GEOLOGY OF THE SCHEP - PANTHER CREEK AREA

MASON COUNTY, TEXAS

A Thesis

By

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A B S T R A C T

The Schep - Panther Creek area is located in the southern part of Mason County on the southwest flank of the Llano uplift of central Texas. Rocks belonging to the Riley and Wilberns formations of the Upper Cambrian are exposed in the area.

The Riley formation, in ascending order, is composed of the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone members. The Wilberns formation in the same order, consists of the Welge sandstone, the Morgan Creek limestone, the Point Peak shale, and the San Saba limestone members. A thick bioherm zone, previously included by some geologists in the Point Peak shale and by others in the San Saba limestone, was mapped in the thesis area as a separate unit within the Point Peak member. The exposed Riley formation was estimated to be over 432 feet thick; the exposed Wilberns formation was estimated to be 306 feet thick.

The exposed strata have a general northeast strike and dip to the southeast. The area is cut by many normal faults which have a general northeast trend. The only major faults occur in the northern part of the area. Numerous tree lineations observed on aerial photographs of the southern part of the area were found in many cases to be associated with small faults.

The stratigraphy and structure of the area are generally consistent with previous interpretations of the regional geologic history. The occurrence of a massive sandstone lens in the Cap Mountain limestone, however, suggests a local influx of detrital material during Cap Mountain time. This has not been previously described in the literature.

GEOLOGY OF THE SCHEP - PANTHER CREEK AREA

MASON COUNTY, TEXAS

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

STATEMENT OF THE PROBLEM

The general objective of this thesis is to furnish additional stratigraphic and structural geologic data for the purpose of broadening the overall understanding of the geology and geologic history of the Llano uplift. The specific objectives of this thesis are: (1) to map and describe the exposed stratigraphic units which occur in the Schep - Panther Creek area by the lithologic determination of formation and member boundaries; (2) to map and determine the structure of the area as expressed by the occurrence and magnitude of faulting; (3) to determine whether tree lineations observed on aerial photographs are the result of jointing or faulting; (4) to establish stratigraphic and structural continuity, if any, between the areas bordering the Schep - Panther Creek area; and (5) to support or modify the previously described geologic history of the Llano uplift through the examination and interpretation of the stratigraphy, structure, and topography.

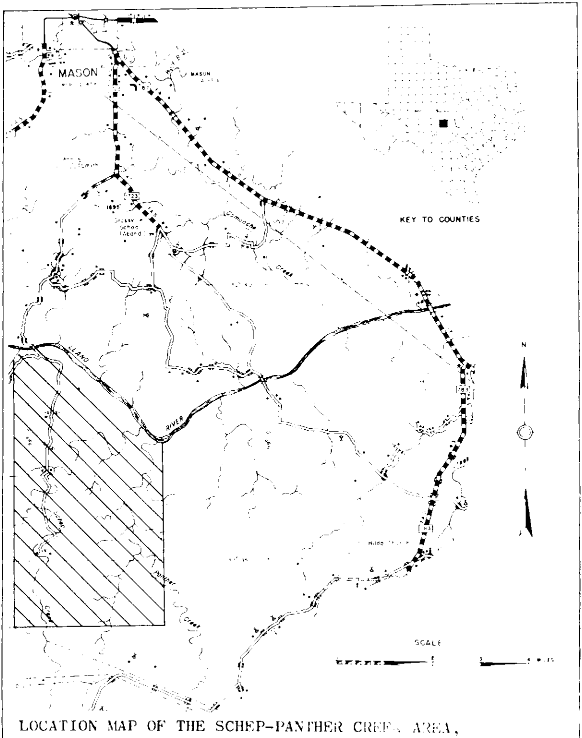
LOCATION

The Schep - Panther Creek area consists of approximately 15 square miles located in the southern part of Mason County and in the southwestern portion of the Llano uplift of Central Texas. The area is bounded on the east and west by longitudes 99° 12.1' and 99° 15.2' west, and on the south by latitude 30° 33.8' north. The northern boundary of the area is formed by the southeast-trending Llano River flowing between latitudes 30° 38.8' and 30° 37.2' north (see fig. 1).

ACCESSIBILITY

The Schep - Panther Creek area is easily reached by traveling 2.4 miles south out of Mason along Farm-to-Market Road 1723, and then turning southwest on a bladed earth road, which is followed to the low water bridge crossing on the Llano River. This bridge is located on the boundary line of the thesis area at its northwestern limit. After crossing the Llano River bridge, the bladed earth road continues south through the western part of the area for about three quarters of its north-south length. Private, rough, but passable, ranch roads, branching off to the east from the above bladed road, afford access to the north and central parts of the area. The southern part of the thesis area is reached by traveling 11 miles southeast from Mason along U. S. Highway 87 to Farm-to-Market Road 783, thence turning south on road 783 and traveling approximately 4 miles to the bladed earth road branching off to the southwest at Hilda Church. Various private ranch roads, branching

Figure 1



LOCATION MAP OF THE SCHEP-PANTHER CREEK AREA, MASON COUNTY, TEXAS

Reproduced from a Highway Map of Mason County, Texas. Prepared by Texas State Highway Department, revised to Jan. 1958 north from this latter road between 2 and 9 miles southwest from Hilda Church provide access to the southern part of the thesis area.

METHODS OF INVESTIGATION

The field work for this thesis was conducted between June 2, and August 1, 1958. U. S. Department of Agriculture aerial photographs DFZ - 1P - 168 through 171 were used as base maps. Lithologic contacts and faults were walked out and marked on acetate overlays covering the aerial photographs. Stereoscopic investigations of the aerial photographs were conducted to aid in the recognition of faults and lithologic boundaries as indicated by patterns of vegetation.

A Brunton compass was used to determine the strikes and dips of exposed beds and was also used with a measuring rod to measure the thicknesses of dipping strata.

Dilute hydrochloric acid was used to determine the existence of calcium carbonate in rocks where its presence was not discernible to the eye.

PREVIOUS INVESTIGATIONS

Early geologic investigations of the Llano uplift were conducted by Ferdinand Roemer (1846, 1848); B. F. Shumard (1861); C. D. Walcott (1884); G. G. Shumard (1886); and R. T. Hill (1887). These investigations were, for the most part, of a reconnaissance nature but were important for their recognition of Late Cambrian and other Paleozoic rocks in the Llano uplift. Roemer (1848) dated the rocks on the San Saba River as Carboniferous and Silurian. Barrande (Bridge and Girty, 1937, p. 240), however, recognized that Roemer's "Silurian" fauna were equivalent to the lowermost Paleozoic fauna of Wisconsin.

T. B. Comstock (1890), in describing the minerals and ores of the region, introduced the names Hickory series and Riley series to apply to the Cambrian rocks exposed in the uplift. The name San Saba series was applied to strata which he erroneously dated as Silurian in age.

R. S. Tarr (1890) deduced that the present drainage in the Llano uplift originated upon the Cretaceous strata overlying the region during Tertiary time, and that it became superimposed on the underlying Paleozoic structure with the erosion and removal of the relatively flat Cretaceous rocks.

Paige (1911) named and described the Cap Mountain and Wilberns formations. His definition of the Cap Mountain included most of the Cap Mountain limestone and all of the Lion Mountain sandstone members of the present Riley formation. Paige changed the name "Hickory series" (Comstock, 1890), to Hickory sandstone and placed the boundary between it and the overlying Cap Mountain formation within the lower beds of the present Cap Mountain member. His definition of the Wilberns formation included all the members of the present Wilberns formation with the exception of the San Saba limestone, which he included with the Ellenburger limestone. Paige (1912) was the author of a U. S. Geological Survey folio, including a detailed geologic map, on the Llano and Burnett quadrangles.

In 1916 the Bureau of Economic Geology of the University of Texas published the first geologic map of Texas. On this map the Paleozoic rocks cropping out in the Llano region were undifferentiated.

Dean (1931) reported on the algal reefs in the Wilberns formation in a paper read before the Paleontological Society of America.

Dake and Bridge (1932) were the first to establish faunal zones within the older Paleozoic rocks of the Llano uplift; they attempted to correlate them with Paleozoic rocks outside of Texas.

Sellards (1934) noticed the thinning of the Mississippian rocks over the Llano uplift and proposed that this indicated the first uplift of the region.

Bridge and Girty (1937) published redescriptions of fossils which were originally described by Roemer from the Llano region. Bridge (1937) also correlated the Upper Cambrian rocks of Texas and Missouri with those of the upper Mississippi Valley, and, in the same paper, designated the Lion Mountain sandstone as the upper member of the Cap Mountain formation.

The ventifacts occurring in the basal Hickory sandstone were described by Barnes and Parkinson (1939) and were interpreted as an indication of eolian conditions during the deposition of the basal Hickory.

Cloud, Barnes, and Bridge (1945), in a comprehensive paper on the Ellenburger group of Central Texas, included the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone members in the Riley formation; they established the top of the Wilberns formation as the top of the Cambrian.

Bridge, Barnes, and Cloud (1947) redefined and described the Upper Cambrian strata of the Llano uplift. This paper serves to date as the standard stratigraphic reference for the Upper Cambrian rocks of the region. The Upper Cambrian was redefined as consisting of: the Riley formation which is composed of the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone members; and the Wilberns formation which is composed of the Welge sandstone, the Morgan Creek limestone, the Point Peak shale, and the San Saba limestone members.

Barnes and Bell (1954) reviewed the stratigraphy of the Llano uplift and included detailed measured sections of the Upper Cambrian formations.

Barnes (1956) described the lead deposits in the Upper Cambrian rocks of the Llano region and briefly described the structure and stratigraphy of the Upper Cambrian strata.

Sliger (1957) mapped approximately 20 square miles bordering and overlapping the western portion of the Schep - Panther Creek area. Sliger identified strata ranging in age from Late Cambrian to Pennsylvanian time and mapped faulting in the area exhibiting a northeast-southwest trend. Only the Late Cambrian rocks, however, overlap into the thesis area.

Wilson (1957) mapped an area bordering the northern boundary of the Schep - Panther Creek area. Wilson identified rocks of Precambrian and Late Cambrian age. His Precambrian rocks, however, do not adjoin the Schep - Panther Creek area. As in the case of Sliger's area, Wilson recognized and mapped faults having a northeast-southwest trend.

Alexander (1952), Polk (1952), Duval (1953), Parke (1953), Grote (1954), Fritz (1954), Dannemiller (1957), Miller (1957), Mosteller (1957), Mounce (1957), Scaife (1957), Sweet (1957) mapped and described the stratigraphy and structure of small scattered areas within Mason County. Goolsby (1957) examined the Hickory sandstone throughout the Llano uplift and proposed elevating the unit to formation status.

ACKNOWLEDGMENTS

Particular appreciation is expressed to Dr. M. C. Schroeder and Professor F. E. Smith of the Department of Geology of the Agricultural and Mechanical College of Texas for their criticisms and suggestions during the progress of the field work.

The constructive criticisms and suggestions of Dr. Peter Dehlinger, Professor S. A. Lynch, and Professor F. E. Smith, during the preparation of this thesis, are deeply appreciated.

Gratitude is also here expressed to Messrs. B. R. Ammer and H. D. Marshall who cooperated with the writer in mapping the southern portion of the thesis area.

A general expression of appreciation is given to the ranchers and farmers who willingly gave access to their properties.

Aerial photographs and other equipment used during the progress of the field work were the property of the Agricultural and Mechanical College of Texas.

G E O G R A P H Y

CLIMATE

Mason County is located in a semi-arid region having an average rainfall of approximately 20 inches per year. For seven years previous to 1958, the region has experienced a severe drought with precipitation far below normal. The rains normally are of short duration and are usually more frequent during the winter and spring months.

Temperatures vary from over 100° in the summer months to slightly below 0° during the winter months. The mean annual temperature is approximately 70°.

VEGETATION

The semi-arid climate and thin soil cover have limited the development of vegetation to a sparse coverage of arid and semi-arid types. Areas underlain by limestone are commonly covered by scrub oak, juniper, yucca, Mexican persimmon, and various cacti. Weathered sandstone outcrops are generally covered by mesquite, cacti, and needle grass. With the recent abundant spring rains the low-lying areas, composed of sandy soil, have been covered by a dense growth of ragweed. In areas where the Welge sandstone forms a persistent ledge, dense growths of oak and cacti occur. Steep slopes formed by the Point Peak shale are densely covered by mesquite, oak, cacti, and juniper. Juniper and oak normally do not grow on Point Peak slopes and their presence in the thesis area is probably the result of talus formed from the overlying bioherm zone. During the recent years of drought, the growth of native grasses was seriously impaired.

INDUSTRY

Industry in the Schep - Panther Creek area is limited to production of beef cattle, goats, sheep, and pigs. A small amount of farming is practiced in the area. Cantaloupe, peanuts, and watermelons are grown on sandy soils where water is available for irrigation.

PHYSIOGRAPHY

The Schep - Panther Creek area is located on the southwest flank of the Llano uplift, a region which is structurally a dome but topographically a basin. The central part of the dome, composed of Precambrian and Paleozoic rocks, is surrounded by a rim of Cretaceous rocks which previously covered the entire region but which have been removed by erosion.

The thesis area may be divided into three physiographic units:

(1) The northernmost unit is composed of slowly rising terrain which proceeds south from the Llano River and culminates with a series of northeast-trending hills which occur in one of the major fault zones of the area. This physiographic unit includes a complete section from the base of the Cap Mountain limestone along the Llano River to within the basal San Saba limestone which caps one of the above mentioned hills.

(2) The central physiographic unit of the area is composed of a low, northeast-trending valley formed by the erosion of the poorly resistant Hickory sandstone.

(3) The southern physiographic unit includes slightly over half of the total area of the Schep-Panther Creek area. The unit is relatively high compared to the northern portion of the thesis area and consists primarily of a highly faulted Cap Mountain limestone plateau.

The southern and eastern boundaries of this plateau are bordered by a series of hills formed by the relatively resistant Welge sandstone and Morgan Creek limestone.

The Schep - Panther Creek area, bordered on the north by the Llano River, is a part of that river's drainage basin. Other than the Llano River, which directly drains the northern part of the thesis area, Schep Creek and Panther Creek drain the western to central and eastern parts of the area respectively. These creeks, as shown on Plate I, are influenced neither by normal stratigraphic boundaries nor by faulting. It is, therefore, apparent, as Tarr (1890) observed, that the stream systems in the Llano region are superimposed. The major streams began their flow on the elevated Cretaceous rocks during Tertiary time and have subsequently eroded through to, and have become superimposed on, the Paleozoic and Precambrian rocks. Both of these creeks drain northward into the Llano River and are ephemeral.

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

GENERAL STATEMENT

Most of the rocks exposed in the Schep - Panther Creek area are of Late Cambrian age. Recent deposits of minor importance were observed. The stratigraphic column of the area is as follows:

Cenozoic Era

Quaternary

Recent

Paleozoic Era

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

All of the recognized members of the Upper Cambrian in the Llano uplift are represented in the Schep - Panther Creek area. Middle and Lower Cambrian rocks are completely absent throughout the Llano uplift.

Riley Formation

The Riley formation, as redefined by Cloud, Barnes, and Bridge (1945, p. 154), is composed of all Cambrian strata below the Wilberns formation and consists, from base to top, of the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone members. The above units were assigned member status because their contacts intergrade laterally, crossing faunal zones. The base and top of the formation are marked by unconformities. The total thickness of the exposed Riley formation in the thesis area is estimated to be 432 feet.

Hickory Sandstone Member

Definition and thickness: Bridge, Barnes, and Cloud (1947, p. 112) described the sandstones of the Hickory in the Llano uplift as non-calcareous, non-glauconitic, and yellow, brown, and red. The thickness of the member varies from a feather edge to 415 feet. This variation in thickness has been attributed to the relief of the Precambrian erosion surface on which Hickory sediments were deposited. In the thesis area the exposed Hickory sandstone is estimated to be 66 feet thick, but because the lower part of the member does not crop out, due to faulting, the total thickness present could not be determined or estimated.

Goolsby (1957, pp. 53-67) proposed that the Hickory sandstone member be elevated to formation status on the basis that (1) it is divisible into three mappable units; (2) its gross lithology is markedly different from the overlying Cap Mountain limestone; and (3) contacts crossing faunal zones are not pertinent criteria for the classification of rock units. As such, Goolsby's reclassification of the Hickory sandstone member to formation status may have some merit, but since his proposal has not been formally accepted, the definition of Bridge, Barnes, and Cloud (1947, p. 112) has been followed. Where correlation in the thesis area has been made with Goolsby's subdivisions (Upper and Middle Hickory), indications of such have been made on the geologic map.

<u>Lithology</u>: The Hickory is poorly exposed in the thesis area because of a thick soil cover produced by the weathering of the sandstone. Outcrops are confined to a northeast-trending valley in the center of the area. Exposures corresponding to Goolsby's definition of Middle Hickory occur as buff to light brown, weathering to gray-brown, distinctly bedded, often cross-bedded, friable sandstone. The sand is composed of clear, sub-rounded, fine to coarse, quartz grains. Individual beds are lenticular and vary in thickness from a few inches to 2 feet and commonly exhibit case-hardening. Layers of brownish-green, shaley, micaceous siltstone, up to 2 inches thick, occur within the sandstone and weather more rapidly, leaving protruding ledges of sandstone. Layers of intra-formational

conglomerate occur in zones up to 6 inches thick. The conglomerate is composed of oblate pebbles of sandstone and small brachiopod fragments, ranging in size from a fraction of an inch to 3 inches in diameter in a coarse sand and ferruginous matrix (see Plate II). There is no preferred orientation of the sandstone and brachiopod fragments. Well developed oscillation ripple marks are exposed in a tributary to Schep Creek in the central part of the area. The ripple marks have an average wave length of 1 foot with an amplitude ranging from 0.75 inch to 1 inch (see Plate II).

Strata corresponding to Upper Hickory sandstone of Goolsby are present, but poorly exposed, in the central portion of the thesis area. Because of thick soil cover, samples could be found only close to the contact with the Cap Mountain limestone member. Samples consist of a dark reddish-brown, well-bedded, sometimes cross-bedded, fine-to coarse-grained, sub-angular to sub-rounded sandstone in a highly hematitic matrix. Individual quartz grains are commonly coated by hematite. The sandstone appears to become coarser as it nears the contact with the Cap Mountain limestone.

Stratigraphic relations: The complete section of the Hickory sandstone member is not present in the Schep - Panther Creek area because the lower portion has been faulted out. The normal transitional contact with the Cap Mountain limestone occurs close to the base of a series of hills that limit the southern side of the previously mentioned valley. The contact was picked at the first appearance of a reddish-brown, calcareous sandstone and on the pronounced change in topography observable on aerial photographs.

Cap Mountain Limestone Member

Definition and thickness: Bridge, Barnes, and Cloud (1947, p. 112) stated that the Cap Mountain limestone member has a total thickness varying from 135 to 455 feet. They reported that alternating dark brown, calcareous sandstones and impure limestones compose the base of the member, and that fairly pure, granular limestones comprise the bulk of the member. Sliger (1957, pp. 75-82) measured a section of the Cap Mountain at a locality part of which is included in the northwest corner of the Schep - Panther Creek area. The Cap Mountain at this locality reached a measured thickness of 315 feet. The only other exposure of the Cap Mountain in the Schep - Panther Creek area is on a dissected plateau in the southern portion of the area where it was impossible to measure the thickness because of faulting. Sliger's measured thickness of 315 feet will, therefore, be used to represent the thickness of the Cap Mountain in the Schep - Panther Creek area.

Lithology: The basal portion of the Cap Mountain limestone member is composed of a rusty-brown, well-bedded, fine-to coarse-grained, calcareous, ferruginous, quartz sandstone. Limonite and hematite are evenly distributed throughout the rock. The sandstone occurs in ledges a few inches to 2 feet thick and commonly weathers and breaks off into reddish-brown flags.

The basal part of the member grades up into a brown, well-bedded, fine-grained, sandy limestone. Very small grains of crystalline calcite cause small areas of the hand specimen to sparkle as it is turned under light. There are occasional occurrences of very thin streaks of white calcite running parallel to the bedding.

Above the preceding beds occurs a dirty gray, thin to massive, finely crystalline, limonitic, glauconitic limestone forming the main body of the member. The limonite is commonly more concentrated in the lower portion while the glauconite is commonly more concentrated in the upper portion. The limonite occurs either as yellow to brown specks and splotches, or as streaks giving the rock a banded appearance. In the southern part of the Arch Burnett ranch, there occurs an outcrop of buff, weathering to gray-brown, massive, very fine-grained, calcareous to non-calcareous sandstone. This sandstone occurs in the lower, limonitic part of the main body of the limestone but does not appear to be continuous (see Plate III). B. R. Ammer, graduate student in geology, (1958, personal communication) has also reported a similar occurrence of sandy facies within the main body of the Cap Mountain southeast of the thesis area.

On the faulted plateau in the southern part of the thesis area, the Cap Mountain limestone commonly weathers into large solution-pitted flags. Prominent joints are locally present and generally have a northeast trend (see Plate IV). A local development of caves was noticed in the southeast portion of the area along Panther Creek (see Plate III).

Two occurrences of solution sinks were noticed in the south central part of the area.

The upper part of the Cap Mountain limestone member is composed of a speckled brownish-gray, weathering to sandy-gray, well-bedded, fine-to medium-crystalline, slightly sandy, glauconitic limestone. The limestone occurs in beds a few inches to 1.5 feet thick. Near the gradational contact with the Lion Mountain sandstone member, the limestone is inter-bedded with greenish-gray, thinly-bedded, fine-grained, glauconitic, highly calcareous sandstone. In many places the sandstone grades laterally into a gray sandy limestone.

Stratigraphic relations: The Hickory - Cap Mountain boundary is transitional and was picked at the first appearance of a calcareous sandstone which occurs close to a sharp change in slope. The Cap Mountain - Lion Mountain contact is also transitional. The contact was picked on the first appearance of a glauconitic sandstone, which occurs above the last persistent limestone of the Cap Mountain member.

Lion Mountain Sandstone Member

Definition and thickness: The Lion Mountain sandstone member was described by Bridge, Barnes, and Cloud (1947, p. 114) as a highly glauconitic sandstone, 20 to 50 feet thick, containing in the lower part tangential lenses of limestone predominantly composed of fragments of trilobites, as well as somewhat continuous beds of glauconitic limestone. In the central portion of the thesis area, along Sandy Creek on

Plate VI

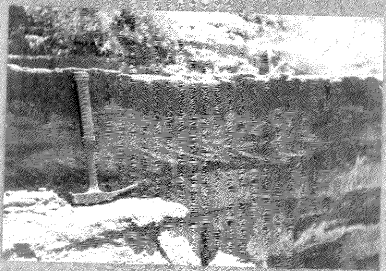


Figure 1

Cross-bedding in the Lion Mountain sandstone along Schep Creek on the Seth Martin ranch

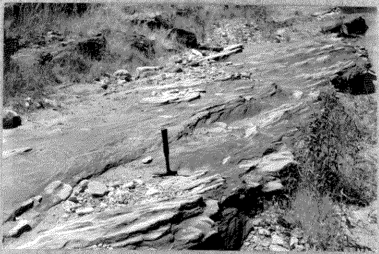


Figure 2

Lenses of limestone in a glauconitic sand of the Lion Mountain sandstone along Schep Creek on the Seth Martin ranch

Plate VII

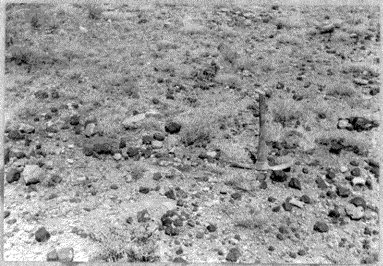


Figure 1

Black hematite nodules on a weathered Lion Mountain sandstone slope

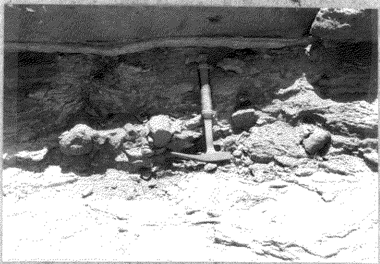


Figure 2

Black hematite nodules in place in a glauconitic sand of the Lion Mountain sandstone along Schep Creek on the Ruth Keller ranch the Seth Martin ranch, the Lion Mountain attains a thickness of 52 feet. This thickness is slightly more than the maximum thickness indicated by Bridge, Barnes, and Cloud (1947, p. 114), but is less than the 80-foot thickness measured by Sliger (1957, p. 26) in the northwest corner of the Schep - Panther Creek area.

<u>Lithology</u>: The Lion Mountain sandstone occurs in the Schep - Panther Creek area commonly as a gentle slope covered by limestone fragments, hematite nodules, and reddish-brown soil (see Plate VII). Occasionally there are found, in place, thin ledges of sandy glauconitic limestone.

In the central portion of the area the erosive action of Schep Creek has exposed a relatively unweathered complete section of the Lion Mountain (see Plate V). The Lion Mountain sandstone is composed of alternating beds of limestone and sandstone varying in thickness from a few inches to 2 feet. Well bedded limestone within the members is greenish-gray, weathered to brown, sandy, and glauconitic, and much of it is composed of trilobite fragments. The sandstone is usually greenish-gray, weathering to gray, slightly fissile, very fine-grained, glauconitic, limonitic, slightly calcareous, and commonly cross-bedded. Limestone composed of trilobite fragments occurs as oblique laminae in the cross-bedded sandstone at the upper and lower parts of the member (see Plate VI). Along Schep Creek, on the southern part of the Emeth Keller ranch, the highly glauconitic sandstone contains nodules, in place, which exhibit partial alteration from glauconite to hematite (see Plate VII). The nodules also commonly contain small amounts of silica.

Stratigraphic relation. The Cap Mountain - Lion Mountain contact is transitional, and where it was sufficiently exposed, the contact was picked on the first appearance of a glauconitic sandstone. Where exposures of the contact were poor, because of soil cover, the contact was picked at the top of the last continuous limestone ledge of the Cap Mountain limestone. The contact with the overlying Wilberns formation is "sharp". (Bridge, Barnes, and Cloud, 1947, p. 114) as the highly glauconitic sand of the Lion Mountain sandstone member is in contact with the non-glauconitic sand of the Welge sandstone member. In the southwestern part of the thesis area, where a very thin undulating shaley layer occurs, the contact is well exposed. It appears that a disconformity exists between the Riley and Wilberns formations.

Wilberns Formation

The Wilberns formation, as redefined by Cloud, Barnes, and Bridge (1945, p. 155), consists of all the Cambrian rocks above the Riley formation, and is composed, from base to top, of the Welge sandstone, the Morgan Creek limestone, the Point Peak shale, and the San Saba limestone members. The zone of large bioherms, lying between typical Point Peak and typical San Saba strata, which in the past has been included by some geologists with the Point Peak and by others with the San Saba, has been mapped in this thesis as a separate unit forming the upper part of the Point Peak member.

Bridge, Barnes, and Cloud (1947, p. 114) assign an average thickness of 580 feet to the Wilberns formation. Its estimated thickness in the Schep - Panther Creek area is 306 feet. This relatively small thickness is attributed to the absence of all but a thin remnant of the San Saba limestone.

Welge Sandstone Member

Definition and thickness: Bridge, Barnes, and Cloud (1947, p. 114) described the Welge sandstone member as a brown, mostly non-glauconitic sandstone, having quartz grains with recomposed faces that glitter in the sunlight, and varying in thickness from 9 feet to 35 feet. In the Schep - Panther Creek area, the Welge was measured to be 20 feet thick.

Lithology: In the thesis area the Welge is a brown to yellowish-brown, massive, medium-grained, ferruginous, non-glauconitic, non-calcareous sandstone. In some occurrences the sandstone is poorly indurated, friable, and often case-hardened. In others, it is well indurated and has a high concentration of ferruginous cement. Veins of concentrated limonite and hematite often give the rock a banded appearance. In the southern part of the thesis area, the Welge appears to have been secondarily cemented by silica in such a manner as to resemble an ortho-quartzite.

Plate VIII

Figure 1

Welge sandstone capping a low hill on the Le Roy Loeffler ranch

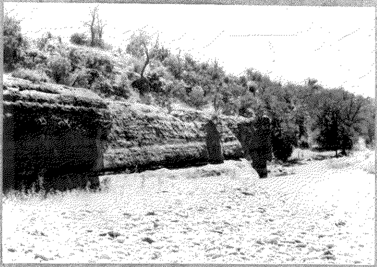


Figure 2

Welge sandstone ledge along Schep Creek on the Emeth Keller ranch

The Welge sandstone crops out in the Schep - Panther Creek area as a resistant ledge, either capping hills and ridges or appearing as a prominent ledge on hillsides (see Plate VIII).

Stratigraphic relations: The lower boundary of the Welge sandstone member was picked at the sharp lithologic change from a highly glauconitic sandstone to a non-glauconitic sandstone. The upper boundary is gradational into the Morgan Creek limestone member and was picked on the first appearance of a purple arenaceous limestone encountered above the Welge. In the thesis area, the Welge ledges caused a sharp topographic break at both their upper and lower boundaries and were often characterized by relatively higher concentrations of vegetation, easily seen on aerial photographs. These features were generally used as boundary criteria for mapping purposes.

Morgan Creek Limestone Member

Definition and thickness: Bridge, Barnes, and Cloud (1947, p. 114) described the Morgan Creek limestone member as a purple to gray, to greenish-gray, medium-to coarse-grained, abundantly glauconitic, sometimes shaley, bedded limestone, frequently having thin stromatolitic bioherms in the upper portion. Throughout the Llano uplift, the thickness of the Morgan Creek limestone varies from 70 to 160 feet, with an average thickness of 120 feet. In the Schep - Panther Creek area, the Morgan Creek limestone was 126 feet thick.

Plate IX

Stromatolitic bioherms in the Morgan Creek limestone along Schop Creek on the Emeth Keller ranch

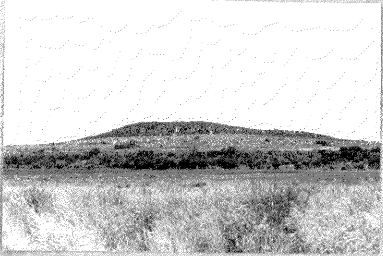
At a point 0.5 mile south of the Emeth Keller ranch house, small stromatolitic bioherms occur 16 feet below the upper boundary of the Morgan Creek. Good exposures of stromatolitic bioherms in the upper part of the Morgan Creek limestone also occur in the southern part of the Emeth Keller ranch on Schep Creek (see Plate IX). The bioherms are composed of gray, massive, very finely crystalline, very slightly limonitic, non-glauconitic limestone, and often weather out into small boulder-shaped masses. Individual bioherms range in diameter from 1 to 5 feet.

Stratigraphic relations: The lower boundary of the Morgan Creek limestone member was picked on the first appearance of a purple, sandy, coarse-grained limestone above the Welge sandstone. The above change coincides with a topographic and vegetational break which was observed on aerial photographs. The upper boundary of the member was picked on the first appearance of a fissile siltstone belonging to the Point Peak shale member. For mapping purposes, the Morgan Creek limestone - Point Peak shale contact was drawn at the base of a steep, densely vegetated slope, which is quite noticeable on aerial photographs (see Plate X). This slope is unusual in that the Point Peak is normally less densely vegetated than the Morgan Creek in the region.

Point Peak Shale Member

Definition and thickness: The Point Peak shale member was named by Bridge, Barnes, and Cloud (1947, p. 115) from an isolated hill

Plate X



Vegetation change at the contact between the Morgan Creek limestone and the Point Peak shale on the Emeth Keller ranch about 4 miles northeast of Lone Grove, Llano County, Texas. At the above outcrop, the Point Peak member was described as well-bedded, soft, greenish, clacareous shales with subordinate amounts of fine-grained dolomite, medium-to fine-grained limestone, intra-formational conglomerate, and, near the top of the member, stromatolitic bioherms. According to Bridge, Barnes, and Cloud (1947, p. 115), the Point Peak shale in the Llano uplift varies in thickness from 25 feet to 270 feet with an average thickness of 160 feet. In the Schep - Panther Creek area, the part of the member below the bioherm zone was measured to be 110 to 120 feet thick.

Lithology: The Point Peak shale member occurs in the Schep - Panther Creek area on steep, heavily vegetated hillsides on the Emeth Keller and Arch Burnett ranches. Caliche and talus commonly cover the slopes. The member is composed chiefly of buff weathering to brown, well-bedded, fissile, friable, calcareous siltstone, inter-bedded with lesser amounts of limestone and intra-formational conglomerate. The limestone is generally greenish-gray to yellowish-gray, finely crystalline, and highly glauconitic, with small specks or veins of limonite. The intra-formational conglomerate is composed of grayish-brown, angular to rounded, flattened calcareous siltstone pebbles in a greenish-gray to brown, fine-to medium-grained limestone matrix. The beds of intra-formational conglomerate average 4 to 5 inches in thickness.

At the top of the Point Peak shale member, a thick bioherm zone occurs that was included in the member by Bridge, Barnes, and Cloud (1947, p. 115). Other geologists, however, have included the bioherms in the

San Saba limestone member or have mapped them as a separate unit. In the Schep - Panther Creek area, the zone was mapped as a separate unit within the Point Peak member. The thickness of the bioherm zone was estimated to attain a maximum of 30 feet.

The bioherm zone occurs in the thesis area as a resistant unit, capping prominent hills in the northern part of the area. A good exposure also crops out in a steep cliff along Schep Creek on the southwestern part of the Arch Burnett ranch. At this locality, large individual bioherms have weathered out of the cliff and have fallen into the creek (see Plate XI).

The bioherms are composed of a light gray, massive, microcrystalline limestone which weathers to a speckled grayish-brown. Cabbage-head structure is characteristically well developed (see Plate XI). The bioherms attain a maximum estimated diameter of 30 feet.

On the top of a hill 0.5 mile south of the Emeth Keller ranch house, it can be noticed that the bioherm zone is not always continuous. On the eastern part of this hill the yellow limestone of the San Saba is in contact with the siltstone of the Point Peak. This contact occurs approximately 10 feet above the base of the bioherm zone. The presence or absence of the bioherm zone appears, therefore, to affect variations in thickness of the Point Peak and the San Saba members in the thesis area.

Stratigraphic relations: The lower boundary of the Point Peak shale member is marked by the first appearance of a siltstone above the

Morgan Creek limestone and by a sharp change in topography from a low angle slope to a steep, heavily vegetated slope. The upper boundary of the member was picked at the top of the last large bioherm. Where the bioherms are not present, the upper boundary was picked at the top of the last significant siltstone or shale. Bridge, Barnes, and Cloud (1947, p. 115) noted that the upper boundary of the Point Peak shale varied vertically because of lateral facies changes from shale to limestone. In the Schep - Panther Creek area, however, exposures of the contact were not of sufficient lateral extent to exhibit any such lateral facies changes.

San Saba Limestone Member

Definition and thickness: The San Saba limestone member was redefined by Bridge, Barnes, and Cloud (1947, p. 117) from exposures along the San Saba River, northwest of Camp San Saba, McCulloch County, Texas. The name applies to all the glauconitic limestones lying between the Point Peak shale member and the Ellenburger limestone of Ordovician age.

The San Saba limestone is the uppermost stratigraphic unit represented in the Schep - Panther Creek area. Bridge, Barnes, and Cloud (1947, p. 117) assigned a thickness to the member of 299 feet at the type locality. In the Schep - Panther Creek area, only an estimated 20 to 50 feet of the lower San Saba limestone are present; the remainder has been removed by erosion. The variation of thickness in the thesis area is dependent upon the presence of absence of the bioherm zone.

<u>Lithology</u>: The San Saba limestone occurs in the Schep - Panther Creek area 1.5 miles southeast of the Emeth Keller ranch house where it caps two hills. The portion of the member present is composed of a mottled, light yellowish-gray, well-bedded, finely crystalline, limonitic, glauconitic, fossiliferous limestone grading into a brownish-gray, well-bedded, medium-to coarsely-crystalline, limonitic, slightly glauconitic limestone. The latter limestone contains remains of trilobites, brachiopods, and tightly coiled gastropods. Individual beds crop out through a mixture of soil and talus. The limestone has a tendency to weather into flags. Beds containing <u>Girvanella</u>, as discussed by Bridge, Barnes, and Cloud (1947, p. 117), were not noticed in the thesis area.

<u>Stratigraphic relations</u>: The base of the San Saba limestone was picked either at the first appearance of a well-bedded limestone above the bioherm zone, where present, or at the base of the limestone immediately overlying the last shale of the Point Peak shale member. Where the San Saba limestone is in normal contact with the bioherm zone, there is no significant vegetation or topographic change. Where the San Saba limestone and Point Peak shale are in normal contact, there is a pronounced change from a steep heavily vegetated Point Peak slope to a gentle sparsely vegetated San Saba slope.

QUATERNARY SYSTEM

Recent alluvium, in the form of rock fragments or mantle, is present in the thesis area and is especially prevalent in the low-lying areas. A pronounced bench of alluvium parallels the southern bank of the Llano River. Where there was any question as to the identity of bedrock underlying alluvium, the alluvium was mapped. A coarse caliche conglomerate is well developed in Schep Creek on the Seth Martin ranch.

S T R U C T U R A L   G E O L O G Y

REGIONAL STRUCTURE

The Llano uplift is a structural dome which has been eroded to a topographic basin. A core of elevated Precambrian and Paleozoic rocks is surrounded by a relatively flat-lying rim of Cretaceous strata. According to Sellards (1932, p. 30), the Precambrian rocks have been uplifted from 6,000 to 7,000 feet. The uplift is approximately 80 miles long and 50 miles wide.

Sellards (1934, p. 84) noted that the first evidence of doming in the region is indicated by the thinning of the Mississippian sediments over the uplift. Cheney and Goss (1952, p. 2249) believed that the structural development of the dome was essentially completed by late Lampassas or early Strawn (Late Pennsylvanian) time, as deduced from well information in Mills County off the northeast flank of the uplift. In these wells, typical Strawn strata showed only minor structural disturbance compared to a difference of 1,000 feet in thickness of the underlying beds.

Cloud and Barnes (1948, p. 121), however, dated the final stage of structural deformation as post-Strawn and pre-Canyon. These authors reported that in the vicinity of Calf Creek in Mason County, unfaulted strata of Canyon age overlap faulted strata of Ellenburger age, and, at the same time, noted that strata of the Strawn formation are in fault-contact with the Marble Falls limestone. It appears that there is not as yet conclusive evidence as to whether the final stage of deformation was post-Strawn or contemporaneous with Strawn deposition.

The major faults within the Llano region have a predominant northeast trend, are normal, and, according to Cloud and Barnes (1948), have dips ranging between 60° and 90°. Most of these faults are downthrown to the northwest. Cloud and Barnes (1948) attempted to explain a connection between the orogenic activity in the Ouachita trough and the faulting in the Llano uplift but were not completely clear in explaining the stress relationships necessary to produce the normal faulting. To date, there has not been any satisfactory published explanation of the cause of faulting in the region. Cheney and Goss (1952) and Cloud and Barnes (1948) correlated the faulting in the region with the final stage of deformation (during Strawn or post-Strawn, pre-Canyon time).

LOCAL STRUCTURE

General

The strata in the Schep - Panther Creek area have an average strike of N 50° E and dip, for the most part, to the southeast. Considering that the area is located on the southwest flank of the Llano uplift, however, the beds would be expected to dip southwest. As no evidence of folding was noticed in the area, the strata therefore apparently occur as tilted, faulted blocks of various sizes.

Faulting

Although normal faults are numerous throughout the area, the only ones having relatively large throws are in the northern part. As is the case regionally, the faults in the Schep - Panther Creek area have a predominant northeast trend.

A major normal fault, the Schep Creek fault, enters the thesis area from the west from the Lower James River area as mapped by Sliger (1957). A similarly named fault was mapped by Wilson (1957) beyond the Llano River northeast of the Schep - Panther Creek area. These two similarly named faults connect as one fault across the thesis area. In the north central part of the thesis area, the Schep Creek fault branches into a complex group of faults. The Schep Creek fault has a general northeast strike through the thesis area, entering through the west central part with a strike of N 56° E. Proceeding through the center of the area, it curves northward to a strike of N 35° E and then back to a strike of N 64° E. As the fault proceeds toward the northern boundary of the thesis area, it gradually curves northward until it reaches a strike of N 41° E. The throw of the Schep Creek fault through the thesis area varies from less than 100 feet in the north central and northeast parts of the area to approximately 500 feet in the west-central part of the area. The maximum throw is expressed where the Hickory sandstone is in fault contact with the Morgan Creek limestone. The fault is downthrown to the northwest and has a dip estimated to be close to vertical.

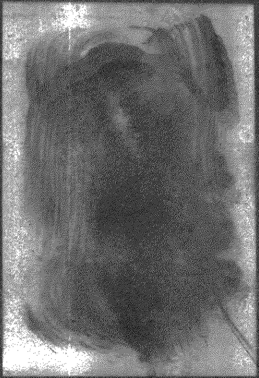


Plate XIII

Exposure of the Burnett fault along Schep Creek
on the Arch Burnett ranch

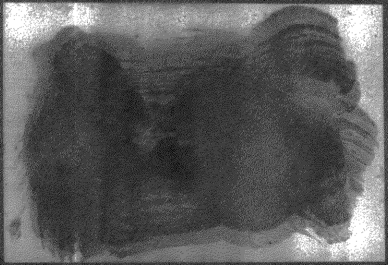


Plate XIV

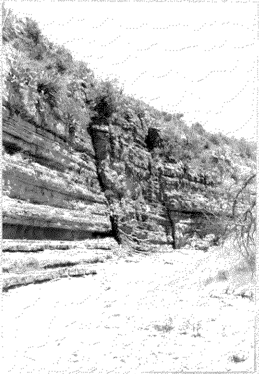
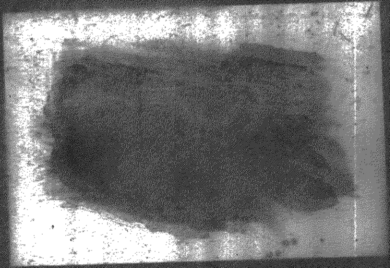
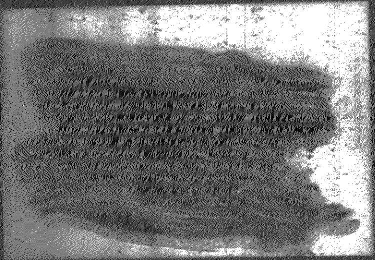


Figure 1: Minor fault within the Morgan Creek limestone along Schep Creek on the Ruth Keller ranch

Figure 2: Minor fault between the Welge sandstone and the Morgan Creek limestone along Schep Creek on the Arch Burnett ranch





Up to 0.5 mile southeast of the Schep Creek fault are two connecting faults (see Plate I). Although these are two individual faults, their combined trends mark a line of large displacement where rocks of the lower Riley formation are brought into contact with those of the lower and middle Wilberns formation. These two faults were named collectively for this study as the Hall faults (see Plate XII). Both faults are normal with dips estimated to be close to vertical. The throw of each of the two faults varies from approximately 275 feet to 390 feet. The faults are downthrown to the north or northwest. The eastern fault has an average strike of N 45° E and roughly parallels the strike of the Schep Creek fault. The western fault has an average strike of N 82° E which causes it to eventually merge with the Schep Creek fault.

A third, relatively large, normal fault in the northeast part of the thesis area is the Burnett fault (see Plate XIII). The fault has a strike of N 44° E and runs between and parallel to the Schep Creek and eastern Hall faults. The Burnett fault is downthrown to the southeast, has a measured apparent dip of 85° SE, and has an estimated maximum throw along Schep Creek of 210 feet. The fault is continuous across the Llano River into the Wilson area but appears to die out in the center of the Schep - Panther Creek area.

Numerous other minor faults occur in the northern part of the thesis area. These faults vary in throw from 2 feet to approximately 100 feet. The faults are normal, have steep dips, have a general

Plate XV

Aerial photograph showing tree lineations in the southern part of the Schep - Panther Creek area

northeast trend, and are downthrown either on the northwest or southeast side (see Plate XIV). Where a few of these faults occurred within the Morgan Creek limestone, their presence was detected by disturbed beds occurring in conjunction with pronounced tree lineations.

There are no major faults in the southern part of the thesis area. Plate XV, however, shows an abundance of tree lineations. Wayne Woolsey, a recent geology graduate student of the Agricultural and Mechanical College of Texas, informed this writer that, as a result of his field work in the Llano uplift, he believed that similar pronounced tree lineations were indicative of jointing rather than faulting. It was noted, however, that many such tree lineations occurred along small faults varying in throw from 2 feet to 20 feet. These faults were mapped when identified as such. Since a large majority of the tree lineations occurred within the Cap Mountain limestone member, detection of faulting was not always possible. Along the extreme southern portion of the thesis area, however, displacements of the Welge sandstone and small faulted blocks of the Lion Mountain sandstone against the Cap Mountain limestone gave supporting evidence for the presence of numerous small faults. It appears, therefore, that although some of the tree lineations may be the result of jointing within the Cap Mountain limestone, probably a great many of them occur in conjunction with small faults.

Efforts were made to determine the stresses which caused faulting in the area. It was concluded, however, that no simple stress distribution involving two horizontal and one vertical principal stress directions could have produced the faulting. It is probable that complex stresses existed, but the resultant principal stress directions could not be determined. Possibly the resultant principal stress directions were not constant over the area during the time of faulting.

GEOLOGIC HISTORY

REGIONAL

As the complete geologic section present in the Llano uplift is not represented in the Schep - Panther Creek area, it is necessary to review the region as a whole in order to determine the geologic history of the thesis area. Paige (1911, 1912), Sellards (1932, 1934), Cloud and Barnes (1948), and others have previously described the geologic history of the region in detail.

During the large expanse of Precambrian time, limestones, sandstones, and shales were deposited over the region. The existence of primitive organisms is suggested by the local presence of graphite within the Precambrian schists. During, or at the close of Precambrian time, the region was subjected to orogenic activity accompanied by uplift, igneous intrusions, and metamorphism of the sediments to schists, gneisses, and marbles. The coarse-grained nature of the granites present in the region gives evidence that the intrusions cooled slowly at depth, and suggests the great thickness of Precambrian sediments that were removed by subsequent erosion. The period of erosion, exposing the metamorphic and igneous rocks, lasted until Late Cambrian time, and an erosion surface, having approximately 800 feet relief was developed.

With the first transgression of the sea, during Paleozoic time, the Hickory sandstone was deposited on the truncated folds of the Precambrian rocks. Ventifacts, rounded sand grains, and other residual material were incorporated in these basal deposits. Oscillation ripple marks and intra-formational conglomerates suggest near-shore conditions during the deposition of the middle part of the Hickory member. As the sea continued to transgress, the supply of detrital material decreased, and the deposition of the Cap Mountain limestone member occurred in a relatively quiet, neretic environment, with slightly reducing bottom conditions. The cross-bedded sandstones and the limestones composed of reworked detrital material that comprise the Lion Mountain member suggest that a slight regression of the sea occurred after the deposition of the Cap Mountain limestone. Thinning of the Lion Mountain and Welge sandstones from northwest to southeast, and facies changes of the Cap Mountain limestone to a sandstone north of the uplift suggest a source area to the north or west (Barnes, 1956, p. 9).

A renewed transgression of the sea is indicated by the deposition of the Welge sandstone. Oxidizing conditions, evidenced by the lack of glauconite, probably existed during the influx of new detrital material. As the sea continued to rise, however, slightly reducing conditions on the bottom returned, and the influx of detrital material gradually decreased as evidenced by the sandy, glauconitic, basal Morgan Creek limestone. A return to a neretic environment resulted in the deposition of the fossiliferous granular limestone comprising the main body of the Morgan Creek member.

Under conditions involving a slight regression of the sea, and the introduction of silty and argillaceous material, the Point Peak shale was deposited. Paige (1912, p. 79) stated that its shale-pebble conglomerates and mud cracks suggest the presence of widespread tidal flats.

A reduction in the amount of detrital material entering the sea and an increase in algal activity produced an environment favorable to the growth of large, stromatolitic bioherms above the Point Peak shale. Conditions favorable for the local growth of these bioherms existed at different times in the region, as evidenced by their presence from the Upper Morgan Creek within the Ellenburger limestone.

Conditions of limestone deposition existed through the remainder of Late Cambrian time, as evidenced by the San Saba limestone member. Barnes (1956, p. 9) and Harwood (1958, personal communication), however, reported the existence of lens-shaped sand facies in the San Saba limestone.

In the western part of the Llano uplift there was no apparent break between the deposition of the San Saba limestone and the limestones of the Ellenburger group of Ordovician age. Cloud, Barnes, and Bridge, (1945, p. 140), however, stated that there is some evidence of erosion of the Upper Cambrian on the eastern side of the uplift before the deposition of the Ordovician strata. They also reported that the Ellenburger is probably, in part, of algal origin and was deposited in an intermittently turbulent, warm, shallow sea.

Upper Ordovician (Barnes, Cloud, and Duncan, 1953) and Lower, Middle, and Upper Devonian marine strata have been recognized in the region.

Most of these rocks have been removed by erosion, but some have been preserved in collapse structures in the Ellenburger.

Thinning of the Mississippian sediments over the Llano uplift was cited by Sellards (1934, p. 84) as evidence of the first stage of uplift of the region. The doming apparently culminated in Late Pennsylvanian (Strawn or Canyon) time and was accomplished by considerable faulting.

The region was evidently an uplifted erosional surface from Late Pennsylvanian time until the last submergence during Cretaceous time. Cretaceous sediments were deposited on the domed erosional surface of Precambrian and Paleozoic rocks.

The last emergence of the region occurred during the Mesozoic Era and caused the Cretaceous rocks covering the central part of the region to be removed, leaving a topographic basin. Streams that had developed on the Cretaceous surface were superimposed on the Precambrian and Paleozoic structures.

At the present time weathered products are forming conglomerate and residual mantle.

THE SCHEP - PANTHER CREEK AREA

The sedimentary and stratigraphic characteristics of the Upper Cambrian rocks in the Schep - Panther Creek area generally support the regional geologic history as described above. There are, however, lithologic, sedimentary, and stratigraphic features in the thesis area which make possible a more detailed interpretation of the conditions of sedimentation during the deposition of these beds.

The portions of the Hickory sandstone exposed in the area are similar in lithology to those described by Goolsby (1957) and appear to support his interpretation of the environments of deposition. The fine-grained sandstones and oscillation ripple marks found in the Middle Hickory suggest a quiet, very shallow sea with the source area being either distant or greatly worn down. Intra-formational conglomerates, identified in this part of the member, were probably formed on flat areas during a temporary lowering of sea level. The pebbles in the conglomerate are composed of well-indurated, rounded sandstone. The medium-to coarse-grained, ferruginous sandstone of the Upper Hickory was most likely deposited under shore conditions close to the source area. The larger grain sizes and greater abundance of ferruginous material compared to the Middle Hickory suggests an increase in the power of the transporting agent which was possibly brought about by a greater amount of rainfall in the source area. An increase in rainfall could move the larger sand particles and, at the same time, could flush a lateritic mantle which may have been present in the source area.

The lithology of most of the Cap Mountain limestone member in the Schep - Panther Creek area is consistent with descriptions of the member in other parts of the region and reflects a shallow, warm, and clear water environment. A local, massive, fine-grained, non-calcareous sandstone, however, appears to indicate a nearby local uplift during its deposition. As previously stated, a similar sandstone has been noticed southeast of the Schep - Panther Creek area. Such a sandstone, however, has not been recognized in areas to the north, south, and west. It is probable that the source area of the sandstone was to the east or southeast of the area. In the upper part of the Cap Mountain member, near the contact with the Lion Mountain sandstone, there occurs a coarse-grained, glauconitic, sometimes cross-bedded limestone composed predominantly of trilobite fragments. The trilobite fragments, and cross-bedding, indicate turbulent conditions (also reported by Sliger, 1957). The glauconite, however, implies quiet, reducing conditions (Cloud, 1955, p. 486). It is possible that turbulent conditions alternated with quiet conditions and that the glauconite found associated with trilobite fragments and cross-bedding had been reworked from earlier deposits. It appears that the conditions which were later to produce the deposition of the Lion Mountain sandstone began during the last phase of deposition of the Cap Mountain member.

The lithologic and sedimentary characteristics of the Lion Mountain sandstone are similar to those at Streeter in Mason County described by Barnes and Bell (1954, p. 42). Inter-bedded and cross-bedded sandstones and detrital limestones of the Lion Mountain member indicate that a turbulent environment was probably present during its deposition. Turbulence is also indicated in the thesis area by the fact that the limestone is predominantly composed of trilobite fragments. The glauconite present throughout the member, however, suggests quiet, reducing, marine conditions (Cloud, 1955, p. 486). Probably, short intervals of such conditions alternated with intervals of turbulence. The glauconite found associated with cross-bedded detrital limestones and sandstones had probably been reworked.

The Welge sandstone in the Schep - Panther Creek area is similar, for the most part, to lithologic descriptions of this sandstone observed elsewhere in the region. In the southwest part of the area, the highly indurated siliceous nature of the Welge member suggests secondary cementation of the sandstone.

Exposures of the Morgan Creek limestone in the Schep - Panther Creek area are generally similar in lithology to regional descriptions of the member and reflect a shallow, warm, clear water environment. Inter-bedded throughout the member, however, occur cross-bedded limestones composed predominantly of trilobite fragments. One of these beds contains the brachiopod Eorthis texana. As in the case of the Lion Mountain member, glauconite, commonly present in these calcarenite deposits, was probably reworked from earlier deposits within the member which were formed under quiet, slightly reducing conditions. At the top of the member in the thesis area occur small stromatolitic bioherms suggesting quiet, clear water conditions. These bioherms are much smaller than the large bioherms which appear in the thesis area At the top of the Point Peak member. It is probable that the advent of Point Peak shale deposition produced conditions that were unfavorable to bioherm growth.

The inter-bedded siltstones, limestones, and intra-formational conglomerates recognized as composing the Point Peak member in the thesis area are similar in character to other descriptions of the member regionally and suggest a new influx of detrital material into shallow water. Fluctuations in sea level and the development of tidal flats possibly produced the intra-formational conglomerates. The calcareous siltstone pebbles, composing the conglomerates are more angular than those found in the conglomerate of the Middle Hickory. Possibly the Point Peak conglomerate pebbles did not undergo as much transportation as did those of the Middle Hickory conglomerate.

The bioherms found at the top of the Point Peak member suggest relatively quiet, clear water conditions. Other geologists have recognized bioherms of various sizes in the region at different stratigraphic levels ranging from the Morgan Creek limestone to the Ellenburger limestone. The bioherms were probably formed during those times when local conditions were favorable for algal growth. The large bioherms are closely associated with the more abundant limestones of the upper part of the Point Peak member. It is probable that a firm clean bottom was required for the algal colony to attach itself and develop.

The San Saba limestone member in the Schep - Panther Creek area is consistent in lithology with other localities described in the region and reflects warm, clear, neritic conditions favorable to limestone deposition. Glauconite disseminated through the limestone indicates slightly reducing bottom conditions.

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A P P E N D I X

The following is a section of the Lion Mountain sandstone, the Welge sandstone, and the basal part of the Morgan Creek limestone. The section along Schep Creek on the Seth Martin ranch, 1.25 miles south of the Emeth Keller ranch house (see Plate 1).

	Thickness in feet
Wilberns formation	
Morgan Creek limestone member:	
21. Limestone; reddish-gray, weathering to purple, well-bedded, coarse -grained, glauconitic, slightly sandy limestone. The limestone occurs in beds 0.5 foot to 1.5 feet thick	8.0
20. Limestone; reddish-purple weathering, to purple, well-bedded, coarse-grained, sandy badly weathered limestone. The limestone occurs in beds 6 to 12 inches thick. At the base of the unit there is a pronounced topographic break where the limestone is in contact with the Welge sandstone	4.0
Total thickness Morgan Creek measured	12.0
Riley formation	
Welge sandstone member	
19. Sandstone; brown to yellowish-brown, massive, medium-grained, ferruginous, non-glauconitic,	

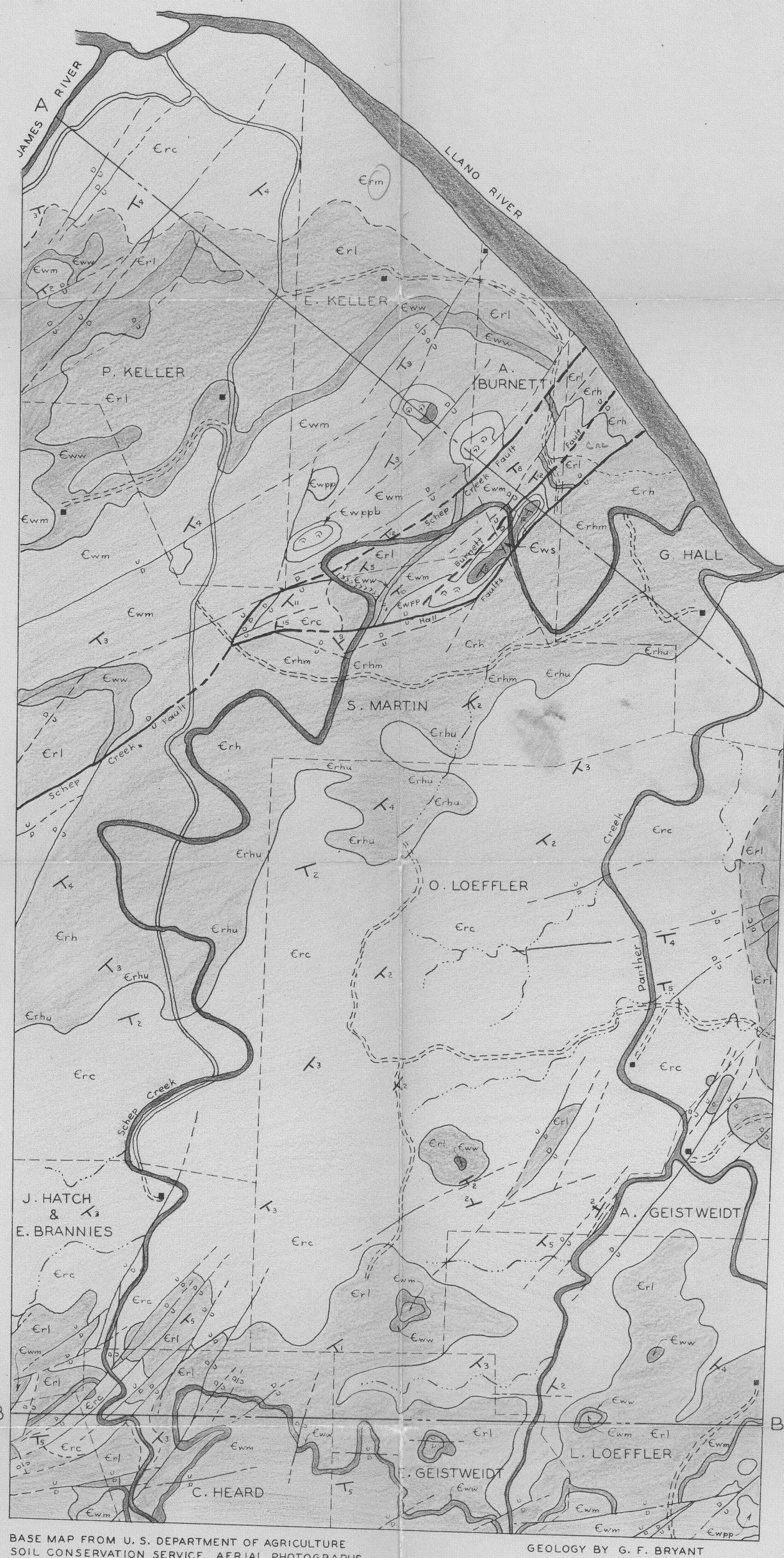
	Thickness in feet
non-calcareous sandstone. The sandstone occurs as a prominent ledge supporting a dense growth of scrub trees	19.8
Total thickness of Welge measured	19.8
Lion Mountain sandstone member:	
18. Sandstone; light green weathering to dark green, cross-bedded, laminated, very fine-grained, highly glauconitic, clacareous sandstone. The sandstone is inter-bedded with small lenses of coarse grained limestone. The limestone is composed almost entirely of trilobite fragments	13.4
17. Limestone; gray with green specks, weathering to brown, well-bedded, coarse-grained, slightly limonitic and glauconitic limestone. Individual beds vary in thickness from 1 to 2 feet and crop out through a thick soil cover. The limestone is composed mostly of fragments of trilobites	7.0
16. Sandstone; gray speckled green, weathering to greenish-brown, flaggy, coarsely-fissile, medium-grained, very glauconitic	

		Thickness in feet
	sandstone. The sandstone contains small, thin lenses of limestone composed of fragments of trilobites and glauconite. The glauconite has altered in small pockets to hematite	8.4
15.	Limestone and sandstone; alternating cross-bedded laminae of grayish-brown, fine-grained, glauconitic, limonitic sandstone with gray weathering to brown, detrital limestone composed mostly of small trilobite fragments.......	1.0
14.	Sandstone; dirty, reddish-brown, weathering to dirty-gray, thinly-bedded, poorly fissile, very fine grained to silty sandstone which contains small specks of limonite	2.2
13.	Limestone; gray speckled greenish-brown, massive, coarse-grained, sandy, glauconitic, ferruginous limestone containing some minor amounts of limonite. The unit grades laterally into a cross-bedded, very fine-grained, limonitic sandstone	1.8
12.	Sandstone; greensih-gray weathering to brownish-gray, thin to thickly bedded, very fine-grained,	

		Thickness in feet
	calcareous, slightly glauconitic sandstone. The unit is more calcareous in the lower portion than in the upper portion	3.7
11.	Limestone; brownish-green weathering to gray, massive, detrital to finely-crystalline, very glauconitic, partially limonitic limestone. Calcite crystals often occur in vein-like structures	0.5
10.	Sandstone; gray speckled green, weathering to gray-buff, massive, very fine-grained to silty, very calcareous, glauconitic sandstone containing specks of limonite	2.2
9.	Limestone; greenish-gray, weathering to brown, massive, finely-crystalline, sandy, slightly glauconitic limestone containing limestone stringers composed of trilobite fragments	2.0
8.	Sandstone; grayish-green, weathering to dark grayish-green, coarsely fissile, fine-grained, highly glauconitic, calcareous sandstone containing small specks of limonite	0.6

		Thickness in feet
7.	Limestone; brownish-gray, weathering to dark grayish-brown, massive, medium-crystalline, sandy, glauconitic, limonitic limestone. The unit is partially composed of fragments of trilobites	1.0
6.	Sandstone; grayish-green, weathering to dark grayish-green, coarsely fissile, very fine-grained to silty, very glauconitic, limonitic, calcareous sandstone	0.6
5.	Sandstone; gray to yellowish-green, weathering to buff-gray, friable, fine-grained, very calcareous, glauconitic sandstone. The sandstone contains calcite occurring in very small pockets or veins	0.9
4.	Limestone; greenish-gray, weathering to light-brown, massive, medium-crystalline, very glauconitic, slightly sandy limestone composed primarily of cross-bedded fragments of trilobites	1.1
3.	Sandstone; greenish-gray, weathering to gray, poorly fissile, very fine-grained to silty, glauconitic, limonitic,	

	Thickness in feet
calcareous sandstone. The sandstone contains dark shale-like partings	0.9
2. Limestone; greenish-gray to buff, weathering to gray, medium-bedded, coarse-grained, glauconitic, sandy, limonitic limestone. The middle of the unit contains a higher percentage of snad cut by small calcite veins. The limestone is mostly composed of trilobite fragments	3.2
1. Sandstone; greenish-gray, weathering to brown, massive, fine-grained, highly calcareous, glauconitic, limonitic sandstone. The sandstone grades laterally into a gray, finely-crystalline limestone. Calcite veins occasionally cut through the unit	1.0
Total thickness of Lion Mountain measured	51.5
Total thickness of section measured	83.3



BASE MAP FROM U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE, AERIAL PHOTOGRAPHS, 1952

GEOLOGY BY G. F. BRYANT

EXPLANATION

GEOLOGIC COLUMN

RECENT

UPPER CAMBRIAN — CAMBRIAN

WILBERNS FORMATION

- Ꞓws — SAN SABA LIMESTONE MEMBER
- Ꞓwppb — BIOHERM ZONE
- Ꞓwpp — POINT PEAK SHALE MEMBER
- Ꞓwm — MORGAN CREEK LIMESTONE MEMBER
- Ꞓww — WELGE SANDSTONE MEMBER

RILEY FORMATION

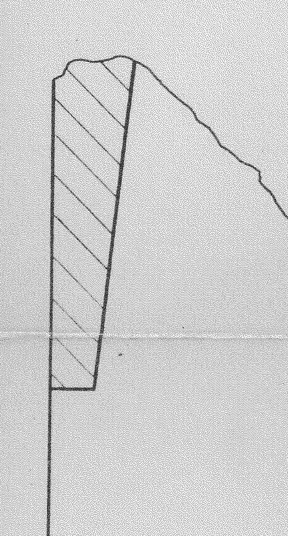
- Ꞓrl — LION MOUNTAIN SANDSTONE MEMBER
- Ꞓrc — CAP MOUNTAIN LIMESTONE MEMBER
- Ꞓrh — HICKORY SANDSTONE MEMBER (WHERE DEFINITELY IDENTIFIED)
  - Ꞓrhu - UPPER
  - Ꞓrhm - MIDDLE

SYMBOLS

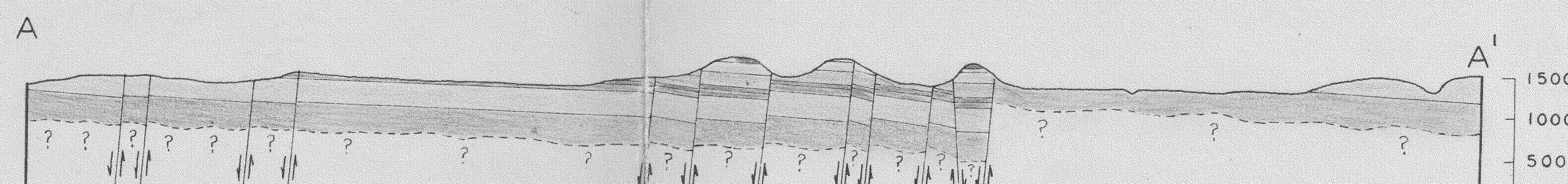
- GRADED & DRAINED ROAD
- RANCH & FARM ROAD
- PROPERTY LINE
- HOUSE
- STREAMS
- EPHEMERAL STREAMS & GULLIES
- MAJOR FAULT
- MAJOR INFERRED FAULT
- MINOR FAULT
- MINOR INFERRED FAULT
- STRIKE AND DIP
- MEASURED SECTION

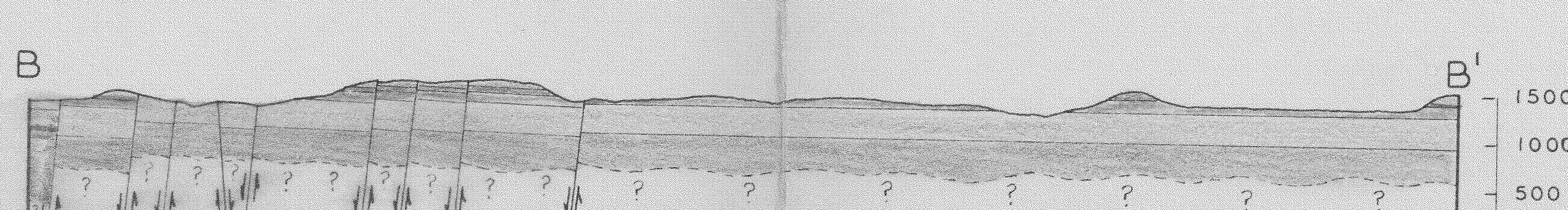
SCALE 1/20 000

0 — 1/2 — 1 — 2 MILES



CROSS HATCHED AREA AFTER SLIGER (1957)





(TOPOGRAPHY AND DIPS OF FAULTS ESTIMATED)

GEOLOGIC MAP OF THE SCHEP-PANTHER CREEK AREA, MASON COUNTY, TEXAS.