

The total thickness of the Riley formation in the research are could not be determined due to the absence of outcrops of the Hickory member and the lower portion of the Cap Mountain member.

Cap Mountain Limestone Member

Introduction

This member varies from 135 to 455 feet in thickness, according to Bridge, Barnes, and Cloud (1947, p. 112). The complete Cap Mountain section is not present in the thesis area, and therefore it was impossible to compare the total thickness in this area to that measured by Bridge, Barnes, and Cloud.

Lithology

That portion of the Cap Mountain member which can be observed in the thesis area is characterized by a buff to gray, finely crystalline, slightly glauconitic, fossiliferous limestone. The beds range from a few inches to several feet in thickness. Some of the beds exhibit a yellow to rust-red color which is a result of the weathering of the glauconite to limonite.

The uppermost beds of gray limestone contain a greater quantity of glauconite, which often results in a greenish or dark brown to tan mottled appearance. Lenses of trilobite shell fragments, often referred to as "trilobite hash", are common in this upper portion of the member.

Topography and Vegetation

The Cap Mountain limestone crops out only in the extreme northwest corner of the research area. This outcrop forms the bed of the James River and relatively steep slopes immediately adjacent to the river. The limestone in the river bed exhibits an unusual feature which has been referred to as "wagon tracks" by H. R. Blank (1958, p. 293). These "wagon tracks" are a series of shallow erosional trenches which are roughly parallel and which trend in the direction of the stream flow. In several instances these trenches connected very deep potholes which were roughly elliptical in surface area with the long axis of the ellipse roughly parallel to the trend of the "wagon tracks".

The vegetation on the Cap Mountain outcrop is rather sparse and very little grass is present. The vegetation is composed predominantly of mesquite, catsclaw, and prickly pear. A few scrub oaks and some Spanish dagger were observed to occur locally.

Lion Mountain Sandstone Member

Introduction

The Lion Mountain sandstone member was named by Bridge (1937, p. 235) for Lion Mountain, the type locality, in the northwest portion of the Burnet Quadrangle, Burnet County, Texas.

The maximum thickness of this member in the Llano region is 50 feet, according to Bridge, Barnes, and Cloud (1947, p. 114). The present writer estimates its total thickness in the Salt Creek area to average approximately 25 feet.

According to Bridge, Barnes, and Cloud (1947, p. 114) the Cap Mountain-Lion Mountain contact is gradational but is usually mapped at the base of the sparsely vegetated topographic bench formed by the Lion Mountain member. In the thesis area the contact was placed at the base of the first glauconitic sandstone appearing above the Cap Mountain limestone member. This placing of the contact agrees with that proposed by the aforementioned authors. The lowermost sandstone of the Lion Mountain member, at the base of which the contact was drawn, occurs where there is a definite change of slope between the steep slope of the Cap Mountain limestone and the gently sloping topographic bench of the Lion Mountain sandstone.

Lithology

The Lion Mountain member is composed of glauconitic, fine to medium grained, calcareous quartz-sandstone interbedded with relatively thin beds of glauconitic, arenaceous limestone containing lenses of "trilobite hash". The sandstone and limestone beds are buff to gray in color with green or reddish-brown specks, depending upon the degree of alteration of the glauconite. In the thesis area the weathered outcrop is covered with a residual soil which is predominantly rust-red in color, indicating a high degree of alteration of the glauconite.

The weathered slopes on the Lion Mountain outcrop are littered with shiny, black, hematite nodules (Pl. 1). It is probable that these nodules are the weathering products of glauconite ($KMgFe_3Si_6O_{18} \cdot 3H_2O$), in which the iron was altered to hematite (Fe_2O_3) and from which some of the silica was removed in the form of a colloid. The nodules contain scattered quartz grains and appear to have some siliceous cement.

Topography and Vegetation

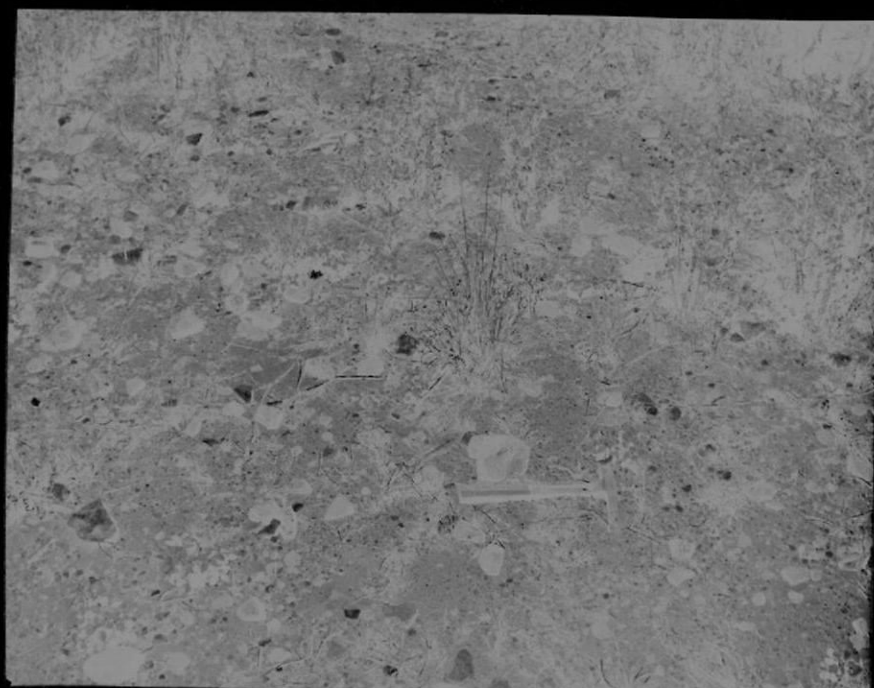
The outcrop of the Lion Mountain sandstone, which is found adjacent to the James River, forms a gently sloping topographic bench covered with loose, red soil. Where the soil is well developed, grain for livestock feed is occasionally raised. For the most part, the vegetation consists of scrub oak, Mexican persimmon, and various grasses, with the scrub oak and Mexican persimmon occurring as patches of thick brush.

Wilberns Formation

Introduction

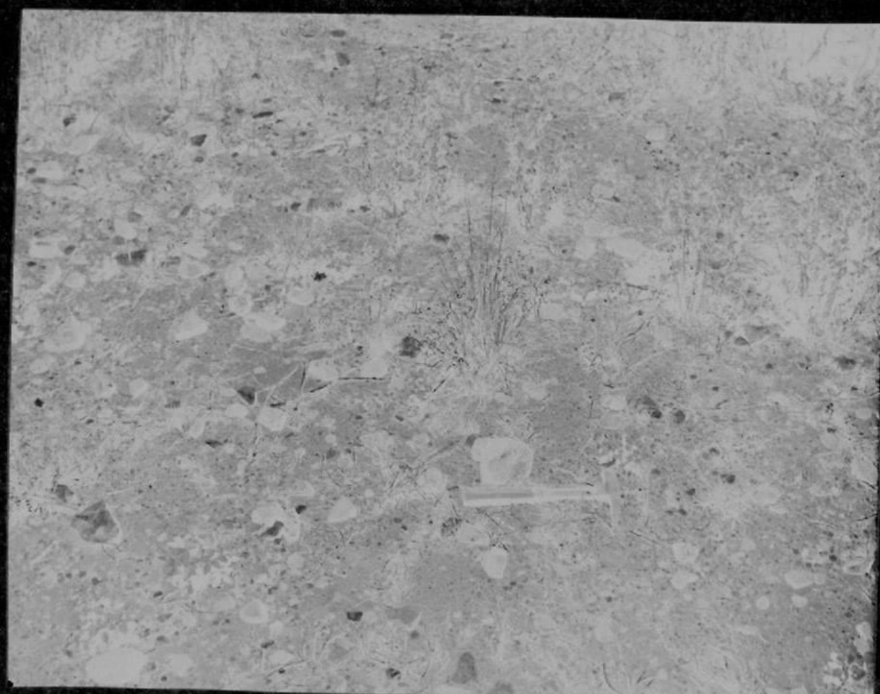
The Wilberns formation was first named by Paige (1911, p. 23) who designated the type locality as Wilberns Glen in Llano County, Texas. Paige's description of this formation did not include the San Saba limestone member. Due to the difficulty of placing the San Saba-Ellenburger contact, and because of the lithologic similarity of the San Saba and Ellenburger limestones, Paige (1912, p. 47) included the San Saba in the Ellenburger group of Ordovician age. Cloud, Barnes, and Bridge (1945, p. 155) redefined the Wilberns formation and divided it into four members

PLATE I



Hematite nodules on a weathered outcrop of the
Lion Mountain sandstone member.

PLATE I



Hematite nodules on a weathered outcrop of the Lion Mountain sandstone member.

which included the San Saba limestone. They placed the upper boundary of the Cambrian system at the top of the San Saba limestone member.

Bridge, Barnes, and Cloud (1947, p. 149) later described the Wilberns formation as having five members which were 1) the Welge sandstone, 2) the Morgan Creek limestone, 3) the Point Peak shale, 4) the San Saba limestone, and 5) the Pedernales dolomite. According to these authors, the total thickness of the Wilberns varies between 540 feet and 610 feet.

Barnes and Bell (1954, p. 35) proposed the deletion of the Pedernales dolomite member as it is equivalent to the San Saba limestone member.

At the present time, the Wilberns formation is defined as having four members which are:

4) San Saba limestone

3) Point Peak shale

2) Morgan Creek limestone

1) Welge sandstone

All four of these members crop out in the Salt Creek area.

This author has mapped the zone of large stromatolitic bioherms, which is usually regarded as being the uppermost portion of the Point Peak shale, as a separate unit which is between the Point Peak shale and the San Saba limestone members.

Welge Sandstone Member

Introduction

The Welge sandstone member, which is the basal sandstone of the Wilberns formation, was named by Barnes (Bridge, Barnes, and Cloud, 1947, p. 114), and the outcrops of this member in the Welge land survey were designated as the type locality. At the type section, which is located on Squaw Creek one-half mile north of the Gillespie County line, the Welge attains a thickness of 27 feet. According to Bridge, Barnes, and Cloud (1947, p. 114), the Welge averages 18 feet in thickness throughout the Llano region. In the Salt Creek area the Welge averages 19 feet in thickness.

Lithology

The contact between the Welge sandstone and the underlying Lion Mountain sandstone is marked by the abrupt change at the top of the purplish, highly glauconitic Lion Mountain member to a light tan, non-glauconitic sandstone. The Welge is a light tan to rusty brown, massive, medium-grained, quartzose sandstone. In the Salt Creek area the Welge contained a few widely scattered brachiopod molds in its upper portion, and was slightly cross-bedded in the lower portion. The sand grains are cemented by siliceous material except in the top few feet of the member where the cement becomes calcareous in nature. Many of the individual sand grains exhibit recrystallized faces which give them a sparkling appearance. Other grains, which do not exhibit this characteristic, appear to be well rounded. The weathered surface of this member generally has a dirty-brown color and is much darker than unweathered surfaces.

Topography and Vegetation

The outcrop of the Welge sandstone member forms a distinct scarp in the Salt Creek area. This scarp rises abruptly from the gently sloping topographic bench formed by the Lion Mountain sandstone member.

The vegetation is noticeably thicker on the Welge sandstone than on either of the adjacent members. Scrub oak, mesquite, and Mexican persimmon are well developed on the Welge member with lesser amounts of prickly pear and tasajillo.

Morgan Creek Limestone Member

Introduction

The Morgan Creek limestone member of the Wilberns formation was named by Bridge (1937, p. 236) for a locality on Morgan Creek in Burnet County, Texas. According to Bridge, Barnes, and Cloud (1947, p. 114) the type section, which is located at the junction of the north and south forks of Morgan Creek, is approximately 110 feet thick. In the Llano region, however, the thickness may vary from 70 to 160 feet. The average thickness, according to the aforementioned authors is 120 feet.

In the Salt Creek area, the continuity of the Morgan Creek outcrop was interrupted by several faults, thereby hindering measurement of the section. According to Sliger (1957, p. 30) the maximum thickness of this member was estimated to be 130 feet in an area located approximately two miles to the north of the Salt Creek area.

Lithology

The Welge-Morgan Creek contact is gradational and therefore its position is somewhat arbitrary. For purposes of this paper, the contact was placed at the base of the first purplish-colored arenaceous limestone overlying the massively bedded, yellowish-brown sandstone of the Welge member.

The lowermost Morgan Creek beds which could be observed consisted of slightly purplish to maroon, thinly bedded, coarse grained, glauconitic limestone which was slightly arenaceous and very fossiliferous. The purplish color of these lower beds gradually changes to dark gray and then to light gray upward from the base of the section. The uppermost beds vary from 0.3 to 2.0 feet in thickness, are light gray to greenish gray, medium-grained, silty, glauconitic limestone. Many of these beds appear to be composed almost entirely of trilobite shell fragments, commonly called "trilobite hash".

The Morgan Creek member is fossiliferous throughout. The marker zone of the brachiopod Eoorthis texana occurs approximately 45 feet above the base of this member according to Barnes and Bell (1954, p. 59). This zone was observed in the cliffs along Salt Creek approximately 1/4 mile south of the James River and occupied the same stratigraphic position as that described by Barnes and Bell.

Small, purplish, sub-lithographic, stromatolitic bioherms ranging from 0.5 to 2.0 feet in diameter were very common near the top of this member (Pl. II).

Layers of glauconitic shale and silt are interbedded with the limestone throughout the section. Both the limestone and the shale layers exhibit crenulated or wavy bedding and many of the "hashy" zones in the limestone appear to have been intensively reworked prior to induration. The foregoing observations tend to indicate rather turbulent conditions during deposition. The glauconite in these zones probably was formed in relatively quiet water and was subsequently reworked and redeposited with the trilobite fragments.

Topography and Vegetation

The outcrop of the Morgan Creek limestone was observed in stream beds and on relatively steep slopes in the thesis area. The slopes are sparsely vegetated with scrub oak, mesquite, Spanish dagger, and prickly pear.

Point Peak Shale Member

Introduction

Bridge (1937, p. 236) named the Point Peak shale member for Point Peak, a conspicuous hill located approximately four miles northwest of Lone Grove in Llano County, Texas.

According to Bridge, Barnes, and Cloud (1947, p. 115), the Point Peak is 270 feet thick at the type locality and averages 160

PLATE II

Small, purplish-colored bioherms exposed on a weathered outcrop of the Morgan Creek limestone.

feet throughout the Llano Uplift. Large variations from this average are common, however, and have been explained as the result of facies changes and irregularities in deposition. In the Salt Creek area, this member was estimated to be approximately 150 feet thick.

The Morgan Creek-Point Peak contact (Pl. III) is gradational and was placed at the base of the first thick sequence of shale and siltstone which overlies the thick beds of Morgan Creek limestone and the small purple bioherms which are included in the Morgan Creek member.

The zone of large bioherms which occurs near the top of the Point Peak shale member varies in its stratigraphic position and may occur within the Point Peak shale member or in the San Saba limestone member. In this paper the bioherm zone is treated as a separate rock unit.

In the Salt Creek area, the bioherms generally occur in a single zone which is overlain by the San Saba limestone member. Along the extreme western boundary of the area, however, two distinct zones of bioherms, separated by a sequence of limestone beds, were observed. The Point Peak-San Saba contact was placed at the top of the upper bioherm zone, thereby including both bioherm zones and the intermediate limestone beds in the Point Peak shale member. This placement of the contact was based on the fact that the intermediate limestone thickens to the west and grades laterally, also to the west, into a shale facies typical of the Point Peak shale member (W. N. White, 1958, personal communication).

PLATE III

Contact between Morgan Creek limestone and Point Peak shale. Photographed at the junction of Salt Creek and the James River.

Due to the presence of Girvanella in the bedded limestone separating the two bioherm zones in the Salt Creek area, the present writer originally thought that this limestone represented the basal portion of the San Saba limestone member. According to Bridge, Barnes, and Cloud (1947, p. 120), however, although Girvanella beds occur mostly in the San Saba limestone member they are not restricted to this unit and are often found in limestones of the Point Peak shale member.

Lithology

The Point Peak shale member consists of greenish-gray to dirty-tan thinly bedded, calcareous shale and siltstone with thin, often fossiliferous, limestone stringers occurring throughout the section.

Some of the limestone beds in the middle portion of this member reach a thickness of approximately one foot and often bear a very close lithological resemblance to either the overlying San Saba limestone or the underlying Morgan Creek limestone. Intraformational conglomerates are widespread throughout the upper half of this member. These conglomerates are composed of pebbles of medium to fine-grained glauconitic limestone in a calcareous matrix.

Topography and Vegetation

The Point Peak shale weathers readily and the lower portion of this member usually forms gentle slopes. In some cases, however, steep slopes and overhanging bluffs characterize the outcrop where it is protected by the overlying highly resistant bioherm zone which forms the caps of the hills and ridges (Pl. IV).

PLATE IV

Exposures of Point Peak shale which forms a high bluff on Salt Creek. The bioherm zone caps this bluff.

The gentle slopes are characteristically covered by a thin, loose soil containing many limestone fragments and much caliche. The vegetation is thin and consists chiefly of mesquite, prickly pear, catsclaw, and Spanish dagger.

Bioherm Zone

Introduction

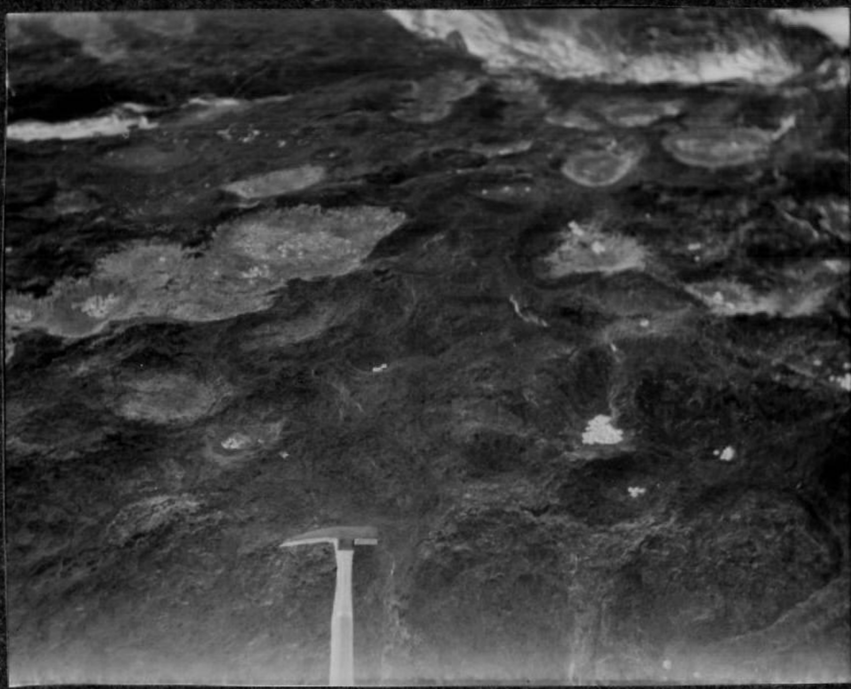
The Point Peak shale, as described by Bridge, Barnes, and Cloud (1947, p. 115), includes the bioherm zone. While conducting the research for this paper, however, the bioherm zone was treated as a separate unit due to its distinctive lithologic character and widespread occurrence.

Lithology

The bioherms are composed of a buff to gray, sub-lithographic limestone which weathers to a grayish-brown color. This weathered surface often exhibits circular forms which are referred to as "cabbage head" structures (Pl. V), and which usually range from 0.5 to 2.0 feet in diameter. The bioherm masses probably were formed by lime-secreting algae.

In many cases the bioherms rest directly upon beds of intraformational conglomerate. These conglomeratic beds may indicate a marine regression succeeded by exposure to subaerial conditions. The thinness of these beds suggests that the subaerial exposure was of short duration and was followed by an advance of the seas, after which the bioherms began to grow on the previously weathered surface.

PLATE V



Weathered surface of bioherms which exhibit typical "cabbage-head" structure.

In the thesis area, these bioherms occur as isolated masses or they coalesce to form biostromes (Pl. VI). In many cases the isolated masses attained a diameter of 40 feet.

Topography and Vegetation

The bioherms, as was mentioned previously, form the caps on many hills and ridges in the Salt Creek area. In contrast to the sparsely vegetated slopes of the Point Peak shale, the bioherm zone supports a thick vegetative cover consisting of live oak, Spanish dagger, prickly pear, mesquite, Mexican persimmon and catsclaw.

San Saba Limestone Member

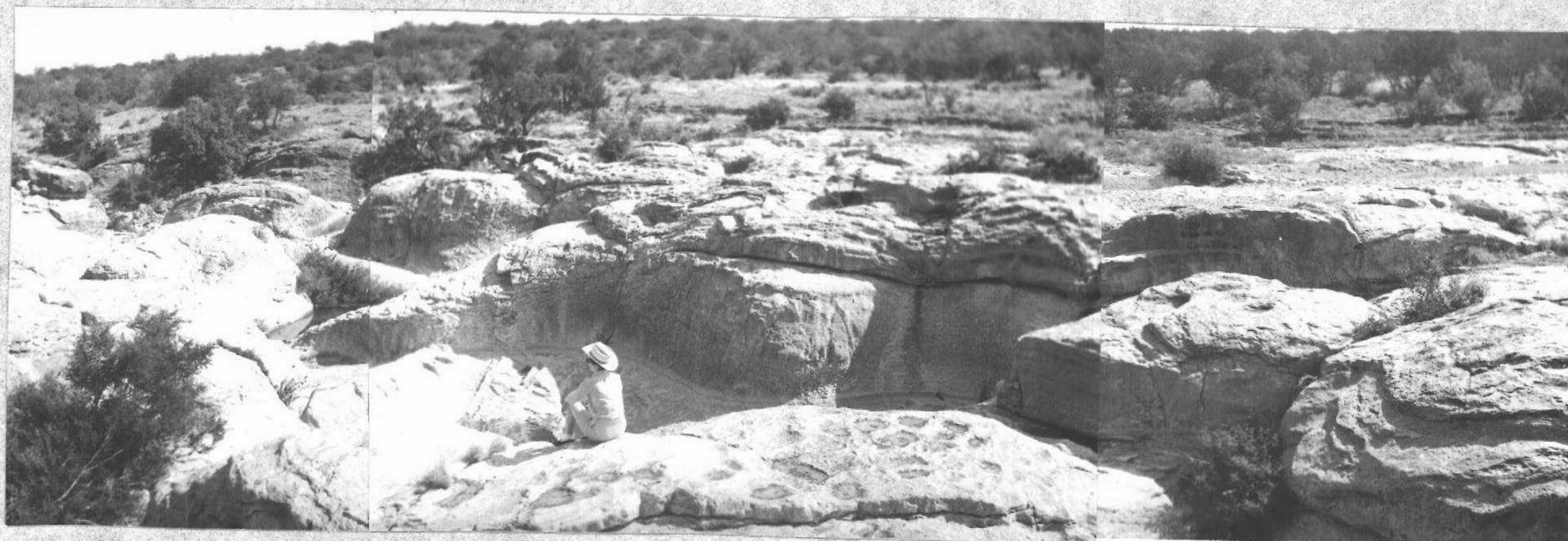
Introduction

The San Saba limestone was named by Bridge (1937, p. 237) and the type locality was designated as the outcrop north of old Camp San Saba where the Mason-Brady highway crosses the San Saba River. According to Bridge, Barnes, and Cloud (1947, p. 117), the name San Saba was originally used by Comstock (1890, p. 301) as a series name which was applied to all or part of the beds now included in the type section.

The type section begins where the Mason-Brady highway crosses the San Saba River and ends 0.7 miles north of this point. At the type locality the outcrop is 280 feet thick. In the Salt Creek area this member reaches an estimated maximum thickness of 300 feet.

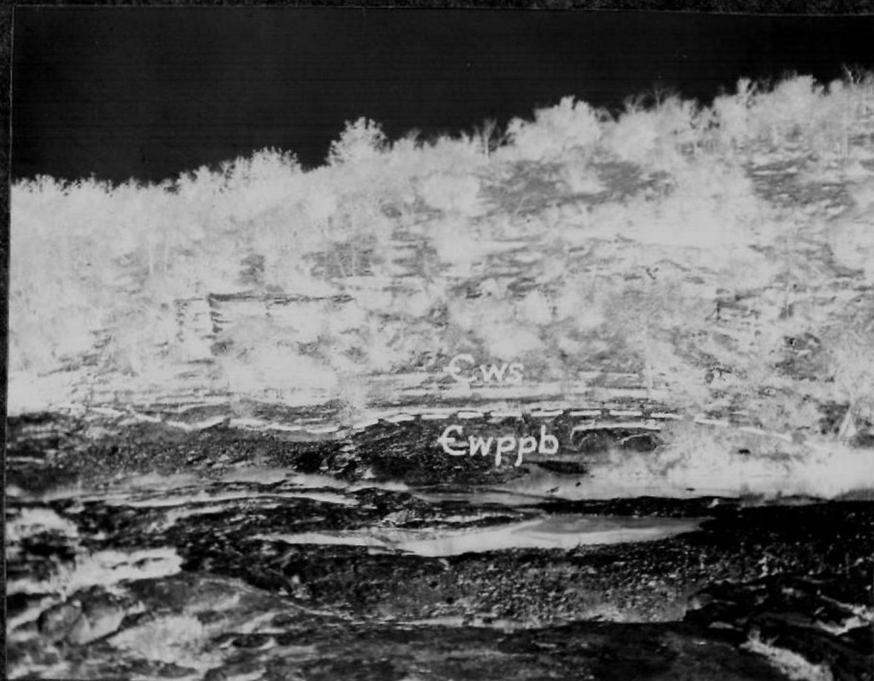
The lower contact is placed at the base of the first well bedded limestone overlying the bioherm zone (Pl. VII) or, where the bioherm zone

PLATE VI



Weathered exposures of the bioherm zone which occurs at the top of the Point Peak shale. Photographed on Salt Creek on Edgar Geistweidt property.

PLATE VII



Contact between San Saba limestone and the bioherm zone which overlies the Point Peak shale. Exposure is in the bed of Salt Creek.

is absent, at the top of the highest significant shale of the Point Peak member.

Lithology

The lithology of the San Saba member is more variable than that of any other member in the Wilberns formation. The San Saba is predominantly composed of limestone beds, but due to facies changes, these beds often grade laterally into siltstones and sandstones and closely resemble outcrops of the Point Peak shale member (Pl. VIII, figs. 1 and 2). Beds of intraformational conglomerate were observed throughout the upper half of the member and a few local occurrences of bioherms were noted. These bioherms were not as prominent as those in the Point Peak shale member.

The limestone beds, which range from 2 inches to 2 feet in thickness, vary in color from buff to greenish-gray to tan and brown with many specks giving the weathered surface a mottled or speckled appearance. The limestones contain glauconite in varying amounts, vary from sub-lithographic to coarse grained, and are fossilferous. The fossils in this member consist of various forms of brachiopods, gastropods, and trilobites. Gastropods predominate over the other fossils, with a tightly coiled unnamed gastropod being the most common form throughout the upper half of the San Saba member. This same form appears to be common in the outcrops of the San Saba member on the Tommy Brook ranch in northern Mason County. Sublithographic, subspherical, pea-sized masses occur in the limestone beds of this member.

PLATE VIII

Similarity of bedding and lithology in outcrops of the Point Peak shale and the silt facies of the San Saba limestone.

Figure 1. Point Peak shale exposed on Salt Creek.

Figure 2. Silt facies of the San Saba limestone exposed on Hey Creek.

PLATE IX

Exposure of San Saba limestone on Hey Creek in which a silty facies may be observed overlying well-bedded limestone.

These small bodies are believed to be of algal origin and are referred to by Bridge, Barnes, and Cloud (1947, p. 120) as _Girvanella_.

The siltstones and sandstones range in color from white to tan, are fine to coarse grained, may be either very tough or friable, and are calcareous. Their weathered surfaces may be tan or brownish-gray and in some cases are a distinctive purplish-red. The thickest section of this siltstone and sandstone observed by this author is 108 feet thick and is located along Hey Creek in the northwestern corner of the southern half of the thesis area. A description of this measured section is contained in the appendix of this paper.

The bioherms, which are exposed in only a few widely scattered outcrops, consist of gray, sub-lithographic to microgranular limestone. Their weathered surface exhibits the spherical pattern previously referred to as "cabbage head" structure. The maximum diameter of the bioherms ranges between 3 and 10 feet.

The intraformational conglomerates are nonfossiliferous and are composed of angular to rounded, sub-lithographic to microgranular limestone pebbles in a medium grained limestone matrix.

Topography and Vegetation

The outcrops of the San Saba limestone are the most extensive in the Salt Creek area. No particular topographic feature is characteristic of the San Saba outcrop. Both the limestone and siltstone facies crop out on hilltops, on gentle and steep slopes, and in stream beds.

The vegetation may be either dense or sparse and consists of mesquite, Mexican persimmon, Spanish dagger, prickly pear, catsclaw, and scrub oak.

ORDOVICIAN SYSTEM

The Lower Ordovician rocks in the Salt Creek area are represented by the Ellenburger group. The middle and upper Ordovician sediments are not present in this area.

Ellenburger Group

Introduction

The name Ellenburger formation was originally used by Paige (1911, p. 24) for the limestone that crops out in and forms the Ellenburger Hills in southeastern San Saba County, Texas. Cloud, Barnes, and Bridge (1945, p. 133) elevated the Ellenburger to group status and divided it into three formations which are, from bottom to top, the Tanyard, Gorman, and Honeycut. The average thickness of the Ellenburger rocks in the Llano region is 1694 feet, according to Barnes and Bell (1954, p. 35). It is impossible to determine the average thickness of this group in the Salt Creek area because the upper units of the group are covered by Cretaceous sediments.

This paper differentiates the limestone and dolomite facies of the Ellenburger group but does not attempt to distinguish any of the formations represented by these rocks.

The San Saba-Ellenburger contact was placed at the highest occurrence of glauconite in the San Saba or at the lowest occurrence of the gastropod, Lytospira gyrocera (Pl. X, fig. 2). This gastropod is very widespread throughout the basal Ellenburger which crops out in the Salt Creek area.

Lithology

The limestone facies of the Ellenburger is more extensive than the dolomite facies in the research area.

The limestone beds vary from 0.1 to 1.5 feet in thickness (Pl. XI) and their weathered surfaces range in color from chalky white to pearl-gray to varying shades of tan. Unweathered surfaces are light gray to light tan. The limestone is sub-lithographic to microgranular, fossiliferous (Pl. X, figs. 1 and 2), and non-glauconitic. The lowermost Ellenburger beds are more fossiliferous than the higher beds.

The dolomite facies does not always follow the bedding planes and it grades both horizontally and vertically into limestone. The outcrops of this facies are usually littered with many angular chunks of dolomite. The weathered and unweathered surfaces of these chunks or small boulders range in color from yellowish-brown to rusty-red. The dolomite is medium to fine-grained and is generally non-fossiliferous.

Scattored pieces of pearl-gray to black chert are usually associated with the dolomite facies, but may also occur with the limestone strata.

Topography and Vegetation

The Ellenburger group generally caps relatively flat-topped hills and exhibits only moderate relief in the Salt Creek area.

PLATE X

Fossils characteristic of the lower portion of the Ellenburger group.

Figure 1. Ophileta

Figure 2. 1) Lytospira gyrocera
2) Ophileta

PLATE XI

Weathered outcrop of Ellenburger limestone.

Exposed approximately 100 yards northeast of the San Saba-Ellenburger contact on Hey Creek.

The vegetation is relatively sparse and evenly distributed over the outcrop area. It consists chiefly of mesquite, scrub oak, prickly pear, and some scattered cedar.

MESOZOIC ERA

CRETACEOUS SYSTEM

Introduction

In the Salt Creek area the Paleozoic rocks are unconformably overlain by those of Cretaceous age. According to Cloud and Barnes (1948, p. 189) the Cretaceous rocks in southern Mason County, Texas represent the basal Commanche Series and comprise the Travis Peak, Walnut, Commanche Peak, and Edwards formations. In this paper these units have been treated as undifferentiated Lower Cretaceous rocks, and the only differentiation made was on a lithological basis.

Lithology

The Cretaceous sediments in the area studied are represented by three distinct lithologic types, which are, from the base upward, (1) sand and silt, (2) argillaceous siltstone and (3) limestone.

The alluvial plain at the base of the Cretaceous plateau is covered by a deep red, very fine silt. The rust-red sand which is found in place at the base of the plateau is medium to coarse grained, calcareous, massive, and grades upward into a buff colored, calcareous siltstone which contains a few large quartz grains scattered throughout. The thickness of this unit ranges from a feather edge to approximately 150 feet.

The middle unit is a buff to yellowish-gray, massively bedded, friable, argillaceous siltstone which contains a few widely scattered oyster shells. Calcareous cement in the upper portions of this unit results in its relative resistance to weathering, and thereby causes this unit to form ledges. In the research area, this unit is approximately 50 feet thick.

The upper unit, which caps the Cretaceous plateau, consists of a bluish-gray to buff-gray, medium to thinly bedded, dense, fine grained limestone which is slightly fossiliferous and contains widely scattered chert nodules. Thin beds of silicified coquina were observed to be scattered throughout the basal portion of this unit. The coquina is composed of many small shell fragments contained in a very fine-grained matrix which weathers to a rusty-red color. In the Salt Creek area, the exposures of this unit were approximately 30 feet thick.

Topography and Vegetation

In the southern part of the Salt Creek area the argillaceous siltstone and limestone units of Cretaceous age form a distinct plateau which abruptly rises approximately 250 feet above the present Paleozoic topography. Topographic relief on top of the Cretaceous plateau is very slight and may be attributed to the resistance to weathering of the limestone which caps the plateau.

The vegetation is composed predominantly of scrub oak, yucca, tasajillo, and prickly pear.

CENOZOIC ERA

The Cenozoic rocks in the Salt Creek area are represented by Recent alluvium and by coarse conglomerates which can be dated only as being of Cenozoic age.

The alluvium, which was deposited by Salt Creek and Hey Creek in the central portions of the area, ranges from rusty-red to dark gray in color and consists of unconsolidated silt and sand sized particles.

The conglomerates are composed of sub-rounded to rounded cobbles and pebbles in a caliche matrix. The cobbles and pebbles consist of tan to gray, medium to coarse grained, dense, glauconitic limestone. Some of the limestone cobbles were identified as being of San Saba age on the basis of certain gastropod fossils which they contained. These conglomerates are the dissected remnants of stream terraces which were formed in valleys of Tertiary or Quaternary age.

STRUCTURAL GEOLOGY

Regional Structure

The Llano region, which includes the Salt Creek area, is a structural dome which has been reduced to a topographic basin by erosional processes. The dome is roughly elliptical with a maximum diameter of approximately 100 miles. Erosion has exposed an extensively faulted complex of Precambrian and Paleozoic rocks which form the core of the dome.

The Llano region has undergone two major deformations. The first occurred during Precambrian time when the Precambrian sediments were intensively folded, metamorphosed, and intruded by igneous masses. The second occurred during the Pennsylvanian period and was dated by Sellards (1934, p. 97) as being post-Bend and pre-Canyon in age.

The Pennsylvanian deformation was responsible for the doming of the Llano region and for the development of an extensive system of normal faults with northeast-southwest trends. According to Cloud and Barnes (1948, p. 118-121), the fault planes dip from 60 to 90 degrees and displacements along the faults range from less than 1 foot to 3000 feet.

The local structures of the Llano region may be divided into seven classes which are (1) spur ridges, (2) normal faults, (3) grabens and horsts, (4) buried ridges, (5) sharp flexures, (6) symmetrical anticlines, and (7) reef masses. These classes were described by Plummer (1940, p. 58-59).

Local Structure

Only three of the seven classes of structure described by Plummer (1940, p. 58-59) are prominent in the thesis area. These are: (1) normal faults, (2) grabens and horsts, and (3) reef masses.

Precambrian Deformation

Precambrian rocks are not exposed in the Salt Creek area. Since the author worked in this area during only one summer, it was impossible to detect any structure related to this era in geologic time.

Paleozoic Deformation

The Salt Creek area exhibits a system of many northeast-southwest trending faults. The faulting is of a normal nature with very steeply dipping fault planes. Many measurements of fault plane dips which ranged between 75 and 85 degrees were recorded along the James River and Salt Creek where the fault planes could be observed in the cliffs bordering the streams.

Major Faults

Five major faults have affected the Paleozoic rocks in the Salt Creek area. These are (1) the Simons fault, (2) the Ziegler fault, (3) the Massie fault, (4) the Salt Creek fault, and (5) the Eckert fault. The Simons fault was named by Alexander (1952, p. 43), the Ziegler fault was named by Sliger (1957, p. 48), and the Massie, Salt Creek, and Eckert faults were named by the present writer. The Massie fault was named for the Jane Massie land survey, the Salt Creek fault was named for Salt Creek which it crosses, and the Eckert fault was named for the Phillip Eckert and G. P. Eckert land surveys.

The Simons fault is tangent to a bend of the James River in the extreme northwest corner of the research area. At this location the dolomite facies of the Ellenburger group has been faulted against upper Cap Mountain limestone, indicating a maximum vertical displacement of approximately 900 feet.

The Ziegler fault (Pl. XII, figs. 1 and 2) is represented by two roughly parallel faults which also cross the northwestern corner of the thesis area and are approximately 1/4 mile south of the Simons fault. This pair of parallel faults has resulted in a graben which indicates a maximum vertical displacement of 175 feet. The magnitude of the throw is indicated by the fault contact of the Lion Mountain sandstone with the Morgan Creek limestone. These faults appear to be decreasing in throw to the northeast.

The Massie fault enters the Salt Creek area on the north-northeastern side and continues in a southwesterly direction for approximately 1.6 miles. Visual detection of this fault was not possible south of the Ziegler-Geistweit property line. The Massie fault is downthrown to the northwest with the middle Point Peak shale being in fault contact with the middle San Saba limestone. This structural relationship suggests a maximum throw of approximately 275 feet.

PLATE XII

Two different views of the Ziegler fault where it crosses the James River in the northwest corner of the thesis area.

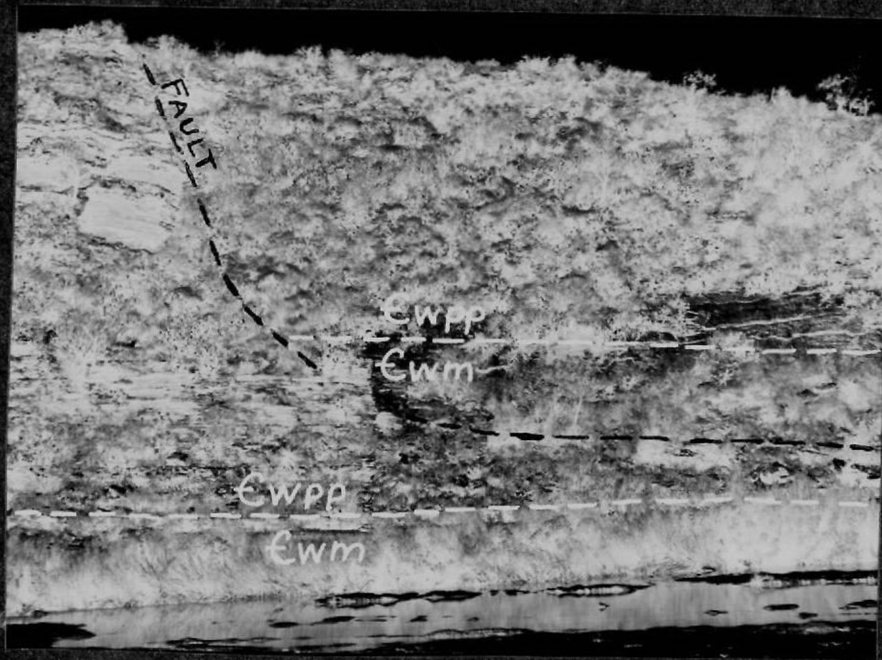


Figure 1. A view perpendicular to the strike of the fault. The fault plane is exposed on the upthrown side of the fault.

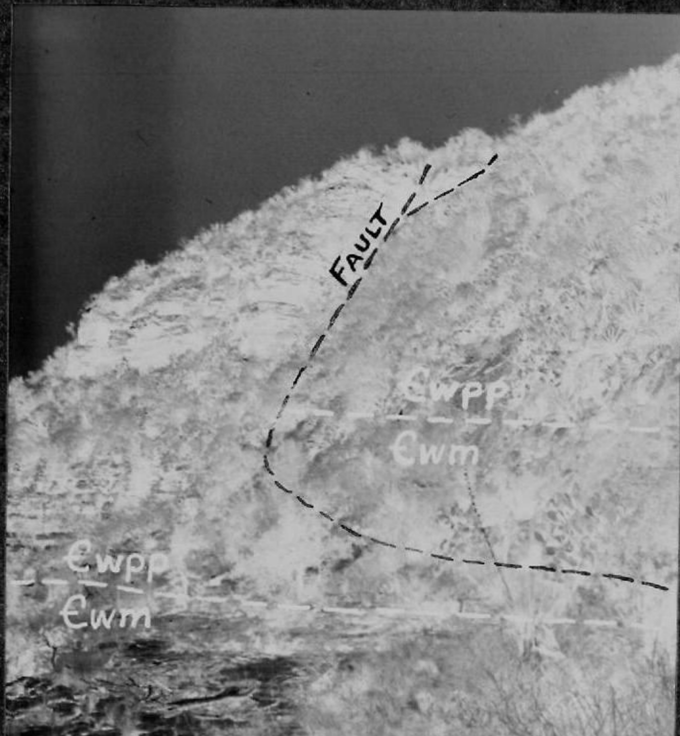


Figure 2. A view parallel to the strike of the fault plane.

The Salt Creek fault trends in a northeast-southwest direction through the south-central portion of the thesis area. On the Ernest Geistweit property this fault diverges into many fault slivers. The main fault and all of the diverging fault slivers are downthrown to the northwest. Where this fault crosses Salt Creek, the upper San Saba limestone is in contact with the sandy facies of the San Saba, indicating a throw of about 100 feet. To the southwest of this location, the Ellenburger-San Saba contact has been affected only slightly by this fault. These two relationships indicate that the throw of the Salt Creek fault increases to the northeast.

The Eckert fault enters the Salt Creek area near the center of the eastern boundary and was traced in a southwesterly direction for approximately 1.3 miles to a point where it was obscured by the outwash plain of the Cretaceous plateau. The Eckert fault is downthrown to the northwest and a throw of approximately 160 feet is indicated where middle San Saba has been faulted against lower Ellenburger. A fault to the north of, and parallel to the Eckert fault, has resulted in the formation of a graben. This latter fault cuts through relatively high cliffs along Salt Creek where a vertical displacement of approximately 10 feet was observed. According to information obtained from Marshall (1958, personal communication) the throw of the Eckert fault increases to the northeast for a distance of approximately 1 mile and then begins to gradually decrease in throw until it can no longer be traced on the surface.

Minor Faults

Many steeply dipping minor faults may be observed throughout the Salt Creek area. These faults exhibit vertical displacements ranging from 1 to 100 feet. The average throw, however, is probably on the order of 10 feet. These minor faults are of the same general trend as the major faults. The apparent random occurrence of the minor faults indicates the possibility that they relieved local stresses caused by the major faults.

Age of Faulting

The youngest rocks affected by faulting in the thesis area belong to the Ellenburger group. Since these rocks were displaced by the Eckert fault and the overlying Cretaceous strata were not affected, this fault can definitely be dated as being post-Ellenburger and pre-Commanchean in age. Since none of the faults in the research area show evidence of being offset by other faults, it can be concluded that there was only one period of faulting within this area.

These observations are in general agreement with the article by Sellards (1934, p. 97) in which he dates the faulting in the Llano region as being post-Bend (Early Ordovician) and pre-Canyon (Late Pennsylvanian) in age. Cloud and Barnes (1948, p. 121) also dated the regional faulting as being pre-Canyon in age.

<u>Cause of Faulting</u>

Paige (1912, p. 10) proposed that the faulting in the Llano region was due to compression. Cloud and Barnes (1948, p. 118) disagreed with Paige and presented their hypothesis that the faulting was the result of "tensional couples" caused by the folding of sediments in the Llanoria geosyncline. Cloud and Barnes pointed out that the folding of these sediments, which were in an area to the south and east of the Llano region, would cause the faulting in the Llano region to be aligned predominantly in the northeast quadrant. Barnes (1956, p. 13) also discussed the Ouachita orogeny and the resultant forces which would subject the Llano region to torque, thereby causing the rocks to fracture.

The northeast-southwest trend of the faults and the southeast regional dip of the bedded rocks within the Salt Creek area are strong evidence against the structure of this area being associated with the doming of the Llano region. Since the thesis area is located on the southwest flank of the Llano uplift, the faults in the thesis area should exhibit a northwest-southeast trend if the faulting was the result of the uplift to the northwest. If the regional dip within the Salt Creek area was the result of doming to the northeast, it seems that the beds would dip to the southwest rather than to the southeast which is the actual case.

The present writer hesitates to associate the deformation of the Llano region directly with the deformation of the Ouachita folded belt.

It is possible that these deformations may have had a genetic relationship, but the writer is unaware of any objective evidence regarding such a relationship.

According to Grote (1954, p. 35) there is evidence of an anticlinal fold approximately eight miles west of the city of Mason, Texas. This fold trends in a general northeast direction and plunges to the southwest. It is possible, therefore, that many small anticlines and synclines, paralleling the aforementioned fold, are imposed on the larger dome of the Llano Uplift. If the foregoing is the case, and if a northeast trending anticlinal axis lies to the northwest of the thesis area, or if a synclinal axis is to the southeast of the area, then the northeast trend of the faults and the southeast regional dip within the area would be explained.

The stresses which resulted in the structural features of the thesis area may have been caused by deep-seated movements or deformation in the basement rocks. The basement rocks, however, are not exposed in the Salt Creek area and their structural relationships to the overlying sedimentary strata could not be observed.

Folding

The only folding observed in the Salt Creek area was in beds immediately overlying and underlying bioherms. The mass weight of the bioherm masses has resulted in local downwarping of the underlying strata.

Differential compaction has caused thinning and arching of the beds immediately above these masses.

GEOLOGIC HISTORY

Precambrian rocks do not crop out in the thesis area, but according to Sellards (1932), Cloud and Barnes (1948), and various other writers who have discussed the geologic history of the Llano region, the Precambrian seas deposited a thick sequence of sandstones, shales, and limestones in this general area. These sediments were then deeply buried and, according to Stenzel (1934, p. 75), were then folded, metamorphosed, and intruded by batholiths and dikes which caused broad northwest-southeast-trending folds. The coarse crystalline character of these intrusive bodies indicates that the magma solidified at great depth. This observation is indicative of a Precambrian sedimentary sequence which was much thicker than that which now remains.

Following the regression of the Precambrian seas, the Llano region was subjected to a long period of erosion which truncated many of the folds and exposed some of the batholithic intrusions. Due to the fact that sediments of Upper Cambrian age were deposited on this eroded surface, Sellards (1932, p. 36) points out the possibility that all or part of this erosion could have occurred during Cambrian time rather than during Precambrian time.

The first Paleozoic sediments (the Hickory sandstone) were deposited on a surface which, according to Bridge, Barnes, and Cloud (1947, p. 113), had as much as 800 feet of topographic relief. Barnes and

Parkinson (1938, p. 665) describe accumulations of dreikanters or ventifacts which characteristically occur in the basal portion of the Hickory Sandstone, which indicate that an arid climate and aeolian erosion prevailed prior to the advance of the Cambrian seas. A littoral environment existing throughout Hickory time is indicated by the general coarse character of the sediments, by ripple marks, and by cross-bedding which may be observed throughout the Hickory sandstone member. The Hickory sandstone is not exposed in the Salt Branch area.

Subsidence of the land mass and transgression of the sea continued during early Cap Mountain time. This is evidenced by the gradational contact between the Cap Mountain limestone and the Hickory sandstone. The sandy limestones of the basal Cap Mountain grade upward into dense, fine-grained, glauconitic limestones. The lenses of trilobite "hash" and the glauconite contained in this member indicate a shallow water environment. In view of the foregoing observations, it may be concluded that by middle Cap Mountain time the source area had been eroded to a low level and relatively few clastics were being carried to the sea by erosional processes.

The interbedded sandstone and limestone of the Lion Mountain member is indicative of unstable conditions on the land and in the sea. The lenses of reworked trilobite "hash" are evidence of currents or turbulent water conditions. The glauconite which is scattered throughout this member must have formed in relatively quiet water and was subsequently reworked during turbulent conditions.

According to Cloud and Barnes (1948, p. 112), the sand deposited during Lion Mountain and Welge time represents a regressive-transgressive phase of the Cambrian sea, and the Riley-Wilberns formational contact is drawn in the middle of this regressive-transgressive sand sequence. The Welge sandstone represents a period of deposition when this arenaceous material prevailed over all other lithologic types. The coarser character of the Welge clastics and the massive bedding of this member suggests that deposition occurred at a faster rate than during Lion Mountain time.

The Morgan Creek limestone was deposited in an environment similar to that existing during Cap Mountain time. Erosional processes lowered the source areas on the land mass and thereby caused a decrease in detrital sediments and an increase of calcareous material as time progressed. The abundance of fossils and glauconite contained throughout the Morgan Creek member, and the bioherms and biostromes in its upper portion, are strong evidence of a warm, shallow water environment. The bioherms most certainly were formed near shore in relatively clear water, and many lenses of intensively reworked trilobite fragments are indicative of turbulent water conditions.

During Middle Wilberns time argillaceous material, along with varying amounts of arenaceous and calcareous material, was deposited to form the Point Peak shale member. According to Cloud and Barnes (1948, p. 112), the sedimentary material which composes this member was derived from a source area which existed to the west of the Llano region. These authors base this conclusion on the fact that the Point Peak member grades eastward into a carbonate facies. The interbedded shale, siltstone, and limestone in this member is evidence of a fluctuating sedimentary environment.

The thick zone of bioherms above the Point Peak shale was formed in warm, relatively clear, moderately deep water. The absence of detrital deposits during this time suggests a low source area on the land mass. This general environment continued during San Saba time, with the exception that during the latter half of San Saba time there was an increase in the amount of arenaceous sediments which resulted in many sandstone and/or siltstone beds in the San Saba limestone member (p. 65, this paper). Barnes (1956, p. 9) states that the sand was derived from an area to the west or northwest of the Llano region, and apparently bases this conclusion on his observation that the sandstones thin or pinch out in an easterly or southeasterly direction. The present writer, however, believes that more conclusive evidence for a western source area is the fact that the sandstone and siltstone facies of the San Saba member grade laterally into limestones in an easterly direction (Bridge, Barnes, and Cloud, 1947, p. 121). The latter authors discussed this facies change and stated that although sandstones are common in the San Saba member in western Mason County, they are absent in this member in the eastern part of the county.

There was no break in deposition between Cambrian and Ordovician time, and the warm, shallow seas persisted throughout Ellenburger time. Practically no clastic or detrital material was deposited during this time and, according to Cloud and Barnes (1948, p. 113) the sea bottom was soft and consisted of relatively pure carbonate muds. According to these same authors (1948, p. 113-114), the local occurrences of fossils in the Ellenburger group might be attributed to varying degrees of softness of the sea floor. Following the regression of the Early Ordovician seas, the Llano region was possibly subjected to the longest period of emergence during Paleozoic time. Cloud and Barnes (1948, p. 113) based the foregoing observation on the fact that no rocks of Silurian or Late Ordovician age are present in the Llano region. These same authors state that at least 680 feet of Ellenburger deposits were eroded away and the entire area was tilted to the east prior to the advance of the Devonian seas.

Devonian sediments are not present in the Salt Creek area, but according to Cloud and Barnes (1948, p. 113), thin deposits of Devonian age are found in solution pits on the eastern and western flanks of the Llano Uplift.

Sellards and Hendricks (1946, p. 48) state that uplift of the Llano region during Mississippian time is indicated by a thinning of the Chappel and Barnett formations as they approach this general area.

The Llano region emerged as a positive land mass prior to the invasion of the Pennsylvanian seas. Sellards (1934, p. 23) states that the Marble Falls limestone, of Pennsylvanian age, was deposited on an eroded surface of truncated Mississippian and Ellenburger strata.

In the thesis area there is no evidence of Mississippian or Pennsylvanian deposition.

According to Sellards (1934, p. 97) the Llano region underwent a period of major deformation during Pennsylvanian time. Sellards dated this deformation as being post-Bend and pre-Canyon in age and attributed the system of northeast-southwest trending faults in this area to this disturbance.

The Llano region was an emergent land mass which was severely eroded during Permian, Triassic, and Jurassic time. It was probably during this period of uplift and erosion that the Precambrian rocks, as well as the older Paleozoic sediments, were exposed to erosion and peneplaned.

The Cretaceous seas advanced and completely covered the Uplift area with a thick sequence of sand, silt, and limestone. Regional uplift and erosion has resulted in the removal of the Cretaceous rocks from the central portion of the Llano Uplift and has exposed rocks ranging in age from Precambrian to Pennsylvanian. In the southern part of the Salt Branch area, the Cretaceous rocks form a high, distinct rim and unconformably overlie Cambrian and Ordovician strata.

Regional uplift has continued to the present time and is evidenced by the incised meander patterns of streams and by the fact that "meander cutoffs" have been formed during recent geologic time.

ECONOMIC GEOLOGY

The most important natural resource in the Salt Creek area is ground water, which is present in sufficient quantities to supply the present domestic and agricultural needs. The water is produced from the Welge sandstone, the Ellenburger limestone, and the basal Cretaceous sandstone. In the research area none of the wells are deep enough to produce from the Hickory sandstone, which is one of the most important aquifers in the Llano region.

Some of the lower Paleozoic and Precambrian rocks in the Llano region have been used for building stone and road metal. In the Salt Creek area, however, none of the rocks have been used for such purposes.

No important mineral deposits have been found in, or immediately adjacent to, the research area.

According to Cloud and Barnes (1948, p. 33), the possibility of finding petroleum in the Llano region is very poor due to the deformation of the potential source beds and the nature of their outcrop pattern.

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A Measured Section of a Siltstone-Sandstone
Facies in the San Saba Limestone Member
of the Wilberns Formation

The section was measured along Hey Creek near the western boundary of the thesis area. The exact location is shown on the geologic map (Pl. XIII) contained in this paper.

	Thickness in feet
Wilberns formation	
San Saba limestone member	
Silt and sand facies	
7. Limestone, siltstone, and shale. Interbedded. The limestone is gray to buff-colored with tan specks, glauconitic, only slightly fossiliferous, and medium grained. The siltstones and shales are buff-colored, calcareous, non-fossiliferous, and friable. Thickness of individual beds: limestone: 0.1 ft. - 0.3 ft. siltstone: 0.2 ft. - 0.6 ft. shale: 0.2 ft. - 0.5 ft. The gross lithology of the foregoing sequence closely resembles the characteristic outcrops of the Point Peak shale member	27.0

Fault - normal - downthrown to the NW with a throw of approximately 0.5 feet.

6. Limestone, gray, fossiliferous, glauconitic with tan specks and medium grained. Fossils occur as concentrated patches of trilobite hash and as zones of small, tightly coiled gastropods. This limestone is very resistant to weathering. Weathered surfaces are gray with buff to tan-colored patches. Beds vary from 1.1 ft. to 2.1 ft. in thickness 13.8

5. limestone and siltstone, interbedded. The limestone is gray to brown in color with tan specks, is glauconitic, fossiliferous, and very resistant to weathering. The siltstone is light brown in color, calcareous, does not exhibit glauconite or fossils, and is much more susceptible to weathering than the limestone. Both the limestone and siltstone beds vary in thickness from 0.5 to 0.9 ft. 22.2

4. Limestone, dirty brown on weathered surface, unweathered surfaces are light gray with rust-colored specks. Thinly bedded. Medium-grained, glauconitic, and fossiliferous. Unweathered surfaces are light gray with tan or rust-colored specks and weathered surfaces are a dirty-brown color. The fossils occur as "hashy" zones in most all the beds and appear to be the remains of trilobites, brachiopods, and gastropods. The individual beds vary from 0.1 to 0.7 feet in thickness and are very resistant to weathering 6.7

__Fault__ - normal - downthrown to NW with a throw of approximately 4.0 feet. Repeats 4.0 feet of unit 3.

__Fault__ - normal - downthrown to N with a throw of 2.0 feet. Repeats 2.0 feet of unit 3.

__Fault__ - normal - downthrown to NW with a throw of approximately 8.0 feet. Repeats 8.0 feet of unit 3.

3. Interbedded siltstone and limestone with sandstone lenses. The beds and the lenses vary from 0.1 to 2.1 feet

in thickness. The limestone is gray with tan specks and may be either fine-grained or coarse-grained. Some, but not all, of the limestone beds contain fossils of small tightly coiled gastropods. The siltstone is gray to buff-colored and in many cases the weathered surfaces are a bright purplish-red color. This siltstone is cemented with $CaCO_3$. The sandstone lenses are always buff or cream colored, calcareous, and friable. The sand particles are medium to fine grained. 26.2

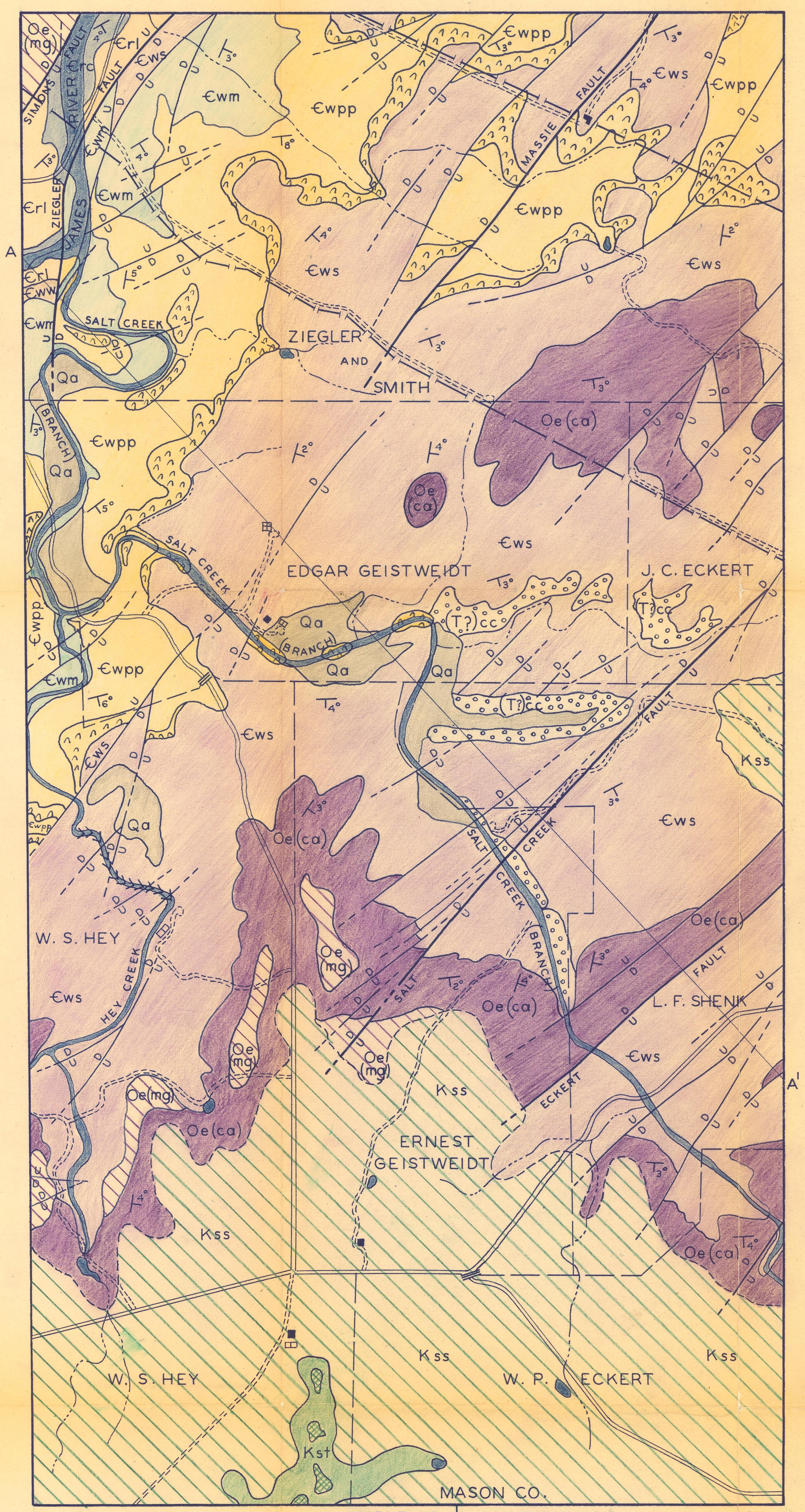
2. Limestone, slate-gray color with tan specks on unweathered surfaces. Dense, medium-grained, glauconitic; weathered surfaces are dirty-gray in color and exhibit many marble-sized weathering pits. Bands of limonite stain parallel bedding planes. Beds vary from 0.1 to 0.8 feet in thickness and contain a few widely scattered fossils of small gastropods. 4.8

1. Arenaceous limestone containing scattered sand and silt lenses. Tan to buff-colored,

cross-bedded, calcareous, and non-
fossiliferous. These lenses vary from
0.3 to 1.0 feet in thickness. 6.2

Total thickness measured 107.8

PLATE XIII



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

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Geology by William E. Harwood 1958

EXPLANATION

CENOZOIC — TERTIARY-QUATERNARY

- Qa — Recent alluvium
- (T?)cc — Caliche conglomerate (Tertiary ?)

UNCONFORMITY

LOWER CRETACEOUS — UNDIFFERENTIATED — CRETACEOUS

- Kls — Limestone
- Kst — Argillaceous siltstone
- Kss — Silt and Sand

UNCONFORMITY

LOWER ORDOVICIAN — ELLENBURGER GROUP — ORDOVICIAN

- Oe(mg) — Ellenburger dolomite
- Oe(ca) — Ellenburger limestone

UPPER CAMBRIAN — CAMBRIAN

WILBERNS FORMATION

- €ws — San Saba limestone member
- €wppb — Bioherms
- €wpp — Point Peak shale member
- €wm — Morgan Creek limestone member
- €ww — Welge sandstone member

RILEY FORMATION

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

UNCONFORMITY

PRECAMBRIAN

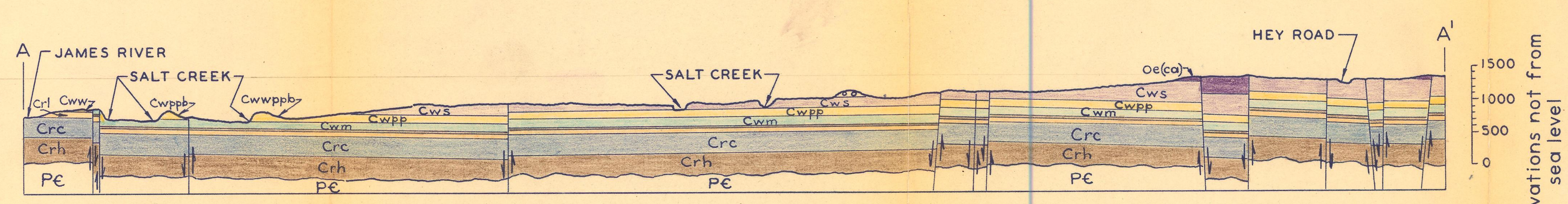
- P€ — Undifferentiated

Major fault
Inferred major fault
Minor fault
Inferred minor fault
Observed contact
Inferred contact
Strike and dip of beds
Stream
Intermittent Stream
County road
Ranch road
Property line
Location of measured section
Pipeline
House
Stock tank
Stock pens
Cattle guard

N
Magnetic N
10°

Approximate mean declination

Crosshatched area modified from DANNEMILLER, (1957)



SCALE 1/20,000

1 0.5 0 1 mile

1700 850 0 8500 feet

GEOLOGIC MAP AND CROSS SECTION OF THE SALT CREEK AREA, MASON COUNTY, TEXAS