STRUCTURAL GEOLOGY OF THE CENTRAL BLUFF CREEK AREA, MASON COUNTY, TEXAS

A Thesis

By

Fred Rankin Grote

Approved as to style and content by:

Horace R. Blank

Chairman of Committee

Head of Department

June, 1954

STRUCTURAL GEOLOGY OF THE CENTRAL BLUFF CREEK AREA, MASON COUNTY, TEXAS

A Thesis

by

Fred Rankin Grote

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

June, 1954

Major Subject: Geology

ACKNOWLEDGEMENT

The writer is sincerely grateful to Dr. H. R. Blank of the Department of Geology of the Agricultural and Mechanical College of Texas for his aid in selecting the problem and his invaluable guidance throughout the project. Dr. Blank supervised the field mapping as well as the preparation of the thesis. Additional thanks are due Mr. S. A. Lynch, Head of the Department; Mr. C. L. Seward; and Dr. T. J. Parker of the Geology Department of the Agricultural and Mechanical College of Texas whose suggestions and constructive criticism were a great assistance to the author.

The writer is especially grateful also to Mr. Joe F. Fritz who shared transportation to the thesis area. Mr. Fritz also furnished considerable data on the geology in the eastern portion of the central Bluff Creek area, a part of which he mapped in detail.

Sincere thanks are expressed to the ranchers and local residents of Mason, Texas, whose friendliness and courtesy were a great help to the writer.

CONTENTS

ILLUSTRATIONS

STRUCTURAL GEOLOGY OF THE CENTRAL BLUFF CREEK AREA, MASON COUNTY, TEXAS

ABSTRACT

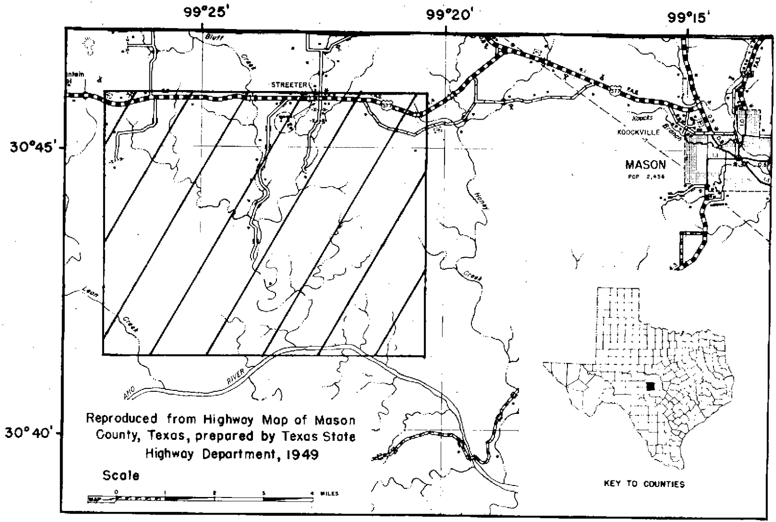
The central Bluff Creek area is located on the southwest flank of the large structural dome in central Texas known as the Llano uplift. The rocks exposed in this thesis area range in age from pre-Cambrian to Mesozoic (?). The rocks of pre-Cambrian age which make up the core of the regional uplift are exposed in the northeast corner of the area studied. Paleozoic and Mesozoic (?) rocks surround these pre-Cambrian exposures to the southeast, southwest, and northwest.

The outcrop patterns and the attitudes of the Paleozoic beds mapped in this study suggest the presence of a northeast-trending fold. The inferred fold seems to plunge to the southwest away from the center of the regional uplift.

Along the axis of this fold is a zone of intense faulting. Two almost perpendicular sets of faults were noted. The most obvious faults are oriented in the northeast quadrant approximately parallel to the axis of the suggested fold. The other set trends northwest approximately perpendicular to the axis of the fold. All of the faults observed in the field were normal and were probably formed by tension in the surface rocks.

It is the writer's belief that the local fold in the thesis area occurred as a part of the deformation accompanying the regional uplift. The intense faulting in this area is thought to be a result of the folding which has caused a concentration of tensional stresses in the near-surface rocks over the crest of the anticline.

Plate IV



LOCATION MAP OF THE CENTRAL BLUFF CREEK AREA,

MASON COUNTY, TEXAS

STRUCTURAL GEOLOGY OF THE CENTRAL BLUFF CREEK AREA, MASON COUNTY, TEXAS

INTRODUCTION

STATEMENT OF THE PROBLEM

The purposes of this paper are (1) to map and describe the geological structure of the central Bluff Creek area and (2) to suggest possible explanations for the occurrence of such structure. The first of these involves the determination of the distribution and attitudes of the faults and folds found within the area. The second consideration includes a brief history of the tectonics of this area and speculation as to the causes of the geologic structure observed.

To accomplish this a great many faults, both large and small, were mapped in detail and measurements of dip and strike were taken throughout the area. From these data maps were constructed to aid in determining the geologic structure. A map of the entire central Bluff Creek area was compiled to show the attitudes of the strata and the general outcrop pattern. A more detailed geologic map of the central portion of the thesis area was also made to study the patterns of the minor faults.

LOCATION AND ACCESSIBILITY

The central Bluff Creek area is located in Mason County, Texas, about eleven miles west of the town of Mason, and lies within the drainage basin of Bluff Creek and its tributaries. It is bounded on the north by the Mason-Junction road, U. S. Highway 377, and on the south by the Llano River. About seven square miles near the center of this thesis area were mapped in detail. This detailed area begins about one mile south of the Mason-Junction highway, and extends southward for a distance of three miles on both sides of Bluff Creek.

The area studied in detail is most easily accessible by the Hofman ranch road which leaves the Mason-Junction highway about one-half mile west of the community of Streeter and continues south following Bluff Creek. The Loeffler ranch road which runs south from Streeter leads to the eastern part of the larger thesis area and the McMillan ranch road which begins about five miles west of Streeter provides an all-weather road to the western portion.

METHODS OF FIELD WORK

The field work was done between August 1 and September 10, 1953, and between July 19 and January 28, 1954. Mapping was done on acetate-covered aerial photographs made by the United States Department of Agriculture. Photographs DFZ - 3E - 189 through 193, DFZ - 95 - 17 through 20, DFZ - 6E - 53 through 57, and DFZ - 6E - 88 through 92 were used in preparing the map of the entire thesis area, and a photostat of photograph DFZ - 6E - 55 enlarged to the scale of about 990 feet to the inch was used as a base map in making the detailed geologic map. A stereoscope was used both in the field and at the drafting table to locate points on the photographs.

Most of the dip and strike measurements found on the maps included in this report were taken in the field with a Brunton compass. Some, however, were obtained from Mr. J. F. Fritz, who worked in the eastern portion of the central Bluff Creek area, and some were obtained from a map of the Bear Spring area published by Cloud and Barnes (1948).

PREVIOUS WORK

Previous to this time the structural geology of the central Bluff Creek area has not been studied in detail. The major faults in the area have been mapped on a small scale and some detailed work has been done in the southeastern portion of the thesis area.

The first mention of the Llano region in geologic literature was made by Roemer (1846). In this publication, Roemer erroneously considered the granites of central Texas as part of the crystalline masses of the Rocky Mountains. His observations concerning the younger strata have proved surprisingly accurate and his contribution to the early geologic knowledge of Texas was considerable. In a second paper, Roemer (1848) gave a more complete account of the geology of central Texas. He recognized the belt of granitic rocks between the Llano and San Saba Rivers and established the Paleozoic age of the rocks immediately overlying the granite.

Hill (1887), in summarizing the facts known about the geology of Texas, mentioned two epochs of disturbance in central Texas. The times of these disturbances were placed after the close of sedimentation of the Llano group (pre-Cambrian rocks of sedimentary origin), and at the close of the Paleozoic. No further mention of the structure of the area was made, but the near-accurate dating of these two periods of deformation was in itself a great contribution to the knowledge of the geology of the region.

In the first annual report of the Geological Survey of Texas, T. B. Comstock (1889) gave a very brief account of the post-Paleozoic uplift in central Texas. He recognized a set of major faults striking approximately east-west and reported their probable age as post-Carboniferous and pre-Cretaceous. It was thought by Comstock that many of the intrusive igneous rocks found exposed in this region were younger than pre-Cambrian and he related the post-Paleozoic disturbances to various crystalline masses in the area. He believed that the latest movement represented by granitic rocks at the surface occurred in Cretaceous time. Mention is made of the divide between Honey Creek and Bluff Creek where, according to Comstock, three or four of the dynamic movements have jumbled the rock " . . . . in such a manner as to almost literally leave not one stone among them which has not been overturned."

Sidney Paige (1912) described the geology of the Llano and Burnet quadrangles and contributed much to the knowledge of the structure of the Llano region. He mapped these two quadrangles and established the regional structural trends in the pre-Cambrian and later rocks. Concerning the deformation of the Paleozoic rocks, Paige contended that the faulting was due to regional compressive forces. The vertical displacement along the faults in the area was used as evidence to support the idea of compression.

Van Der Gracht (1931) in discussing the Permo-Carboniferous orogeny in south-central United States considered the regional structure of the Llano-Burnet region. He indicates that the effect of the Quachita orogeny on the Llano-Burnet "massif" was only to accentuate the uplift and cause some northeast faulting. He maintains that the Llano uplift existed as a stable positive area during the period of intense thrusting and folding in the Ouachita belt and that the uplift was not a product of the Quachita orogeny.

H. B. Stenzel (1934) provided a description of the pre-Cambrian structure in the Llano area. On the basis of structure he divided the pre-Cambrian rocks of the Llano uplift into three series which are, oldest to youngest, folded frame metamorphic rocks, batholithic intrusions, and late dike intrusions. He recognized the very complex structure of the area and verified the structural trends noted by Paige. Stenzel suggested that the later dikes in the area lie in a system of north-south striking fractures that seem to "foreshadow" some of the later Paleozoic north-south faults.

An account of the Paleozoic tectonic activity in central Texas was provided by Sellards (1934). He showed that uplift in the Llano region began as early as Mississippian time. Thinning of the Chappel and Barnett formations in the area of uplift was used as evidence of this early movement. Sellards discussed the faulting in the Llano region very briefly. He mentioned the northeast-southwest trends of the major faults and referred to this group as the Llano system of faults. He also described the San Marcos, Edwards, Lampasas, Concho, and Bend arches which radiate from the Llano uplift.

Darton et al (1937) provided a geologic map of the entire state of Texas on a scale of 1 to 500,000. The general areas of outcrop of the larger units are shown along with the major structural features.

A brief account of regional and local structure in the Llano area was given by Plummer (1940). In considering the regional structure he states that the area is not actually an uplift, " ... but an old, worn-down remnant of ancient crystalline and metamorphic rocks which have stood as a kind of monadnick during different epochs in early Paleozoic and early Cenozoic history, furnished sediments to the surrounding seas, and been buffeted by wave action of advancing shorelines during several epochs." He attributed the dip of the formations away from the central granite mass to original depositional dips, settling, and compaction.

Plummer divided the local structures of the area into seven classes. The seven groups were spur ridges, normal faults, grabens, buried ridges, sharp flexures, symmetrical anticlines, and reef masses. He gave a very brief description of each of these structural types and in most cases mentioned a specific example in the Llano area.

Cheney (1940) proposed changes in the nomenclature of the time and rock units of the later Paleozoic in north-central Texas. Among the changes proposed was substitution of the name Lampasas series to include the Smithwick and Big Saline groups which were previously included in the Bend group (Sellards 1932).

Cheney suggests that the evidence of thinning of the Ellenburger indicates uplift of the Concho arch as early as Ellenburger time. The uplift and major deformation of the Llano area is dated as post-Lampasas and pre-Canyon.

Cloud and Barnes (1948), in a bulletin primarily concerned with the Ellenburger group, provided an excellent general reference for the Paleozoic geology of central Texas. Included in this paper is a summary of the structural geology of the Llano area. Faulting and folding in the area are discussed briefly. Paleozoic faulting in the area is indicated to have occurred during or after Strawn time and before the Canyon epoch. An area in the southeastern part of the central Bluff Creek area is mapped in the report and referred to as the Bear Springs area.

In his publication on the Carboniferous rocks of central Texas, Plummer (1950) makes no mention of the geologic structure. The geologic map of the Llano region which is included with the report is, however, the most complete and detailed geologic map of the area compiled to date. The pre-Carboniferous formations are undifferentiated, but local structures, particularly in the areas of Carboniferous outcrop, are shown on the map.

PHYSIOGRAPHY

CLIMATE

Mason County is located in a semi-arid region and has an average annual rainfall of about 20 inches, occurring as widely spaced, heavy rains which have a high percentage of runoff.

The average annual temperature in this area is about 70.5°F. The area is characterized by dry, hot summers with temperature up to 110°F. and rather cold winters with a low temperature of -5°F. The average summer daytime temperature is 90°F.

VEGETATION

The vegetation in the central Bluff Creek area is limited to those types which exist in a hot, dry area with rather poor soil development. One exception to this is the willow tree which is found occasionally along the spring-fed streams in the area. The plants common on the limestone outcrops are scrub oak, cedar, Spanish dagger, and several varieties of cactus. The sandstones usually support growths of mesquite and needle grass. Dense growths of mesquite and Mexican persimmon are characteristic of the shale outcrops. The correlation between lithology and vegetation is well displayed in the area of Carboniferous outcrops where zones may be traced for long distances on the aerial photograph by their typical vegetation.

PHYSICAL FEATURES

The central Bluff Creek area is located on the southwest flank of the Llano uplift. The core of the uplift consists of pre-Cambrian igneous and metamorphic rocks which are exposed over an area approximately 60 by 36 miles. Surrounding this core are bands of more resistant sandstones and limestones. The coarse granites and metamorphics outcropping in the center of the dome are more susceptible to erosion than the surrounding sediments and form a topographic basin in the area of uplift. On the southern and western sides of the uplift the rim of the topographic basin is the almost flat-lying Cretaceous limestone which rests on the Paleozoic rocks in the area.

The thesis area is located on the outcrops of the Paleozoic and pre-Cambrian rocks. There is about 200 feet relief in the area mapped and the maximum elevation is probably about 1800 feet. The highest elevations are found in the areas of limestone outcrop in the southern and western portions of the thesis area. In the area of the Hickory sandstone outcrop in the northeastern part of the map the land is almost flat with gentle slopes. To the south the limestone outcrops form rather sharp ridges, cuestas, and scarps. There is, however, no good development of the extended cuesta pattern common on the Paleozoic outcrops of this region. This is due to the faulting which has offset the beds and prevented the formation of cuestas of any great length.

In the western part of the map is an area which, though underlain by limestone, is quite flat and barren of outcrops. It is believed that this represents the pre-Cretaceous pene-planed surface which has not yet been breached by erosion. This is substantiated by the presence of reddish sandy soil which is possibly the remnants of the basal Cretaceous sands, now largely removed by erosion.

DRAINAGE

The entire Llano region is drained to the south and east by the San Saba, Llano, and Colorado Rivers. The area considered in this paper lies several miles north of the Llano River and is drained by Bluff Creek and its tributaries. Bluff Creek flows southward through the center of the thesis area and empties into the Llano River. Several branches of Bluff Creek extend both to the east and to the west of the main stream. These smaller streams, as well as the main creek, are in many cases controlled by the geologic structure. The stream courses commonly follow the strike of the faults found in the area and because of this take zigzag paths.

STRATIGRAPHY

GENERAL STATEMENT

The rocks in the central Bluff Creek area range in age from Cambrian to Mesozoic(?). A study of the stratigraphy was made to enable the writer to trace faults in the field and to map a portion of the area in detail.

A columnar section of the units which outcrop in the central Bluff Creek area is as follows:

Mesozoic era (?)
  Unnamed arkose

Paleozoic era
  Carboniferous system
    Pennsylvanian series
      Lower Pennsylvanian
        Marble Falls limestone
    Mississippian series
      Barnett formation
      Chappel limestone
  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

Pre-Cambrian eras
  Various metamorphic and igneous rocks

PRE-CAMBRIAN SYSTEMS

Outcrops of pre-Cambrian rocks are present in the north-eastern part of the central Bluff Creek area and extend for some distance beyond the limits of the larger map (Plate I). These rocks are not exposed in the area included in the detailed geologic map (Plate II).

The pre-Cambrian rocks in the thesis area are of metamorphic and igneous types. The metamorphic rocks consist of schists, gneisses, and marbles which have been badly distorted by pre-Cambrian tectonic activity and are found now in tight, very complex folds. The age relations of the pre-Cambrian metamorphic rocks have not been definitely determined.

The igneous rocks of pre-Cambrian age in this area consist of two pink granites which differ mainly in texture. Barnes and Bell (1954) correlate the coarser granite with the Town Mountain and the fine-grained one with the Oatman Creek. Both were intruded into the pre-Cambrian rocks of sedimentary origin before the beginning of the Paleozoic era.

CAMBRIAN SYSTEM

Rocks of the Riley and Wilberns formations of Upper Cambrian age outcrop over a large part of the central Bluff Creek area. The Riley rests unconformably on the eroded pre-Cambrian surface. The Wilberns formation overlies the Riley and represents continuous deposition until the end of the Cambrian period.

RILEY FORMATION

The Riley formation was defined by Cloud, Barnes, and Bridge (1945) to include the Hickory sandstone member, the Cap Mountain limestone member, and the Lion Mountain sandstone member. The name was taken from the Riley Mountains in Llano County where the thickness of the entire formation is 780 feet. Throughout Central Texas the Riley formation varies in thickness from 20 to 814 feet. The average thickness given by Barnes and Bell (1954) is 695 feet.

Hickory Sandstone Member

The Hickory sandstone is the oldest member of the Riley formation. It is a noncalcareous, ferruginous, sandstone which, according to Barnes and Bell (1954) has an average thickness of about 340 feet.

The Hickory sandstone outcrops over a large area in the northeastern part of the central Bluff Creek area. The area of outcrop is quite broad and is marked by an abundance of cultivated fields. The uncultivated outcrop is characterized generally by flat sandy land with mesquite trees and a thick grass growth. A zone of more resistant rock near the middle of the member forms some ridges and small hills in the thesis area. These areas are generally covered with very dense vegetation, principally oak, and are too rocky for cultivation.

The eroded pre-Cambrian surface on which the Hickory was deposited is considered by Cloud and Barnes (1945) to have had as much as 800 feet of relief at the time of Hickory deposition. The thickness is, therefore, quite variable throughout the Llano region, and in places the Hickory is entirely absent due to nondeposition. The upper contact is a gradational one. The dark red noncalcareous sandstones of the Hickory grade into and interfinger with the light brown sandy limestones of the overlying Cap Mountain member. The contact wherever possible is picked on the first predominently calcareous bed. In most instances, however, the contact is mapped at the base of a cuesta formed by the Cap Mountain limestone.

The range in thickness given by Barnes and Bell (1954) for the Hickory is 0 to 497 feet. The thickness in the thesis area is considered to be approximately 375 feet.

The base of the Hickory is a coarse, sometimes conglomeratic sandstone. In this coarse material are often found wind polished pebbles with largest dimensions up to three or four inches. The grain size decreases above the base and throughout most of the member the sandstone is medium grained. There are several beds of fine siltstone and shale near the center of the member. Several of these finer beds, varying in color from pink to light tan, are well exposed on the banks of Bluff Creek about 300 yards north of the Jack Hofman ranch house.

The Hickory member is noncalcareous and nonglauconitic throughout. Its color varies from generally light yellowish tan at or near its base to a dark red or maroon at its top. Various shades of red and brown are found between these extremes. In most places the sandstone is medium bedded to massive. The shaley and silty beds mentioned before display fine to medium bedding. Cross-bedding is common, particularly in the lower part of the member.

Cap Mountain Limestone

The Cap Mountain member which overlies the Hickory sandstone is a sandy, often glauconitic, limestone. The thickness of the Cap Mountain, like that of the underlying Hickory, varies greatly due to differences in depositional conditions. An average thickness given by Barnes and Bell (1954) is 305 feet.

In the area mapped for this report the Cap Mountain limestone outcrops in a band broken by many faults which extends from the north-central part of the area southeastward to the fork of Bluff Creek in the vicinity of the Jack Hofman ranch house. East of this point the Cap Mountain member is missing on the outcrop due to faulting. In most of the central Bluff Creek area the Cap Mountain limestone forms a distinct ridge or east-facing cuesta. Vegetation on the Cap Mountain generally consists of scrub oaks, mesquite, prickly pear, and catclaw.

The lower contact of the Cap Mountain is gradational. The lower boundary is placed at the lowest limestone bed. The upper contact is also gradational. The sandy limestones of the Cap Mountain grade into the highly glauconitic sandstones and limestones of the Lion Mountain member. The contact is picked where the sandstones become predominant and the limestones become lenses or thin beds within the sandstones. The Lion Mountain sandy beds are more susceptible to erosion than the limestones of the Cap Mountain and the contact is generally marked by a change in slope from the dip slope of the Cap Mountain to the flat bench of the Lion Mountain.

The thickness of the Cap Mountain member varies from 0 to 497 feet. The thickness measured by Alexander (1952) in an area about 10 miles east of the thesis area was slightly less than 200 feet.

The Cap Mountain member is a sandy, glauconitic, granular limestone. Its color is grey to light brown, with a pinkish brown weathered surface quite characteristic. Very fine sand is present in the limestone in varying amounts and causes an uneven weathering of the rock which often produces a mottled or honeycombed appearance. The limestone beds range in thickness from several inches to several feet with the thicker beds predominating.

Lion Mountain Sandstone

The Lion Mountain member is the uppermost member of the Riley formation. It consists mostly of highly glauconitic sandstone and at the type locality in northwestern Burnet County has a thickness of 20 feet.

The outcrop of the Lion Mountain sandstone forms a broken band which extends from the northern edge of the central Bluff Creek area to about the center of the area. Though the sandstone of the Lion Mountain weathers easily and is not too often exposed, the band of outcrop is quite characteristic. A flat sparsely vegetated bench is its usual surface representation.

The lower boundary of the Lion Mountain is gradational, but the upper contact, which is also the boundary between the Riley and Wilberns formations, is sharp. The change from the highly glauconitic sands of the Lion Mountain member to the massive, yellow, nonglauconitic sandstone of the Welge member occurs in a narrow zone. In some exposures within the thesis area the change is quite sharp and the contact may be located exactly.

The thickness of the Lion Mountain sandstone ranges up to 69 feet. The average thickness given by Barnes and Bell (1954) is 50 feet. The Streeter section, which is located in the northern part of the thesis area, contains a 29-foot thickness of Lion Mountain, measured by Barnes and Bell (1954).

The Lion Mountain member is a highly glauconitic sandstone with small amounts of clay and limestone. The member is mostly fine grained at the base and becomes coarser higher up. The rock is green at fresh exposures, but weathers to yellow, brown, red, or black. Green clay which weathers to a yellowish brown color occurs as thin stringers within the sandstone. The limestone occurs near the base of the member as thin ledges and as small lenses which are composed almost entirely of trilobite fragments.

Wilberns Formation

The Wilberns formation was named by Paige (1911) and is now considered to include four members. From oldest to youngest the members are the Welge sandstone, the Morgan Creek limestone, the Point Peak shale and the San Saba limestone. The thickness of the Wilberns formation ranges from 360 to 619 feet with an average figure given by Barnes and Bell (1954) as 500 feet.

Welge Sandstone

The Welge member is a rather uniform, massive sandstone which has a thickness of 27 feet at the type locality in Gillespie County. The average thickness over the entire Central Mineral region is about 20 feet.

The Welge sandstone is well exposed in the northwestern part of the central Bluff Creek area. Over much of the remainder, however, the change from Lion Mountain to Welge is apparent only because of a vegetation change on the outcrop. The topography on the Welge is very similar to that on the Lion Mountain outcrop. A continuation of the Lion Mountain bench with much denser vegetation is the common expression of the Welge at the surface.

The lower contact of the Welge with the highly glauconitic sandstones of the Lion Mountain is a sharp one and where the rocks are well exposed can be picked easily. Where good exposures are absent the lower contact is picked on vegetation change. The upper contact of the Welge is gradational. The yellowish brown sands of the Welge grade into the red sandy limestones of the Morgan Creek member. The contact is placed at the lower limit of the limestone beds.

The Welge member was found by Barnes and Bell (1954) to be 22 feet thick in the Streeter section. Thicknesses of 26 and 29 feet were measured by Alexander (1952) in an area about 10 miles east of the thesis area.

Lithologically the Welge member is very consistent. Throughout its thickness it is a fine to medium grained, massive, light yellow to brown, non-glauconitic, noncalcareous sandstone. Characteristic of this sandstone are quartz grains with recomposed crystal faces which cause the rock to glitter in the sunlight.

Morgan Creek Limestone

The Morgan Creek member is a medium to coarse-grained, generally glauconitic limestone. At the type locality on Morgan Creek in Burnet County the limestone is 110 feet thick.

The outcrop of the Morgan Creek covers a considerable portion of the central Bluff Creek area. Throughout much of the area it forms a ridge which rises steeply from the flat bench of the Welge and slopes away to a small valley on the Point Peak shale which overlies the Morgan Creek.

The lower contact of the Morgan Creek member is gradational. The lowermost arenaceous reddish limestone is picked as the base of the Morgan Creek. Where the rocks are covered by soil in the northwestern part of the thesis area the contact is placed at a soil and vegetation change. At the upper contact the Morgan Creek limestone member grades into the shales and siltstones of the Point Peak member. The upper contact is placed at the lowermost thinly bedded silty shale of the Point Peak. This contact is rarely exposed and the boundary is usually mapped at the beginning of the dense growth of mesquite common on the Point Peak member.

The range in thickness given by Barnes and Bell (1954) for the Morgan Creek limestone is 114 to 143 feet. The average thickness over the entire area of outcrop is given as 130 feet. In the Streeter section a thickness of 141 feet of Morgan Creek limestones was measured by these authors.

The Morgan Creek member is a very glauconitic, coarse-to medium-grained limestone containing considerable sand in the lower part. The color is grey to green through most of its thickness. The basal portion of the member, however, has a characteristic purplish red color. These reddish limestones are found just above the lower contact at every exposure in the thesis area. The limestone beds vary in thickness from several inches to about a foot. There are several beds or zones of stromatolitic bioherms about 12 to 18 inches thick in the upper part of the member. The small size and limited thickness of these bioherms distinguish them from those found in the overlying Point Peak shale member.

Point Peak Shale

The Point Peak shale member is named from exposures on the south slope of Point Peak in Llano County, where the member is 270 feet thick according to Bridge, Barnes, and Cloud (1947). The average thickness for the entire Llano region given by Barnes and Bell (1954) is 130 feet.

In the central Bluff Creek area the Point Peak member consists of two distinct zones which were mapped separately in this report. The lower zone, which consists mainly of shales, is represented on the outcrop by a densely vegetated slope. Also characteristic of the lower zone outcrop is a dark soil with caliche and shingle conglomerate litter. The upper zone of the Point Peak member consists of dense stromatolitic limestones which cap the slopes formed by the underlying shales.

The lower contact of the Point Peak shale member is placed at the lowermost shale bed above the bedded limestones of the Morgan Creek member. The contact between the shale and bioherm zones of the Point Peak is placed at the base of the stromatolitic limestones which are consistently found at the top of the member. The contact of the member with the overlying San Saba limestone is placed at the top of the bioherms where the bedded limestones of the San Saba pass over the stromatolitic structures. Brown sandy limestone beds are commonly found overlying the bioherms in the thesis area and are placed in the base of the San Saba limestone member.

The thickness of the entire Point Peak member was measured by Alexander (1952) to be 260 feet. This figure seems slightly large for this member and it is probable that the thickness of 130 feet given by Barnes and Bell (1954) is nearer the average thickness in the central Bluff Creek area.

The lower part of the Point Peak shale member consists of green to grey calcareous shales with ledges of siltstone, limestone, and intraformational shingle conglomerate. The beds in this part of the member are thin and few exceed a thickness of 6 inches. The upper or stromatolitic bioherm zone of the Point Peak member consists of grey sub-lithographic limestones of the bioherm masses and some bedded limestone and shales which occur between the bioherm structures.

San Saba Limestone

The San Saba limestone is the uppermost member of the Wilberns

PLATE V

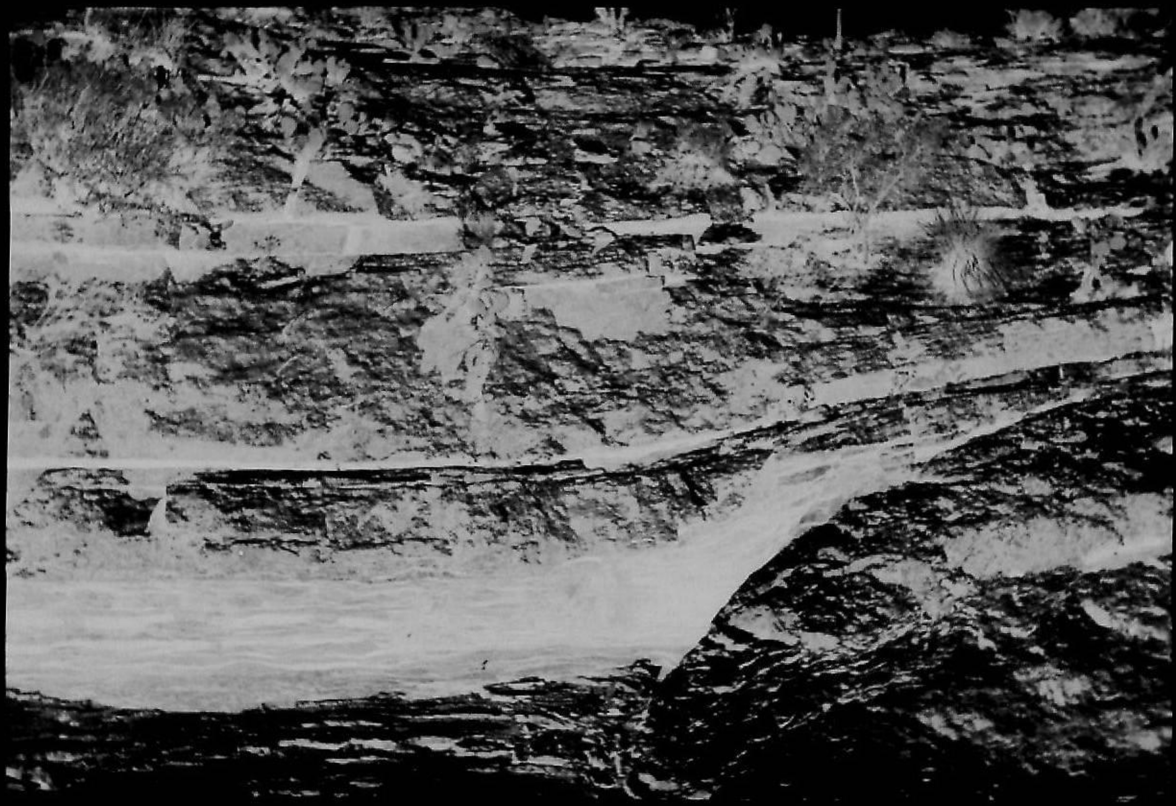


Figure 1. Contact of bedded limestones with stromatolitic bioherm exposed in the bank of the west branch of Bluff Creek

formation and represents the youngest Cambrian deposits in the central Bluff Creek area. At the type locality in McCulloch County the San Saba member consists of about 280 feet of medium-to-coarse-grained limestones with several sandy zones.

In the central Bluff Creek area the outcrop of the San Saba limestone covers a large area. It directly underlies the limestones and dolomites of the Ellenburger group and it is quite similar to these formations on the outcrop. The vegetation on the San Saba is generally more dense than that found on the limestones of the lower Ellenburger. Rocks of both of these units form hills and ridges in the thesis area with the topography controlled by structure and drainage. The outcrop of the San Saba is often almost bare of soil and consists of exposed ledges of the limestone. An exception to this exists in the northwestern part of the thesis area where the pre-Cretaceous plain has not been cut by erosion and a thick layer of soil is present.

The lower contact of the San Saba member is placed at the top of the stromatolic zone of the Point Peak member, the bedded limestones directly overlying the bioherms being taken as basal San Saba. This boundary is generally well exposed, but the bioherms occur at different elevations in the section and the bedded limestones are interbedded with and draped over them; consequently the contact is difficult to determine and to map. Where bedded limestones and bioherms were thus intermingled, both were included in the upper Point Peak.

The upper contact of the San Saba member of the Wilberns formation with rocks of the Ellenburger limestone is grational. The boundary mapped in this report was picked on lithologic differences. The presence of glauconite in the coarse-or-medium-grained limestones of the San Saba and its absence in the extremely fine grained to sublithographic limestones of the lower Ellenburger was used to select this contact.

The range in thickness of the San Saba limestone given by Barnes and Bell (1954) is 221 to 299 feet, with an average thickness of 270 feet. Thicknesses of 190 to 175 feet were measured by Alexander (1952) in the vicinity of the town of Mason.

The San Saba member is for the most part a coarse-to-medium-grained, sometimes glauconitic limestone. The limestone beds vary in thickness from several inches to more than a foot, the average thickness being 6 to 10 inches. Zones of tan to grey-brown, fine grained dolomite occur in the member. Also found within the limestones are zones of calcareous sandstones. One of these sandy zones is well exposed on the western branch of Bluff Creek where the sandstone is brick red in color and very calcareous.

ORDOVICIAN SYSTEM

The Ordovician rocks found in the central Bluff Creek area are part of the Ellenburger group of early Ordovician Age. The Ellenburger group has been divided into three formations; the Tanyard, the Gorman, and the Honeycut. In this report no attempt has been made to map the individual formations of the Ellenburger as this would involve concentrated stratigraphic studies.

Ellenburger Group

The term Ellenburger was originally used by Paige (1911) for the limestones making up the Ellenburger Hills in southeastern San Saba County. The term is now used as a group name to include all of the limestones and dolomites of Lower Ordovician age outcropping in Central Texas. The non-truncated average thickness given by Barnes and Bell (1954) is 1739 feet.

Outcrops of Ellenburger rocks cover a large area in the southern and western portions of the central Bluff Creek area. The outcrop is often expressed by a flat soil-covered plateau with displaced limestone slabs or dolomite blocks scattered on the surface. In areas where this plateau has been cut by erosion the Ellenburger forms rounded, rather bold hills. Vegetation on the Ellenburger outcrop is generally less abundant than on the underlying Wilberns or the overlying Carboniferous. The typical Ellenburger topography and vegetation are shown in Plate VI.

PLATE VI

Figure 1. Typical Ellenburger topography shown looking east from a point about one-half mile west of the Bill Hofmann ranch house

The lower contact of the Ellenburger group with the San Saba member of the Wilberns formation is gradational and is quite difficult to locate accurately. The boundary mapped in this report is picked on lithologic differences. The coarser texture of the San Saba limestones and the presence of glauconite in the lower formation are used to establish this contact. The upper contact of the Ellenburger rocks with the Chappel formation of Mississippian Age is rarely exposed in the thesis area. This boundary is unconformable and where it is exposed is easily located. Where the rocks are not exposed a very heavy growth of vegetation on the outcrops of the Mississippian rocks enables the upper limit of the Ellenburger to be established with ease.

The thickness of the Ellenburger along the Llano River several miles southeast of the thesis area was found by Cloud and Barnes (1948) to be 970 feet. This includes rocks of the Tanyard and Gorman formations, but no rocks of the Honeycut formation are known in this vicinity.

The limestones of the Ellenburger are usually very pure and range in color from light grey to ivory. They are very fine grained to sub-lithographic and are non-glauconitic throughout. The beds are variable in thickness, ranging from less than an inch to more than a foot. The dolomites found in the group are medium grained light grey to light tan in color and usually appear on the outcrop in irregular masses which have a brecciated appearance on the weathered surface. White to caramel colored chert is commonly found embedded in the dolomite beds.

MISSISSIPPIAN SERIES

Rocks belonging to the Chappel and Barnett formations are found in the southern part of the thesis area. Faulting has placed a wedge of these younger rocks in the area of Ellenburger outcrop just west of Bluff Creek.

Chappel Formation

The Chappel formation in central Texas consists of several inches to as much as 50 feet of crinoidal limestone. In the central Bluff Creek area the Chappel is found in a very narrow band surrounding the downthrown fault block of Carboniferous strata. The band is evidently quite thin and probably discontinuous. The outcrop is often completely covered by soil and debris from beds higher on the slope and must be mapped from scattered exposures. Because good exposures are lacking the exact thickness of the formation in this area is undetermined, but probably does not exceed 5 feet.

The Chappel limestone found in this study consists of rosy pink to dull red, medium grained limestones with contrasting white crinoid fragments. It is distinguished from the Marble Falls limestones by the red color and the smaller size of the crinoid stems present.

Barnett Formation

The Barnett formation is described as a black shale with siltstone and crinoidal limestone ledges. On the outcrop in Central Texas it averages about 35 feet in thickness.

In the thesis area the Barnett formation is mapped on a zone of dense mesquite vegetation and black soil which overlies the red crinoidal limestones of the Chappel. The zone is about 150 feet wide on the outcrop and is located on a rather steep slope.

The local thickness of the Barnett formation is estimated to be about 30 feet. Because of lack of exposure the lithology is doubtful but is assumed to be black shale which weathers to produce the soil found on the outcrop. Fragments of tan and grey siltstone are commonly found associated with the Barnett zone and may represent the siltstone beds of this formation.

PENNSYLVANIAN SERIES

Rocks of the Marble Falls group of lower Pennsylvanian Age are the youngest Paleozoic strata found in the central Bluff area.

Marble Falls Group

Plummer (1950), Sellards (1933) and others have used the term Marble Falls as a group name to include the Pennsylvanian beds in Central Texas below the Smithwick formation. The Marble Falls group is divided into the Sloan and Big Saline formations. The upper formation, the Big Saline, and the overlying Smithwick formation are considered by the above authors to make up the Bend series.

Cheney (1940) proposed several changes in the nomenclature of the

Pennsylvanian units in Central Texas. He proposed the name Lampasas as a series name to replace the term Bend. Cheney gave group status to the Smithwick and Big Saline formations and called these two groups the Lampasas series. The rocks below the Big Saline he placed in the Marble Falls group of the Morrow series.

The terminology of Plummer which considered the Marble Falls group to consist of the Sloan and Big Saline formations, is used in this report. The Sloan formation is possibly absent in the thesis area and no effort has been made to divide the beds of Marble Falls actually found in the area.

The Marble Falls outcrops in the central Bluff Creek area are found overlying the Barnett formation on the down-dropped fault block mentioned previously. The surface on the outcrop is often quite rugged, with rather dense vegetation. The lower contact is placed at the top of the density vegetated zone of the Barnett formation which is easily picked on the aerial photograph and on the ground.

The entire thickness of the Marble Falls group is not present in the thesis area. The lower portion, including most or all of the Sloan formation, is probably absent in this area as is the case on Big Saline Creek in Kimble County. The upper portion of the Big Saline formation is missing due to erosion. The total thickness of Marble Falls found in the area mapped is probably in excess of 200 feet but does not approach the maximum thickness in the Llano region of 400 feet noted by Plummer (1950).

The Marble Falls group is represented in the central Bluff Creek area by steel grey to dark grey, siliceous, hard, fine grained limestones. The beds range in thickness from several inches to several feet. Included in the limestones are beds of bluish grey and black chert which weather to a light grey or tan color. The beds are often very fossiliferous and crinoid fragments were noted throughout the section. A zone of abundant Chaetetes was noted near the top of the section of Marble Falls rocks found in the area.

MESOZOIC (?) SYSTEMS

Rocks which are probably Mesozoic in age were noted in a spot about one mile northwest of the Carter ranch house. The particular rocks found in this exposure are overlying the Lion Mountain sandstone. The rock is an arkose conglomerate with very hard, siliceous, hematitic cement. The pebbles in the material are mostly pink microcline with some quartz. The pebbles average less than .5 centimeters in diameter, but some quartzite fragments with dimensions up to 6 inches were observed.

The beds of arkose are more than 20 feet thick and were found only in this one location in the thesis area. Dr. H. R. Blank has noted similar exposures of this type of rock along the upper portion of Bluff Creek north of the Mason-Junction highway. At both locations the "Mesozoic arkose" is found to rest on the Lion Mountain sandstone. Dr. Blank has suggested that the cementing material for this arkose conglomerate is a product of weathering which occurred on the outcrop of the Lion Mountain sandstone on the pre-Cretaceous peneplain. Another outcrop of rock similar to this was noted by Mr. C. L. Seward and Dr. T. J. Parker about five miles west of the thesis area, but no investigation of this exposure has been made to date.

To the north and west of the small area covered by the "Mesozoic arkose" in the thesis area is a broad plateau with an abundance of red sandy soil. This sand is possibly the remnants of the Hensell sand of Cretaceous age, which is the lowermost Cretaceous formation found in this region. The "Mesozoic arkose" and the sandy soil are both found at high elevations which may perhaps represent position of the Paleozoic-Cretaceous unconformity in this area.

STRUCTURAL GEOLOGY

GENERAL STATEMENT

Regional Structure

The Llano uplift is a broad structural dome in which according to the prevailing geological interpretation the pre-Cambrian basement rocks have been raised as much as 7000 feet. The doming affected an area over 100 miles in diameter. Since the area was uplifted erosion has removed the Paleozoic and later sediments over the center of the dome and exposed the pre-Cambrian core over a large area. Surrounding this core of crystalline rocks are bands of younger sedimentary rocks of Paleozoic and Mesozoic ages.

The two main periods of structural deformation in the Llano region were in pre-Cambrian and Pennsylvanian times. There have been several other periods in geologic history when subsidence or uplift occurred in this area, but it was during these times that the most obvious and pronounced deformation took place.

Very little information is available concerning the deformation of pre-Cambrian rocks which took place before the beginning of the Paleozoic era. From the degrees of metamorphism of the pre-Cambrian gneisses and schists it must be assumed that these rocks have been affected by compressive forces of great magnitude. Very tight folds of various sizes are common in the pre-Cambrian rocks. These folds often plunge at a high angle and cannot be easily traced for any great distance. The folds noted in the pre-Cambrian rocks are predominantly aligned in the northwest-southeast quadrants.

The granitic intrusions which occurred at several different times before the beginning of the Paleozoic era served to further complicate the pre-Cambrian structure. This complex basement is separated from the younger Paleozoic rocks by a very extensive unconformity, and the trends of pre-Cambrian deformation are not reflected in the Paleozoic and younger rocks.

The Pennsylvanian deformation, which has produced the regional uplift, is believed by Cheney (1941) to have occurred after Lampasas time and before deposition of the Canyon series. Some evidence of shallowing of the Mississippian sea in the Llano area is provided by the thinning of the Barnett formation in this area. It seems probable that some slight uplifting of the area may have begun as early as Mississippian time, but the presence of rocks of the Lampasas series in the area of uplift indicates that the area remained low enough to collect sediments as late as Pennsylvanian time.

Aside from the dome itself, the most prominent structural features of Pennsylvanian age to be found in the Llano region are the large normal faults. These faults have been noted principally on the north side of the uplift where their strike is in a general northeast direction. They divide the northern part of the area of uplift into several large horsts and grabens. Cheney (1941) has referred to the horsts as the Richland Springs, Pontotoc, San Saba, and Lampasas axes after the most prominent town located on each of the uplifted blocks.

Regional folding of the rocks of the Llano area has been recognized principally on the flanks of the uplift where several broad anticlines are found to radiate from the dome. The Bend, Concho, San Marcos, and Edwards arches are the most prominent of the radiating anticlines. Plummer (1951) recognized the presence of some additional regional folds in the Paleozoic sediments, but no detailed study of these features has been published.

Minor Structures

The local structures of the Llano region were divided by Plummer (1940) into seven classes. The seven structural types are spur ridges, normal faults, grabens, buried ridges, sharp flexures, symmetrical anticlines, and reef masses. All of these local structural movements occurred, according to Plummer, during or since the Carboniferous. Several of the above mentioned types of structures are found in the central Bluff Creek area and will be considered in some detail.

LOCAL STRUCTURE

Folding

In the central Bluff Creek area the outcrop of the upper contact of the Hickory sandstone forms a "U" shaped pattern on the map. As may be seen on the structure map (Plate I) the "U" of the outcrop is oriented in the northeast-southwest quadrants with the open end of the "U" to the northeast. Though this contact is in some places normal and in other places a fault contact, it is generally found in the thesis area at a rather constant elevation and is therefore little affected by topography and represents the general strike of the beds. The shape of the outcrop pattern, along with the presence of older beds within the "U" formed by the outcrop, suggests a fold plunging to the southwest away from the center of uplift.

The many strike and dip measurements taken in the area substantiate the idea of an anticline plunging to the southwest. Throughout the thesis area the strikes of the Paleozoic beds approximately parallel the Hickory-Cap Mountain contact as shown on Plate I. The trend lines which were drawn from the strike and dip data attempt to show the strike of the formations where no geologic horizon can be satisfactorily traced due to faulting. These trend lines also show the "U" pattern oriented in about the same position as the "U" of the contact mentioned above.

The strike and dip measurements taken in the thesis area are somewhat erratic, due probably in large part to the intense faulting in the area. Nevertheless, the majority of the dips measured show the strata to be dipping outward from the interior of the suggested fold. In general, the strikes swing gradually counterclockwise from northeast in the northwestern portion of the thesis area through northwest in the central part to southwest in the southeastern part.

The axis of the proposed fold cannot be definitely and accurately located due to the interruption of the structure by the many faults. There is some indication from the strike measurements recorded on the map and the trend lines drawn from these measurements that the fold was not a single symmetrical anticline even before the effect of faulting was superimposed upon it. The presence of several small folds or "wrinkles" on the larger fold is suggested by the irregular shapes of the trend lines. It is not improbable that the broad fold consisted of several smaller flexures; however, the minor changes in the strikes of the beds which suggest this may be explained as the effect of tilted blocks caused by faulting.

The angle of dip on the northwest flank of the proposed fold is probably slightly less than on the southeast side. Dips on the order of 4 or 5 degrees are most common on the northwest side of the anticline while dips on the southeast side range from 4 to 10 degrees. The position of the thesis area relative to the center of the regional uplift presumably would give the strata a northwest strike with a southwest dip. If on this original attitude a fold whose axis was oriented more than 45° east of north were superimposed, the dips produced on the limbs of the resulting anticline should be similar to those found in the field. The dips on the southern flank of the fold would reinforce the original dip and cause a steepening of the dip to the southeast. On the opposite flank the dips of the fold would be opposing the original dip and the result would be lesser dips to the northwest. As the dips found in the thesis area are generally steeper on the southeast flank of the structure than on the opposite limb, it is suggested that the axis of the proposed fold is located in the east northeast octant.

FAULTING

Perhaps the most obvious structural phenomena observed in the central Bluff Creek area are the numerous faults.

The fault planes observed in the field rarely vary more than 15° from the vertical. Figures 1 and 2, Plate VII show several small faults and joints which are parallelling larger displacements and have almost vertical fault planes. All of the inclined faults have the hanging wall down-thrown and may be considered normal faults. Many of the observed fault planes, however, are actually vertical and the terms normal or gravity are in these cases meaningless. Because all of the faults obviously have a common origin the terms normal or gravity will be used to refer to all of the faults within the thesis area.

The throws on a few of the faults shown on the detailed map of a part of the thesis area range up to about 1000 feet. Most of the faults, however, have vertical displacements of less than 50 feet. Many still smaller faults with displacements of several inches to several feet are present in the areas between the faults actually mapped. These small faults as well as the many joints in the area generally follow the trends of the larger faults. The direction of displacement is inconsistent from one fault to the next and many small horsts and grabens are formed

PLATE VII

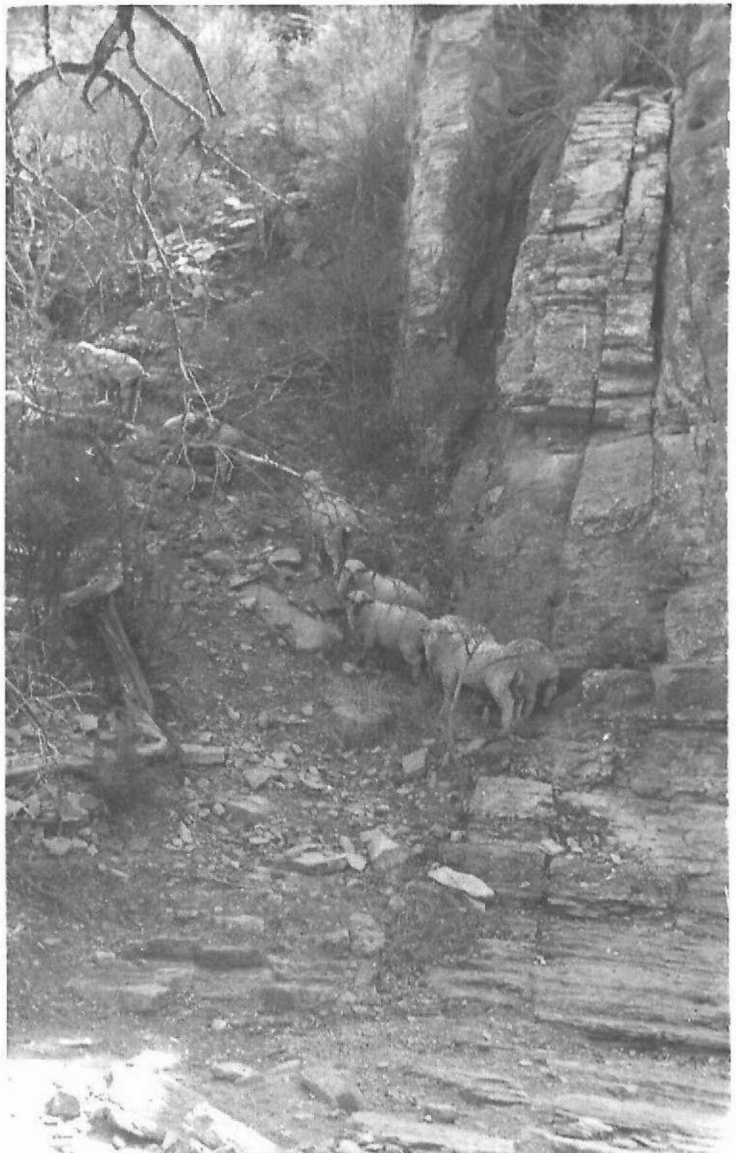


Figure 1. Steeply dipping faults and joints in Ellenburger limestone along the west branch of Bluff Creek

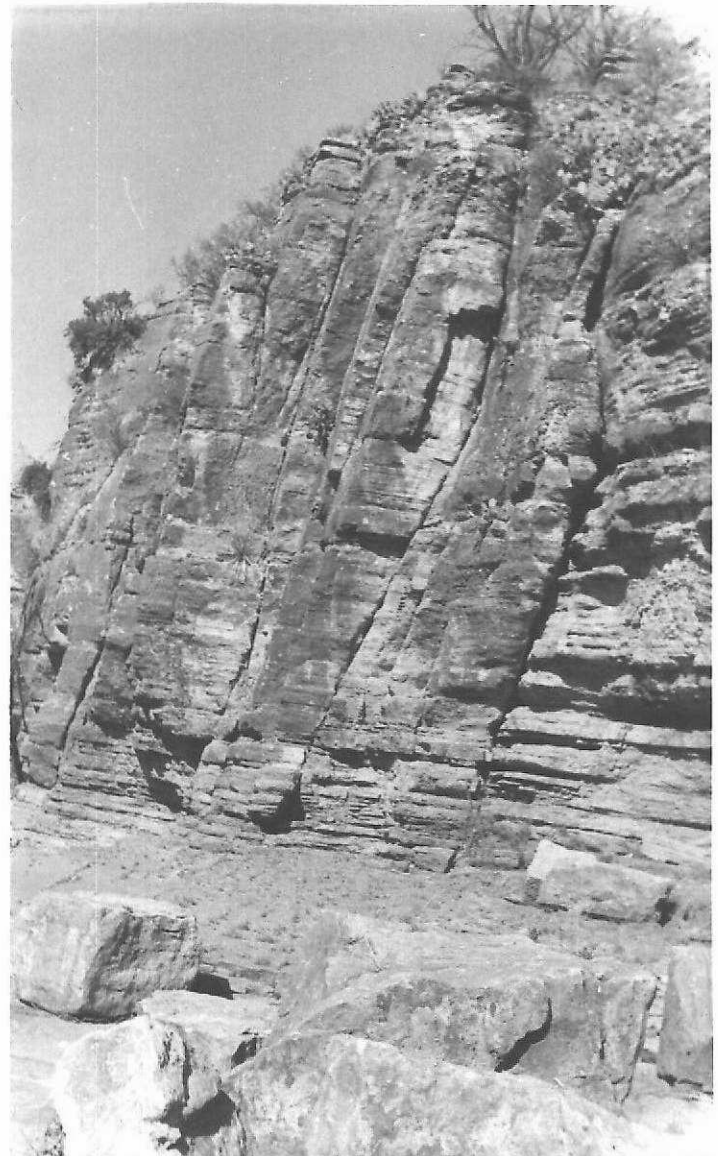


Figure 2. Faults and joints in the San Saba limestone about one-half mile south of the Bill Hofmann ranch house

throughout the area.

The disturbed zones adjoining the faults vary in width and in degree of disturbance. It is common for a large fault to divide into several smaller ones, forming a fault zone rather than one sharp break. In these zones, where the displacement is distributed among the several faults, small slivers have been dropped down by gravity below the final position of the major down-thrown block. The formation of these "sliver grabens" is indicative of tension in the surface rocks as a cause of the faulting. Tilted blocks between faults are present in several places. Dips on the tilted blocks are often quite steep. Dips approaching 25° were measured over a relatively large area on one of these tilted blocks. Figure 1, Plate VIII, shows some of the steeply dipping beds along a small fault in this disturbed block on the west branch of Bluff Creek. This tilting is also responsible for varying the strike of the beds, as is demonstrated along the McMillan ranch road in the western portion of the thesis area. The drag of the beds along fault planes was noted in several places. The actual bending of the beds is in most cases, however, restricted to a narrow zone along the fault and is in many cases entirely absent. The deformation which may actually be termed drag does not along any of the faults studied extend more than 15 feet horizontally from the plane of the fault. Figure 2, Plate VIII, shows beds along a small fault which are relatively undisturbed along a clean break.

Zones of fault breccia are common along the faults and in many cases include boulders of large size. Blocks with dimensions up to 4 feet are found in several places cemented in the material along a

PLATE VIII

Figure 1. Small fault in a tilted fault block on the west branch of Bluff Creek about one-half mile from the Jack Hofmann ranch house

Figure 2. Beds of Cap Mountain limestone displaying a clean break along a fault near the location shown in Figure 1.

fault plane. Slickensides were not present along any of the faults observed in the thesis area.

The majority of the faults mapped are aligned in the northeast quadrant. Less numerous are a series of northwest-striking faults which are approximately perpendicular to the first set. The northeast faults are practically parallel throughout the thesis area and show only slight convergence to the southwest. Most of these northeast faults can be traced on the ground and on the aerial photograph from the Hickory sandstone outcrop in the northeastern part of the detailed map to the Ellenburger outcrop in the southwestern portion. No attempt has been made to trace the smaller faults into the areas of Hickory and Ellenburger outcrops. The approximately parallel alignment of the northeast faults and their random displacement form many small grabens and horsts trending northeast across the thesis area.

The less numerous northwest-striking faults are generally found to lie between the more prominent northeast faults. These northwest faults are most common in the central portion of the area mapped in detail and in almost all cases are found to be downthrown to the southwest. The effect of these faults is usually to shorten the section by faulting out one or more of the geologic horizons mapped in this area. Where these faults trend approximately parallel to the strike of the formations they are very difficult to locate on the ground and are often evidenced only by an incomplete section.

From the description of the faults and their alignment it seems probable that they have been produced by tensional forces simultaneously applied in two perpendicular directions. Neither of the two almost perpendicular sets of faults is definitely shown to offset the other so movement is believed to have occurred simultaneously. The tensional character of the forces involved is indicated by the presence of normal faults and specifically by the presence of the "sliver grabens" mentioned previously.

The zone of most intense faulting is located over the crest of the fold proposed previously. Direct connection between the folding and faulting is possible and furnishes a reasonable explanation for the concentration of minor faults in this area. The faults are so aligned as to be considered almost parallel to the axis of the anticline in the case of the northeast faults and transverse or peripheral in the case of the northwest faults. Both of these types of faults are known to be associated with plunging anticlinal structures. Stretching of the beds over the uplifted ridge could cause the tension normal to the axis of the fold necessary to produce normal faults paralleling the axis of uplift and account for the northeast fault set. The bending of the axis of the structure resulting from maximum uplift to the northeast and minimum uplift to the southwest could be responsible for the northwest faults, which are downthrown to the southwest away from the plunging nose of the anticline.

It is the writer's belief that the local structure of the central Bluff Creek area consists of an anticline plunging to the southwest which has produced an area of intense faulting over its crest. It is possible that this feature is the southern extension of the Richland

Springs axis, Cheney (1941)

Age of Deformation

The faulting and folding described above affect all of the geologic formations present in the thesis area with the possible exception of the Mesozoic (?) arkose. Definite dating of the structural movements from local evidence is therefore impossible. The youngest formation definitely known to be cut by the faults in the central Bluff Creek area is the Marble Falls limestone of Bend age. The only positive evidence available locally is that the structure was formed after deposition of the Marble Falls group.

The trend of the local structure coincides closely with the regional trends of major Paleozoic deformation which have been dated by several authors. It is logical to assume that the local uplift occurred as a part of and simultaneously with the regional deformation. This places the age of the structure as post-Bend and pre-Canyon.

Speculation as to Causes of Structure

In considering the ultimate cause of the structure found in the thesis area consideration will be given to three possible explanations, horizontal compression, settling or compaction, and basement uplift. The first of these, horizontal compression, could produce the fold as noted in the thesis area; however, if these compressive forces were present in the sedimentary rocks near the surface the formation of normal or tension faults would be unlikely. Only if the compression were deep-seated and were not transmitted to the near-surface rocks, could the fold form with the fault patterns observed.

Settling or compaction of the sedimentary rocks over a ridge on the pre-Cambrian surface could possible produce an anticline of the type noted in the central Bluff Creek area. The intense faulting in the area, however, points to a more dynamic origin for the structure. It is hard to visualize faults of the type and magnitude found in the thesis area caused by compaction. Also, the presence of a sizable ridge on the pre-Cambrian surface would have caused distinct thinning if not actual absence of the Hickory sandstone over the axis of the structure. This thinning is not noted in the thesis area. If the faulting connected with the structure were due only to adjustments in the strata while settling and compaction were taking place the faults would not involve the pre-Cambrian basement which is the case in the area studied. There is little basis, therefore, for considering compaction as responsible for the structure present in the central Bluff Creek area.

Basement uplift, which is here considered to be local uplift of the basement rocks caused by deep-seated orogenic disturbances, is perhaps the best explanation of the structure observed. Northeast-trending zones of more positive uplift may have been present in the basement rocks during the Pennsylvanian deformation. These zones may be represented by the Richland Springs, Pontotoc, San Saba, and Lampasas axes and may be a result of the Ouachita orogeny. The presence of the proposed fold along the trend of the Richland Springs axis suggests that the fold is a product of the excessive uplift in this zone.

REFERENCES

Alexander, W. L. (1952) Geology of the South Mason Area, Texas, M.S. Thesis, Texas A. & M. College

Barnes, V. E. (1940) Pre-Cambrian of the Llano region with emphasis on tectonics and intrusives, Excursions 53rd annual meeting of the Geol. Soc. Am. and affiliated societies, December 26-28, 1940. pp. 44-49.

Barnes, V. E. and Bell, W. C. (1954) Cambrian rocks of Central Texas, San Angelo Geol. Soc. Cambrian field trip, March 19-20, 1954. pp 35-69.

Barnes, V. E. and Parkinson, G. A. (1939) Dreikanters from the basal Hickory sandstone of Central Texas, Univ. Texas Bull. 3945, pp. 665-670.

Bridge, Josiah and Barnes, V. E. (1941) Stratigraphy of the Upper Cambrian, Llano uplift, Texas Geol. Soc. Am., Bull., Vol. 58, pp. 1996.

Bridge, Josiah, Barnes, V. E. and Cloud, P. E., Jr. (1947) Stratigraphy of the Upper Cambrian, Llano uplift, Texas, Geol. Soc. Am. Bull. Vol. 58, pp. 109-124.

Cheney, M. G., Geology of North-Central Texas, Bull. Amer. Assoc. Petrol. Geol., Vol. 24, pp. 65-118.

Cheney, M. G. and Goso, L. F. (1952) Fictonics of Central Texas, Bull. Amer. Assoc. Petrol. Geol., Vol. 36, pp. 2237-2265.

Cloud, P. E., Jr., Barnes, V. E., and Bridge, Josiah. (1945) Stratigraphy of the Ellenburger group of central Texas - a progress report, Univ. Texas Pub. 4301, pp. 133-161.

Cloud, P. E., Jr., and Barnes V. E. (1948) The Ellenburger group of central Texas, Univ. Texas Pub. 4621, 473 pp. 8 fig. 45 pl.

Comstock, T. B. (1890) A preliminary report on the geology of the central Mineral region of Texas, Texas Geol. Survey, 1st An. Rept. (1899), pp. 235-391.

Darton, N. H., Stephenson, L. W., and Gardner, Julia (1937) Geologic Map of Texas, U. S. Geol. Survey

Hill, R. T. (1887) The Present condition of Knowledge of the geology of Texas, U. S. Geol. Survey, Bull., Vol. 45, 95 pp.

Jones, R. A. (1929) The Paleozoic of the Pedernales Valley in Gillespie and Blanco County, Texas, Univ. Texas Bull. 2901, pp. 95-130.

Paige, Sidney (1911) Mineral Resources of the Llano-Burnet region Texas, with an account of the Pre-Cambrian geology, U. S. Geol. Survey, Bull., Vol. 450, 103 pp., 22 fig., 5 plates, maps.

Paige, Sidney (1912) Description of the Llano-Burnett quadrangles, U. S. Geol. Survey, Geol. Atlas, Llano-Burnet folio No. 183, 16 pp.

Plummer, F. B., (1940) Paleozoic of the Llano region, Excursions 53rd annual meeting of the Geol. Soc. Am. and affiliated societies, December 26-28, 1940, pp. 56-65.

Plummer, F. B. (1943) A new quartz sand horizon in the Cambrian of Mason County, Texas, Univ. Texas, Bur. Econ. Geol., Min. res., Cir.22.

Plummer, F. B. (1950) The Camboniferous rocks of the Llano region of Central Texas, Univ. Texas Bull. 4329, 117 pp., 14 fig., 22 plates, 4 charts.

Roemer, Ferdinand (1846) A sketch of the Geology of Texas, Am. Jour. Sci. (2), Vol. 2, pp. 358-365.

Roemer, Ferdinand (1848) Contributions to the geology of Texas, Am. Jour. Sci. (2) Vol. 6, pp. 21-28.

Sellards, E. H. (1932) The pre-Paleozoic and Paleozoic systems in Texas, in the Geology of Texas, Vol. I, Stratigraphy, Univ. Texas Bull. 3232, pp. 15-238.

Sellards, E. H. (1934) Major Structural features of Texas east of Pecos River, Univ. Tex. Bull. 3401, pp. 11-136.

Stenzel, H. B. (1932) Pre-Cambrian of the Llano Uplift, Texas, Geol. Soc. Am. Bull., Vol. 43, pp. 143-144.

Stenzel, H. B. (1934) Pre-Cambrian structural conditions in the Llano region, Texas, Univ. Texas Bull. 3401, pp. 74-79.

Stenzel, H. B. (1935) Pre-Cambrian unconformities in the Llano region, Univ. Texas Bull. 3501, pp. 115 fig.

Udden, J. A., Baker, C. L., and Bose, Emile (1916) Review of the geology of Texas, Univ. Texas Pub. 44, 164 pp.

Van Der Gracht, W. A., J. M. van Waterschoot (1931) The Permo-Carboniferous orogeny in South-Central United States, Bull. Amer. Assoc. Petrol. Geol., Vol. 15, pp. 991-1057.

PLATE I

Base from U. S. Department of Agriculture, Soil Conservation Service, aerial photographs, 1948

Geology by F. R. Grote

Scale 1/20000

0 1/2 1 2 miles

GEOLOGIC STRUCTURE OF THE CENTRAL BLUFF CREEK AREA, MASON COUNTY, TEXAS

Carboniferous
- C — Carboniferous undifferentiated

Ordovician
- Oe — Ellenburger group

Cambrian
- Єmps — Morgan Creek, Point Peak, and San Saba members of the Wilberns formation
- Єclw — Cap Mountain and Lion Mountain members of the Riley formation and Welge member of the Wilberns formation
- Єh — Hickory member of the Riley formation

Pre-Cambrian
- pЄ — Pre-Cambrian metamorphic and igneous rocks

10°
N

Known fault

Inferred fault

U Upthrown side

D Downthrown side

Surfaced highway

Observed contacts

Graded road

Inferred contact

Unimproved trail

Boundary of area mapped in detail

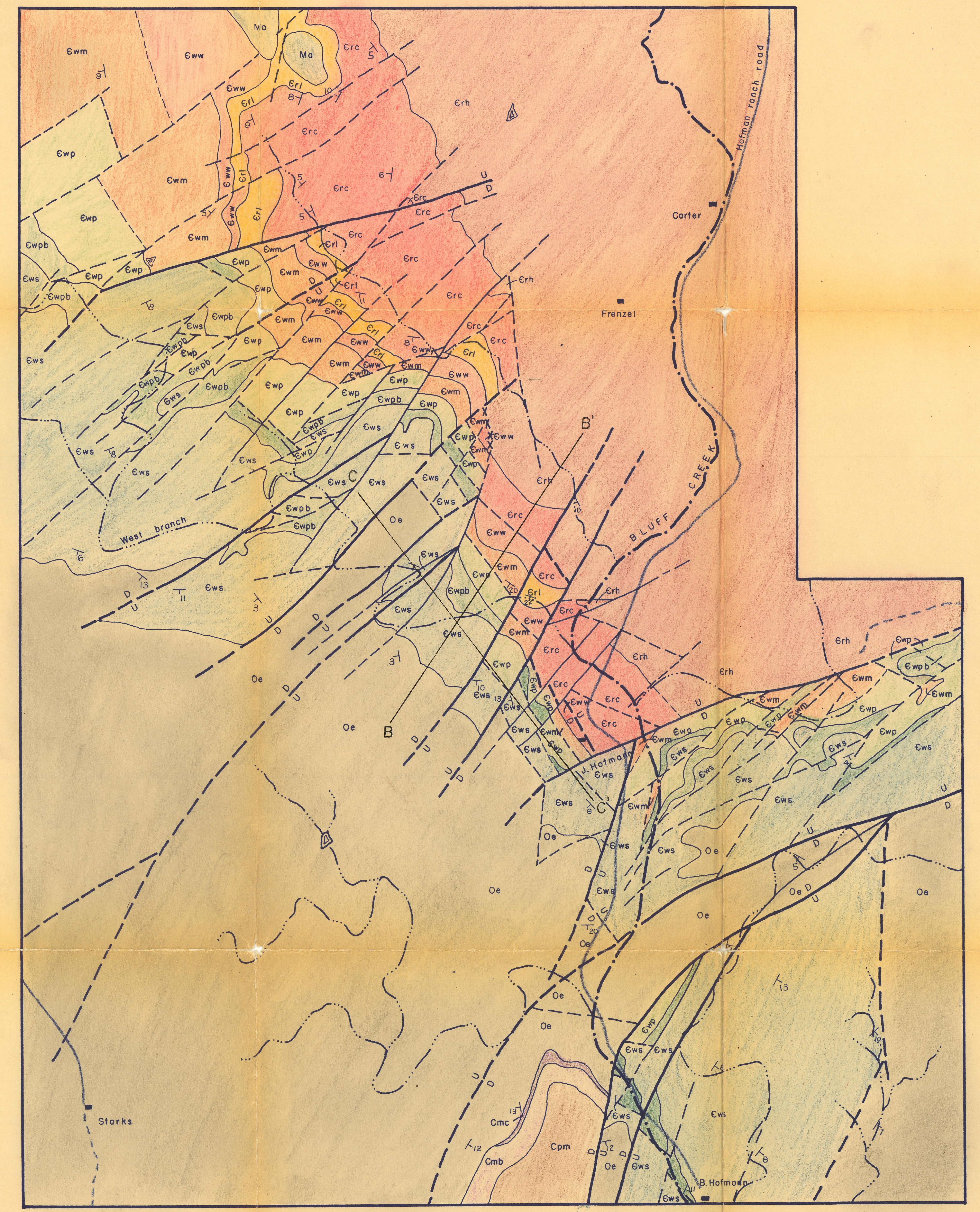
Tank

Strike and dip of the beds

Ranch house

Trend lines showing approximate strike of the beds

PLATE II



Base from U.S. Department of Agriculture, Soil Conservation Service, aerial photographs, 1948

Geology by F. R. Grote

Scale: 0, 1/4, 1/2, 1 mile

Scale about 1/10900

GEOLOGIC MAP OF A PORTION OF THE CENTRAL BLUFF CREEK AREA

Mesozoic(?)
- Ma — Mesozoic(?) arkose

Carboniferous
- Cpm — Marble Falls group
- Cmb — Barnett formation
- Cmc — Chappel formation

Ordovician
- Oe — Ellenburger group

Cambrian

Wilberns formation
- Ꞓws — San Saba member
- Ꞓwpb / Ꞓwp — Point Peak member (bioherm zone at top)
- Ꞓwm — Morgan Creek member
- Ꞓww — Welge member

Riley formation
- Ꞓrl — Lion Mountain member
- Ꞓrc — Cap Mountain member
- Ꞓrh — Hickory member

Fault zone

Known major fault

Inferred major fault

Known minor fault

Inferred minor fault

U Upthrown side

D Downthrown side

Observed contact

Inferred contact

Strike and dip of beds

Graded road

Unimproved trail

Tank

Ranch house

10° N