GEOLOGY OF THE FREDONIA AREA,

McCULLOCH, MASON, and SAN SABA COUNTIES, TEXAS

A Thesis

By

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ABSTRACT

The area mapped is in central Texas on the northwestern flank of the Llano Uplift and centers around Fredonia, including parts of Mason, McCulloch, and San Saba Counties. Rocks of the Pre-Cambrian, Upper Cambrian, and Ordovician were mapped in detail.

The Pre-Cambrian complex is composed of the Valley Springs gneiss, the Packsaddle schist, and intrusives. The first is a pink granite gneiss, the second is mostly a biotite schist, and the intrusions are mostly coarse-grained, pink granite.

The Upper Cambrian is subdivided into the Riley formation and the overlying Wilberns formation. The white, yellow, and red Hickory sandstones, the grey, sandy, glauconitic Cap Mountain limestones, and the glauconitic Lion Mountain sandstones and limestones make up the Riley formation. The members of the Wilberns formation are the yellow and red Welge sandstones, the white, crystalline, glauconitic Morgan Creek limestones, the green, calcareous shales of the lower Point Peak overlain by reef limestones, and the uppermost glauconitic San Saba limestones.

The Ellenburger group is the Ordovician deposit and consists of grey limestone and granular dolomite. Excluding Recent deposits, no beds younger than Ordovician are present in the Fredonia area.

The beds strike north to northeast and dip to the east. Normal faults, downthrown to the west, disrupt the strata over the entire Fredonia area. Displacement along most of the faults increases to the southwest until they are lost in the Hickory sandstone member. Folding

has also occurred forming broad synclines.

After deposition over the Llano area in Pre-Cambrian time igneous intrusions and metamorphism were followed by a period of uplift and erosion. The area was again covered by Upper Cambrian and Ordovician seas, and periods of transgression and regression ensued. In Mississippian and Pennsylvanian time the entire Llano area was domed causing the faulting and folding of the older Paleozoic beds. Later submergence of the entire Llano region resulted in the Cretaceous limestones. When this general area was again uplifted, the Cretaceous beds remained high because of their superior position and resistance to weathering while the older rocks were eroded. Thus erosion has developed a topographic basin while the structure is a dome.

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INTRODUCTION

The Fredonia area is located in central Texas approximately 150 miles northwest of Austin. Fredonia is in Mason County about twenty-three miles southeast of Brady near the junction of Farm Road 734 and Farm Road 386. (see Location Map, Plate I). This area measures six miles in a north-south direction and five miles in an east-west direction with Fredonia approximately in its center. The southern portion of the area is in Mason County, the northwestern part in McCulloch County, and the eastern part in San Saba County.

Method of Mapping

Field work was started in August, 1950, and completed after many short, irregular periods of mapping. The mapping was done on aerial photographs of the United States Department of Agriculture series CJC 16-98 to 16-103, CJC 51-143 to 51-148, and CJC 2-6 to 2-11, made in 1939 and 1940. These have a 1:20000 scale which is approximately three inches to one mile.

Many of the formational contacts were mapped on the photographs from the apparent changes in vegetation. Evidence of faulting was also shown by the abrupt offsetting of benches and hills or vegetation. A stereoscope was used to accurately note changes in topography and was useful in the detection of faults.

Physiography

Physiographically the Fredonia area is situated on the northwestern flank of the Llano Uplift. Topographically this uplift is now a basin, since it is surrounded on the east, south, and west by the higher, flat-lying formations of Lower Cretaceous age, the most prevalent being the Edwards limestone which forms the Edwards Plateau. To the north, beds of Mississippian and Pennsylvanian age are exposed as the overlying Cretaceous beds have been eroded. The area studied forms part of about 3500 square miles of Pre-Cambrian igneous and metamorphic rocks and tilted Paleozoic sediments which are exposed in the Llano region.

The general topography of the Fredonia area is not rugged but consists of rolling hills and shallow valleys. These have a linear, parallel arrangement from differential erosion which lowered the sandstone and shale and left the limestone beds as ridges. The ridges and valleys therefore parallel the strike of the beds. The maximum relief is about two hundred feet, while the average elevation is 1700 feet.

Drainage

This part of central Texas is drained by the Colorado River system. The San Saba River is its largest tributary locally and flows in a northeasterly direction about seven miles north of the Fredonia area. The smaller streams are tributaries to the San Saba River.

The majority of the smaller streams are intermittent, but a few are spring-fed and flow all year. The largest streams near Fredonia are Loafer Creek, flowing north in the western part of the area, and Lost Creek, which is located just north of the town and flows west into Loafer Creek. Loafer

Creek valley is in the Pre-Cambrian complex and is broad and covered with granite wash, while Lost Creek and other streams are in sedimentary rocks and occupy narrow and more V-shaped valleys.

Climate and Vegetation

The region is semi-arid, having a rainfall of approximately twenty inches a year. However, most of this is concentrated in spring and autumn rains. In 1950 and 1951 a severe drought has resulted from the decrease in rainfall to a few inches per year.

The vegetation consists of cedar, oak, mesquite, cacti, and grass, with the latter making the area good for pasture lands. The mesquite and live oak help in mapping, for the mesquite grows almost entirely on soil from the more sandy members while the live oak generally grows on the limey soils. On aerial photographs the scattered mesquite appears as lighter areas than the oaks.

STRATIGRAPHY

The age of the rocks in the Llano Uplift ranges from Pre-Cambrian to Recent. However, only Pre-Cambrian, Cambrian, Ordovician, and Recent rocks occur within the confines of the area mapped. The sequence of formations and members or geologic units present is:

Recent

Ordovician system

Ellenburger group

Cambrian system

Wilberns formation

San Saba limestone member

Point Peak shale member

Morgan Creek limestone member

Welge sandstone member

Riley formation

Lion Mountain sandstone member

Cap Mountain limestone member

Hickory sandstone member

Pre-Cambrian

Granite intrusives

Valley Springs gneiss

Packsaddle schist

Pre-Cambrian

The Pre-Cambrian complex is composed of the Packsaddle schist, the Valley Springs gneiss, and intrusions of granite. The Packsaddle schist and the Valley Springs gneiss were named in 1889 by Comstock (10) and later redefined by Sidney Paige (15). Paige states that the Valley Springs gneiss is older than the Packsaddle schist, but the writer is more in favor of Stenzel's interpretation (19) of the schists being the oldest rock present with the granite injected into them and forming layers of gneiss. The interbedded arrangement of the schist and gneiss within the Fredonia area would be more indicative of such an origin.

The Packsaddle schist and Valley Springs gneiss were mapped as one unit because of their interbedded nature. By far the greatest part of the Pre-Cambrian complex in the Fredonia area is the gneiss. Only a small part is granite, and this lies in the extreme southwest. However, just west of the area mapped large masses of granite occur.

Packsaddle Schist

The Packsaddle schist is composed of grey to black, biotite and biotite-hornblende schists which weather brown to black; a few dull, grey-green chlorite schists are present. A few thin beds of grey, crystalline marble less than two inches thick were also found at one locality. Between some of the beds were very thin streaks of pink feldspar which probably were injected from the large granitic mass to the west.

Valley Springs Gneiss

The Valley Springs gneiss is a pink, granitic gneiss ranging from fine to coarse-grained and occuring in beds of variable thickness which generally weather pink and grey to black. The beds are composed chiefly of pink feldspar, with biotite, hornblende, and quartz present as accessory minerals. A few of the gneisses have augen-structure with pink feldspar as the largest grains. One layer of pink feldspar gneiss has small octahedrons of magnetite present.

Intrusives

Almost all the intrusive rocks are granites, although one out-crop of medium-granied, green and white diorite was observed in the northwest part of the Fredonia area. The granites are pink, fine-grained and coarse-grained and weather to a dull grey color. The finer-grained granites are composed almost entirely of pink feldspar and grey quartz. The coarser-grained variety, although containing small percentages of quartz, plagioclase, and biotite, is composed mostly of pink feldspar grains, probably microcline, up to one-half an inch in size. These larger grains dot the exposed rock and cause a very rough weathered surface. It appears that after chemical weathering of the plagioclase and biotite the smaller quartz grains on the exposed surface are mechanically weathered out and leave the resistant pink feldspar.

Several quartz veins ranging up to one foot thick were found in the metamorphic rocks; one contains large grains of pink feldspar. A pegmatite dike of graphic grainite was located in which the flesh-pink feldspar contained grey, striated quartz one inch long and one-eighth of an inch long.

Cambrian

Rocks of Lower and Middle Cambrian age are absent, thus the youngest Paleozoic beds are the Upper Cambrian sediments. These are represented by the Riley and Wilberns formations.

The name Riley was first used in the Riley series as described in 1889 by T. B. Comstock (10), and is from the Riley Mountains in Llano County. This rock unit totaling 300-4000 feet included the upper beds of the present day Hickory sandstone and also the Cap Mountain limestone member. This same author proposed the name Hickory series for the beds beneath the Riley series. However, Sidney Paige (15) in 1911 showed the Hickory beds to be actually part of the Riley series. Paige proposed the name Cap Mountain formation (16) for the limestone beds overlying the Hickory. In 1937 Bridge (3) named the Lion Mountain sandstone member of the Cap Mountain formation. Then the name Riley formation was introduced by Cloud, Barnes, and Bridge (5) and includes rocks known as Hickory, Cap Mountain and Lion Mountain. These units are now designated as members of the Riley formation, which is immediately above the Pre-Cambrian and overlain by the Wilberns formation. The total thickness of the Riley formation is about 630 feet in the Fredonia area.

The Wilberns formation was named by Paige (15) in 1911 and included all the Cambrian rocks above the Riley series and below the Ellenburger group. The name was chosen from Wilberns Glen, Llano County, Texas. Barnes (5) subdivided this formation into the Welge sandstone, the Morgan Creek limestone, the Point Peak shale and the San Saba limestone members. The Pedernales dolomite member is equivalent to the San Saba limestone but is absent in this area. Comstock used the names Katemcy series, Leon series, and San Saba series for the present Wilberns formation. The Katemcy included the present Welge, Morgan Creek, and Point Peak members while the Leon and San Saba series included beds that later were found to be Ordovician in age. The Wilberns formation totals approximately 700 feet in thickness, thus making the Upper Cambrian 1330 feet in the Fredonia area.

Riley Formation

Hickory Sandstone Member

At the base of the Hickory is a white to yellow, coarse conglomerate, composed of pebbles of quartz from one-eighth of an inch up to two inches in diameter cemented together by a combination of iron oxide and silica. Above this is a zone of white, yellow, and brown, fine- to coarse-grained sandstones. However, the main part of this member is composed of red to dark-brown to purple, fine- to coarse-grained, friable, ferruginous sandstone which generally occurs in beds one foot thick although some are more massively bedded. Many of the sandstones are fractured and have veinlets of quartz in them. Thin siltstones and shale occur at the old high school on Farm Road 386 south of Fredonia. Occasional phosphatic brachiopod shells are present in the upper Hickory beds, but most of the beds are not fossiliferous. At the top of this member is a fifteen to twenty foot section of dark red-brown, medium-grained sandstone with much oolitic hematite and a few brachiopod shells. This is the transitional zone between the Hickory and the overlying Cap Mountain member. These upper beds weather to a bright red soil and may easily be identified. In the Fredonia area the thickness of the Hickory member varies between 220 and 440 feet because it was deposited on a very irregular surface, but the average thickness is about 340 feet. Since no continuous exposure was available for exact measurement, the thickness was determined from the width of surface exposure and the dip angle. The thickness of the other members was determined in a like manner. Topographically the Hickory sandstone member forms a wide, flat lowland generally under cultivation.

A few hills in the northeast corner of this area are Hickory, but these are the result of faulting.

Cap Mountain Limestone Member

The Cap Mountain limestone conformably overlies the Hickory, the dividing line being drawn where the calcium carbonate exceeds the sand. On aerial photographs this contact may be picked by both a vegetational and a topographic break. The lower beds are a fine-grained, dull red to light brown, calcareous sandstone and weather with a dark grey or black coating. Upwards are found fine-grained, speckled, grey-brown, slightly glauconitic limestones with yellow streaks and some brown, laminated sandy limestones which weather a light red to brown to black. Some of the beds contain brachiopod shells, and small clusters of calcite and calcite seams are present in many. The thickness of the individual beds ranges from one inch to several feet. The overall thickness of this member is 260 feet.

A short but well-exposed section of the Cap Mountain member was measured 250 yards north of Farm Road 386 about 1.2 miles east of Fredonia.

Cap Mountain limestone member

13. Limestone- red to grey, sandy, thin-bedded, laminated; some coarsely crystalline with white clusters of calcite; weathers a grey-tan . . . . 8'10"

12. Limestone- brown to purple, medium-grained, glauconitic; weathers tan . . . . 1'

11. Limestone- grey to purple, sandy, weathers tan to black 2'7"

10. Limestone- grey to brown, laminated, fine-grained; weathers grey . . . . 1'4"

9. Limestone- red to brown and white, medium-grained, glauconitic; weathers a dark red . . . . 7"

8. Limestone- reddish-grey, very fine-grained, sandy, laminated, flaggy, slightly glauconitic; weathers grey and red . . . . 5'2"

7. Limestone- grey, sandy, thick-bedded, friable, glauconitic, occasionally laminated; weathers grey-tan . . . . . 5'8"

6. Limestone- grey-green, sandy, laminated, glauconitic . . 2'

5. Limestone- grey, laminated, fine-grained, slightly sandy; weathers black to grey . . . . 1'

4. Limestone- dark-grey to purplish-brown, sandy, fine-grained, friable, glauconitic . . . . 4'9"

3. Limestone- tan, very fine-grained, sandy, glauconitic, weathers grey-tan . . . . 1'2"

2. Limestone- dark grey to light purple, glauconitic; weathers brown . . . . 8"

1. Limestone- grey-green, crystalline, limonitic-stained, weathers reddish-grey . . . . 1'5"

Total thickness . . . . 34'4"

(Locally units 4 through 7 grade into one massive unit.)

Topographically the Cap Mountain is found as a series of hills, for the limestone is durable in comparison with the overlying and underlying sandstone members. The isolated outcrop in the southern part of the area is a small hill capped by this limestone.

Lion Mountain Sandstone Member

Because of the lack of outcrops and small stritigraphic thickness of the members, the Lion Mountain and Welge were mapped as one unit.

The Lion Mountain is for the most part a medium-grained, green, glauconitic, friable sandstone. Some of the layers are a purplish-red, coarse-grained sandstone. The base is marked by a white, slightly to highly glauconitic, medium-grained limestone containing many broken fragments of trilobites. A few thin layers of hard, black to yellow, clay ironstone are present. Only one good outcrop of this member was found in the entire area because of its poor resistance to weathering and erosion.

Wilberns Formation

Welge Sandstone Member

The Welge member is composed of yellow, orange, and red, medium-grained, friable sandstone. Many black-purple iron oxide nodules up to 10" in diameter weather out from these beds and are a good surface indication of this member. One nodule found showed impressions of brachiopods. The origin of the iron is probably in the weathering of glauconite in older beds. The yellowish sandstone grades into white, coarse-grained, calcareous sandstone and then into limestone which is the overlying Morgan Creek member. Some quartz seams are present, and the grains are poorly cemented by iron oxide and silica. The combined Lion Mountain and Welge thickness in this area is about 80 feet. All the outcrop areas of these members have been lowered by erosion to form valleys between the Cap Mountain limestone and the overlying Morgan Creek limestone.

Morgan Creek Limestone Member

The Morgan Creek limestone is a white-red-brown, medium-grained to coarse-grained, sandy, glauconitic limestone which generally weathers a dull red or grey. Beds containing broken fragments of Elvinia are found, as are also beds with Billingsella. The latter generally occur in local clusters in a grey-green, fine-grained, slightly glauconitic limestone which also contains small broken trilobite fragments. One thin solid layer of glauconite was found, as was also a white limestone containing fragments of yellow sandstone. The beds are thin- to thick-bedded with a few shale partings, and in general the bedding planes are wavy. The overall thickness of this member is 165 feet. The Morgan Creek limestone resists weathering and thus occurs as a prominent hill maker in this region.

Point Peak Shale Member

The Point Peak member is composed chiefly of calcareous shale, although many conglomerates, limestones, and reef-like structures are included. This member may be subdivided into the lower shale section and the upper bioherm zone. However, in places the top of the bioherm zone may not be exact because bioherms also occur in the San Saba member.

The shale is grey to green, soft to hard, silty, calcareous, unfossiliferous, and mostly thin-bedded. Many intraformational conglomerates composed of flat-pebbled, green limestone gragments are interbedded with the shales. These conglomerate beds average three inches in thickness, with a few as much as fifteen inches thick. Many of the limestone fragments are covered with dendrites. The numerous thin limestone beds in this member are either grey-green and fine-grained to sublithographic or white and fine-grained containing rounded glauconite grains.

The reef structures are biostromes and bioherms and are found in the upper part of this member. These terms are used as Cummins (11) defines them. A bioherm is a lens-like structure of organic origin while a biostrome is an extensive bedded structure of organic material. These reef structures contain many "cabbage heads". These are calcareous concentric bands ranging up to one foot in diameter and are more prevalent in the lower part of the bioherm zone. Most of the bioherms range from one foot to about three feet in thickness with the majority about one foot. However, just west of the Fredonia fault in the northern part of this area, one reef structure is present that is approximately forty feet thick. The bioherms are light to dark grey-green, sublithographic limestones which weather to an uneven pitted grey surface.

The thickness of the entire member is approximately 240 feet in the Fredonia area. The lower Point Peak is generally found as a topographic low or a bench between the more resistant bioherms and underlying Morgan Creek limestones.

A well-displayed partial section is exposed just east of Fredonia in a road cut on Farm Road 386.

Point Peak shale member

12. Conglomerate- green, flat-pebbled limestone conglomerate; disc-like fragments 3" x 1/4" . . . . 1'10"
11. Shale- grey-green, soft with 2" calcareous concretions 1'
10. Limestone-grey-tan, sublithographic, reef limestone, ring-like nature on yellow weathered bedding plane; grades into dark grey limestone . . . . 3'10"
9. Shale- green, calcareous, minor faulting, interbedded thin grey, granular limestones . . . . .6'1"
8. Shale- green, soft, calcareous, interbedded thin, sandy, medium-grained limestone weathering a rough grey, brown, and thin green, glauconitic limestone conglomerate . . . . 1'
7. Conglomerate- brown to grey, flat-pebbled, limestone conglomerate containing glauconite; few pebbles covered with dendrites . . . . 1'2"
6. Shale- dark grey-green, sandy; few interbedded grey laminated limestones . . . . .2'6"
5. Limestone- brown, fine-grained, soft, sandy, speckled with limonite stains . . . . 4"
4. Limestone- grey, fine-grained, shaly, weathers to a purplish brown . . . . 5"

3. Clay- purple, soft . . . . 2"

2. Limestone- dark grey-green, fine-grained, with a few limonitic stains; glauconitic, one thin limestone conglomerate included . . . . 8"

1. Shale and Limestone- interbedded grey-green, calcareous thin-bedded shale; grey to green, silty, shaly, limestone; both weather green to brown . . . . . 40'7"

Total thickness . . . . 59'7"

San Saba Limestone Member

The San Saba limestone is the uppermost member of the Cambrian. It is composed of white to yellow to grey, sublithographic limestones, and tan, medium-grained, sandy, glauconitic limestones. A few red, fine-grained limestones are present, and several bioherms were observed in the lower part of this member in the Fredonia area. The beds vary from two inches to three feet in thickness. Most of them weather to an irregularly pitted, grey surface, but some of the lower beds weather to a yellow-brown color.

The dividing line between the San Saba member and the overlying Ellenburger group is taken at the last appearance of glauconite. Otherwise the beds are continuous vertically, and no good stratigraphic break is evident. The total thickness of the San Saba member in this area is about 270 feet.

A section was measured about 200 yards south of Farm Road 386 .8 miles east of Fredonia.

San Saba limestone member

29. Limestone- white to grey, sublithographic, slightly sandy, finely crystalline, thin- to thick-bedded; weathers grey . . . . 3'11"

28. Limestone- grey to pink, fine-grained, sandy; weathers grey . . . . 2'5"

27. Limestone- white to grey, fine-grained, glauconitic, weathers reddish-grey . . . . 1'2"

26. Limestone- grey, fine-grained; weathers grey-green . . 3'

25. Limestone- red, fine-grained; weathers red . . . . . . 1'11"

24. Limestone- grey-green, medium-grained; weathers grey-tan 3'

23. Limestone- grey, coarse-grained, glauconitic, fossiliferous . . . . 4'

22. Limestone- red, fine-grained, sandy; weathers red . . . 6'

21. Limestone- grey, fine-grained, sandy, glauconitic .. , . 3'

20. Limestone- red and white, glauconitic, coarsely crystalline, fossiliferous; weathers red . . . . . . .1'2"

19. Limestone- red, coarse-grained, glauconitic, limonitic stained; weathers reddish-purple . . . . .5'3"

18. Limestone- grey to reddish-brown, medium- to coarse-grained, sandy, glauconitic . . . . 2'6"

17. Limestone- grey to green, sublithographic; weathers grey 8'10"

16. Limestone- brown, finely crystalline, sandy, glauconitic 1'
15. Limestone- grey, sublithographic; tan sandy, fine-grained;
and few thin limestone conglomerates . . . . 5'10"
14. Limestone- tan, generally sandy, fine-grained to sub-
lithographic, thin- to thick-bedded with clusters
of white calcite up to 1/2 inch . . . . 8'2"
13. Limestone- white to grey to brown, coarsely crystalline,
glauconitic . . . . 1'7"
12. Limestone- grey to tan, sublithographic, glauconitic . . 3'3"
11. Limestone- yellow-brown, sublithographic to finely granular,
thin- to thick-bedded, glauconitic . . . . 7'4"
10. Limestone- yellow-tan, fine-grained, sandy . . . . . . 6"
9. Limestone- white to tan, coarsely granular, very
glauconitic, fossiliferous . . . . 1'8"
8. Limestone- white to grey to brown, finely granular to
sublithographic, thick-bedded . . . . 6'1"
7. Limestone- grey, sublithographic, glauconitic,
limonitic stained, thick-bedded . . . . 2'5"
6. Limestone- grey, fine-grained, with specks of yellow
and white calcite . . . . 1'5"
5. Limestone- yellow-brown, finely crystalline . . . . . 1'2"
4. Limestone- grey-tan, sublithographic . . . . 1'2"
3. Limestone- yellow, tan, glauconitic, with brown specks 1'4"
2. Limestone- grey-green to yellow, finely crystalline,
fossiliferous, glauconitic . . . . 4"

1. Limestone- brown, finely granular, fossiliferous, glauconitic . . . . 4"

Total thickness 102'8"

Ordovician

Ellenburger Group

The only strata of Ordovician age in the Fredonia area belong to the Ellenburger group. The beds are of white to grey, sublithographic to granular, dolomitic limestone with small seams of calcite; grey to green, crystalline limestone with a few chert nodules; grey, granular dolomites; and some pink, fine-grained limestone with small dendrites. At one locality the dolomites appeared almost reef-like. In general the Ellenburger is well-bedded with thin to thick layers which weather to a light grey and cause a relatively uneven topography. The thickness of the Ellenburger group in the Llano area is 2000 feet, but only about 800 feet are present in the Fredonia region.

Recent

All deposits from the Ordovician period until the Recent are missing in the area mapped. The youngest sediments, excluding mantle and unconsolidated alluvial deposits, are Recent conglomerates exposed in several of the stream beds. Nowhere else were they observed. These conglomerates consist of rounded fragments of quartz, sandstone, and limestone ranging up to 20" in length, with a maximum thickness of the deposits about six feet. These deposits are alluvial fill that was later solidified.

STRUCTURE

The Fredonia area is situated on the northwestern flank of the Llano Uplift. Structurally the Llano Uplift is a dome, since the beds all dip away from the Pre-Cambrian core, but topographically it is a basin. The Cretaceous limestones rim the area because of their superior position and resistance to weathering and erosion. The rim is therefore higher than the center, causing a large basin.

In the area limited by this paper the main Pre-Cambrian complex is to the west with the sedimentary rocks striking north or northeast and dipping to the east. Both folding and faulting have occurred. The folding is not sharp but consists of broad undulating warps. All the faults strike between north and N 45° E, and the faulting is believed entirely normal with the block to the west having moved down in relation to the eastern block. (See Geologic cross-sections in back.) Only one fault plane was observed, and this dipped 60° to the west. The dips of the other faults are here assumed to be between 60° and 90°. The main movement along these faults was vertical, but the possibility of small horizontal displacement is not excluded.

The Fredonia fault curves from its north-south strike to a N 45° E strike in the southern part of the area. The fault is assumed vertical and shows a vertical displacement of 1500 feet in the north and south where the Ellenburger is dropped against the Cap Mountain and Hickory, and a minimum of 700 feet in the central part where the Ellenburger is in contact with the Morgan Creek member. The fault brings all members from the Hickory sandstone through the Morgan Creek limestone into contact with the

Ellenburger. This fault probably continues farther to the southwest, but no evidence was found by which it could be traced. The area there is relatively flat-lying and underlain only by soft sandstone, so no topographic or vegetational change is present.

Minor faults are present both north and south of Fredonia. Those to the south strike N 20° E and carry two slivers of Cap Mountain limestone into the Hickory sandstone. Both of these may be easily traced in the field. The faults gradually disappear to the northeast into an undeformed sequence of rocks; thus, it is most likely that the movement was of a rotational nature with the displacement increasing to the southwest.

North of Fredonia is the Field fault—a large normal fault striking N 30° E and disrupting the entire Upper Cambrian sequence. Weathering and erosion coupled with the plowing of the land have obscured the areas at the ends of this fault. Whether it does continue to the northeast or the southwest is uncertain. The magnitude of displacement decreases to the northeast, and the fault disappears in the San Saba limestone. The northern block moved down in relationship to the southern block with the formations offset due to the truncation of the south block by erosion.

Farther north a series of parallel normal faults occurs. These are similar to the Field Fault mentioned above with all the Cambrian members being broken by the movement.

Narrow alternating outcrops of Hickory sandstone and granite gneiss occur in the southwestern sector just west of the Thomas fault. Since the area is relatively level, the Hickory sandstone probably occurs because of its preservation from erosion by having been deposited in low areas in the previously eroded Pre-Cambrian gneiss. However, it is also possible that these Hickory beds may have been downfaulted against the gneiss similar to movement along the Thomas fault.

The Thomas fault strikes N 15° E and dips 80° west. Pre-Cambrian gneiss is brought into contact with lower Hickory sandstones. Since the Cambrian sediments are here the hanging wall and moved downward, the faulting is definitely normal.

Broad, undulating warps probably cause the wide expanse of Hickory sandstone in the southern part of the mapped area. Since the surface of the Pre-Cambrian complex was unevenly eroded, the shallow-dipping synclines in the Hickory are probably caused by a combination of original dip and differential compaction over local highs. Some of the higher dips in younger Paleozoic rocks may be the result of uneven uplift over the area. It is possible that there may be faults in this section bringing Hickory against Hickory, but since the area is mostly under cultivation, their presence would be difficult to prove.

The Eastman fault brings Hickory against Cap Mountain; thus, the throw is less than three hundred feet. It is difficult to calculate exactly because of uncertainty as to the stratigraphic position of some of the beds within the Hickory member. The Cap Mountain limestone both east and west of this fault in the south-central part of the area forms several small synclines which affect the course of the tributary stream flowing north into Lost Creek. This folding causes the wide exposure of this member here.

Farther north, and east of the Fredonia fault, is a small hill which is the highest part of the area mapped. It is capped by a resistant reef limestone of the Point Peak. North of this, repeated sequences of Hickory and Cap Mountain occur. These are faulted limbs of synclines and anticlines with the faults parallel to the strike of the beds. Topographically they are alternating ridges and valleys with the Cap Mountain limestone as the ridges.

In the central part of this area the Point Peak bioherm zone, the San Saba limestone, and the Ellenburger limestone are warped into two large synclines which have been faulted on the east side.

Age and Cause of Faulting and Folding

Uplift in the Llano area occurred in the late Paleozoic. Cloud and Barnes (7) believed that the movement was pre-Canyon in age. The Mississippian deposits are thinned in the direction of the Llano area which indicates that uplift may have started by mid-Mississippian time and continued into the Pennsylvanian period.

Since most of the faults in the Llano area strike northeast to southwest, the uplift could not have been a true domal uplift. Compressive forces in a southeast-northwest direction probably folded the beds upward. Tensional faults would occur due to stretching of the beds, and their strike would be at right angles to the direction of the force.

HISTORY OF THE REGION

To accurately determine the history of this area, the entire region of the Llano Uplift must be considered, for many of the important formations are not present in the limited area studied.

In Pre-Cambrian time sediments were deposited over the Llano area in the form of shale and limestone. Subsequent deformation caused uplift and folding, metamorphosing these deposits into schists and a few beds of marble. These beds now compose the Packsaddle schist. Batholithic intrusions of granite occurred, and separate intrustions are recognized in the Llano area by Stenzel (20): 1) the Town Mountain, a pink, coarse-grained granite, 2) the Oatman, a pink and grey, medium-grained granite, and 3) the Sixmile, a grey, fine-grained biotite-granite.

The area was not covered in the earliest Paleozoic, and the land was eroded into rugged relief. In some areas arkoses formed while in others the weathered material was shifted back and forth by wind action until only pure, white, rounded, quartz grains remained from the granite and metamorphic rocks. Barnes and Parkinson (2) found ventifacts in the lower Hickory sandstone giving evidence of eolian deposition. The first sea encroached on the land from the east or northeast and reworked this material, which when solidified formed the white sandstone layers in the basal Hickory. Many of the younger beds probably contained abundant glauconite which weathered to the present reddish color.

As the sea transgressed, less and less sand was being deposited and calcium carbonate began to be precipitated from solution. The sand thus grades into limestone which is the overlying Cap Mountain member. Glauconite occurs, which seems to indicate that the sea did not attain any great depth. As yet no definite reasons for the formation of glauconite are acceptable to all, but the general agreement is that it indicates shallow marine deposition.

A regression followed and again closer-to-shore sediments in the form of the Lion Mountain and Welge were deposited. The conditions favorable for glauconite deposition occurred, and the maximum amount of glauconite is found in these beds. Some of the beds are entirely composed of grains of this material. The widespread "trilobite hash" indicates a neritic facies.

Either clearer water or water of greater depth then resulted in the deposition of the Morgan Creek limestone. Glauconite is present in almost all of the beds and seems to indicate a chemical deposit; however, many quartz grains are also included.

The Point Peak shale formed as shallowing of the seas occurred. The intra-formational conglomerates give evidence of unstable conditions as the sea level rose and subsided. As deposits formed, the sea level dropped, exposing partially solidified beds to erosive forces. The fragments when incorporated into younger beds formed the flat-pebbled limestone conglomerates. Successive transgressions caused the shale to be deposited. In several areas favorable to marine organisms, reef structures grew, surrounded by fine detrital material which eventually even covered the reefs.

A gradual change from clay to calcareous matter caused the transition into the San Saba limestones. Most of these limestones are sandy and contain small amounts of glauconite. The conditions favorable to glauconite changed gradually, and finally the deposits become entirely white or grey limestone devoid of glauconite. This marks the end of the Cambrian period and the beginning of the Ordovician. There was no withdrawal of the sea between these two periods.

The Ellenburger group is the only one of Ordovician age in the area. No other Ordovician or Silurian deposits are present in the Llano area which indicates that the sea must have withdrawn for a long period of time. The seas again covered the Llano area in the Devonian, and in the Mississippian the thinning of sediments in this direction indicates that uplift had again started by Mid-Mississippian time. This uplift probably continued into the Pennsylvanian period and caused the folding and faulting present in the area. The exact position of the Pennsylvanian seas is obscure because of the long period of erosion between that period and the Cretaceous. This erosion affected all the older formations, and therefore, the Cretaceous limestone rests on the beveled beds of all earlier periods represented in the Llano area. Thus, following the uplift there was an interval of erosion, then subsidence while the Cretaceous limestones were being formed.

The final elevation from the sea occurred in Cretaceous time with relatively no deformation, leaving flat-lying limestone over the entire region. These beds were then stripped from the center of the dome by erosion, leaving a topographic basin. The present day topography is a result of weathering and erosion since that time, with Recent deposits of conglomerate and mantle still being formed.

ECONOMIC IMPORTANCE

The main industries of the Fredonia area are farming and ranching. The farmers raise peanuts, cotton, corn, and soy beans in the shallow valleys formed mostly by the sandy beds. The fields under cultivation, however, do extend over some of the limestone beds, and in the northern and western parts of the area the farming is on granitic soil.

The hills are covered by enough vegetation to support sheep, cattle, and goats. By damming small streams or low areas, tanks are made which may hold water all year. Some of these are equipped with wells and windmills to pump water into them. The well water is mostly from the Hickory sandstone. The red upper Hickory sandstones are also locally used for road metal.

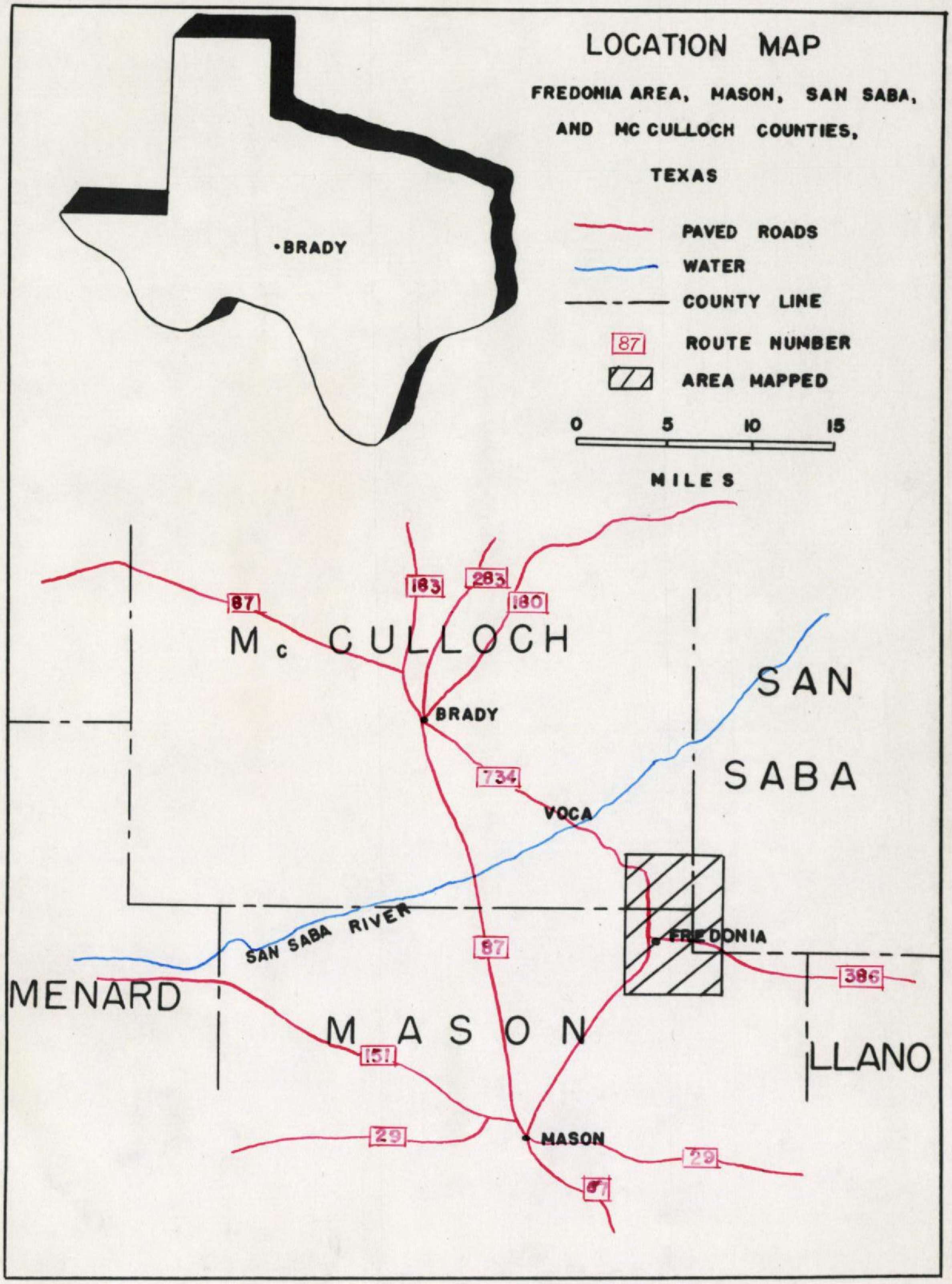
LOCATION MAP
FREDONIA AREA, MASON, SAN SABA, AND MC CULLOCH COUNTIES, TEXAS
PAVED ROADS
WATER
COUNTY LINE
87 ROUTE NUMBER
AREA MAPPED
0 5 10 15
MILES
BRADY
Mc CULLOCH
SAN SABA
MENARD
MASON
LLANO
BRADY
VOCA
FREDONIA
MASON
SAN SABA RIVER
87
183
283
180
734
87
151
29
29
87
386

PLATE I

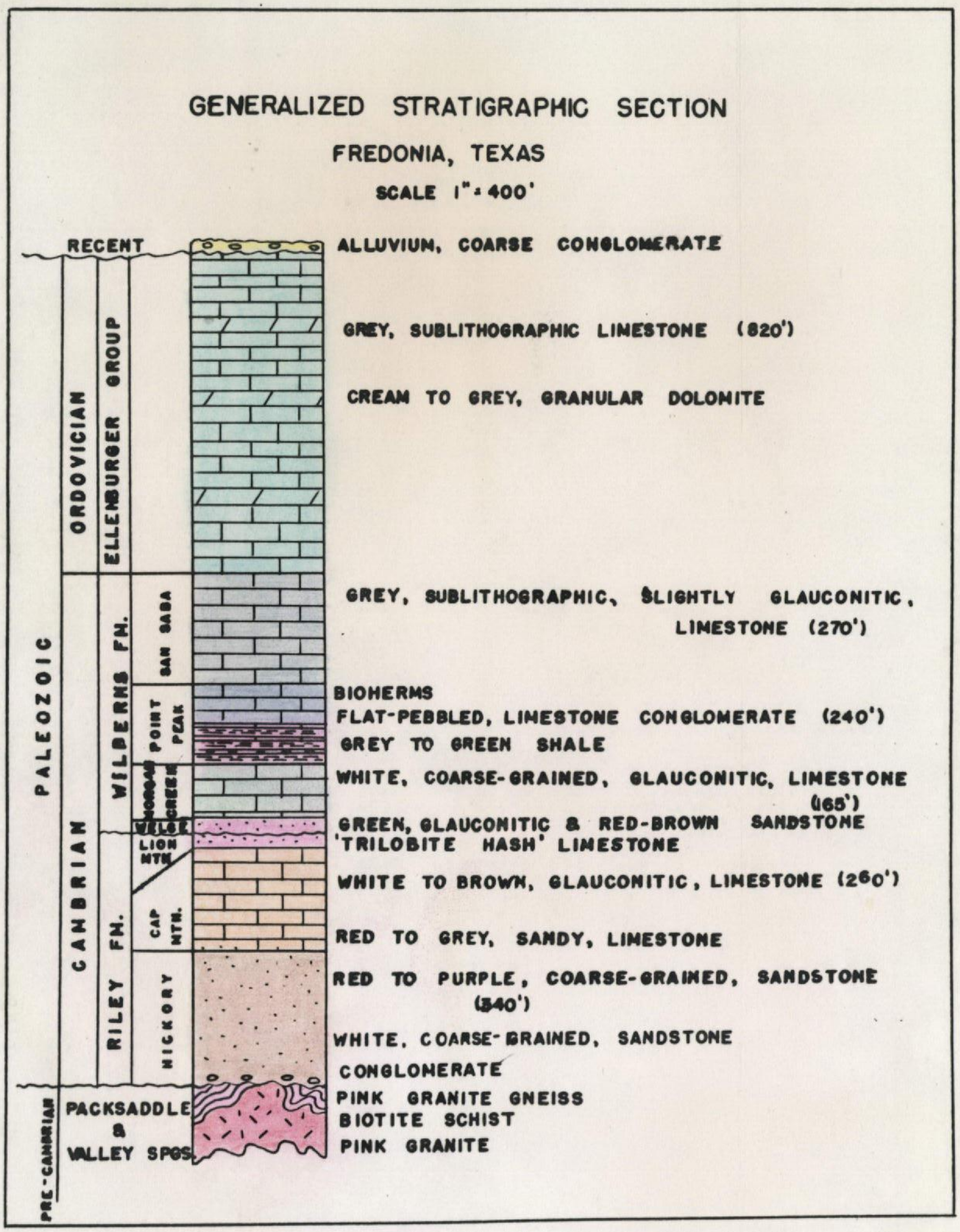
GENERALIZED STRATIGRAPHIC SECTION
FREDONIA, TEXAS
SCALE 1" = 400'
RECENT
ORDOVICIAN
ELLENBURGER GROUP
PALEOZOIC
CAMBRIAN
WILBERNS FM.
SAN SABA
POINT PEAK
MORGAN CREEK
WELGE
LION MTN
CAP MTN.
RILEY FM.
HICKORY
PRE-CAMBRIAN
PACKSADDLE & VALLEY SPGS
ALLUVIUM, COARSE CONGLOMERATE
GREY, SUBLITHOGRAPHIC LIMESTONE (820')
CREAM TO GREY, GRANULAR DOLOMITE
GREY, SUBLITHOGRAPHIC, SLIGHTLY GLAUCONITIC, LIMESTONE (270')
BIOHERMS
FLAT-PEBBLED, LIMESTONE CONGLOMERATE (240')
GREY TO GREEN SHALE
WHITE, COARSE-GRAINED, GLAUCONITIC, LIMESTONE (165')
GREEN, GLAUCONITIC & RED-BROWN SANDSTONE
'TRILOBITE HASH' LIMESTONE
WHITE TO BROWN, GLAUCONITIC, LIMESTONE (260')
RED TO GREY, SANDY, LIMESTONE
RED TO PURPLE, COARSE-GRAINED, SANDSTONE (340')
WHITE, COARSE-GRAINED, SANDSTONE
CONGLOMERATE
PINK GRANITE GNEISS
BIOTITE SCHIST
PINK GRANITE

PLATE II

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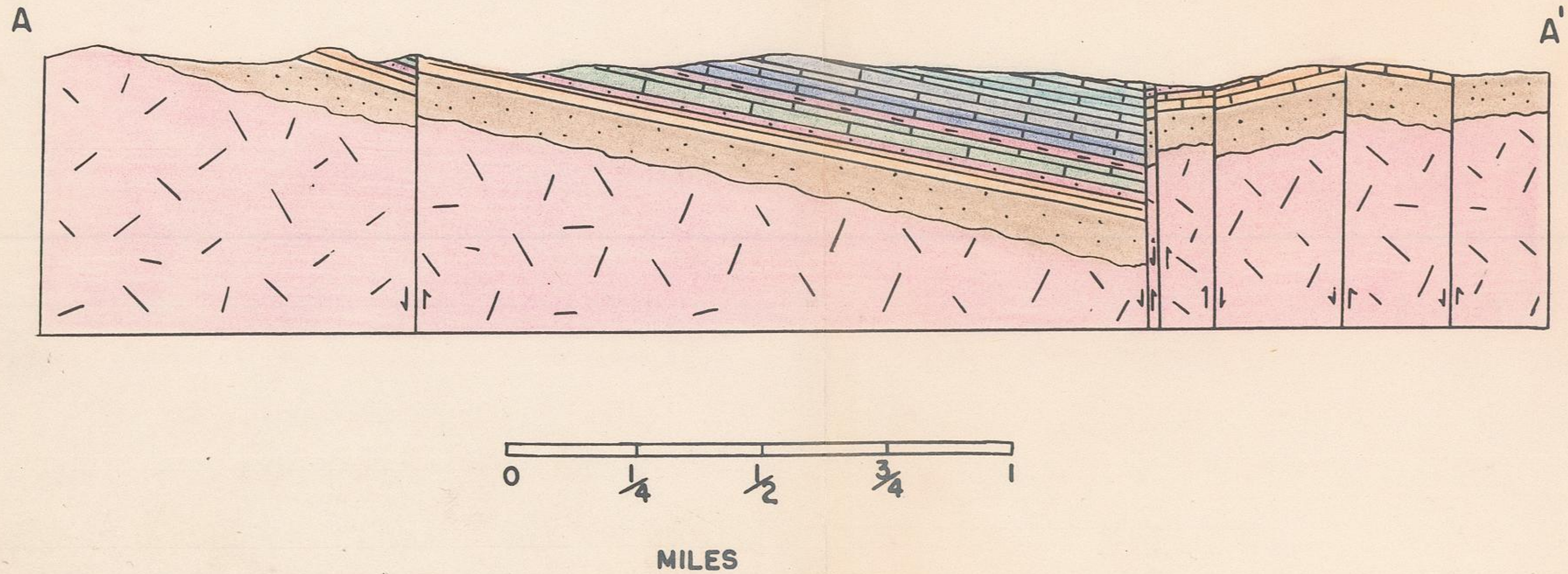
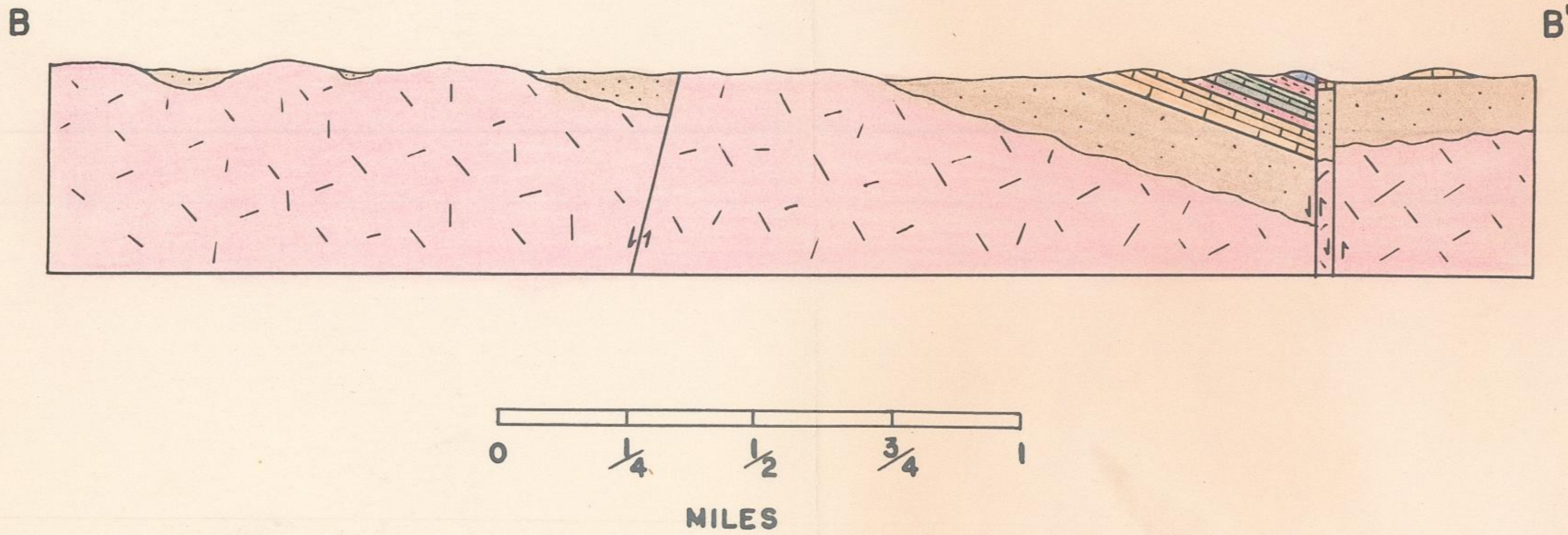
STRUCTURAL CROSS-SECTION

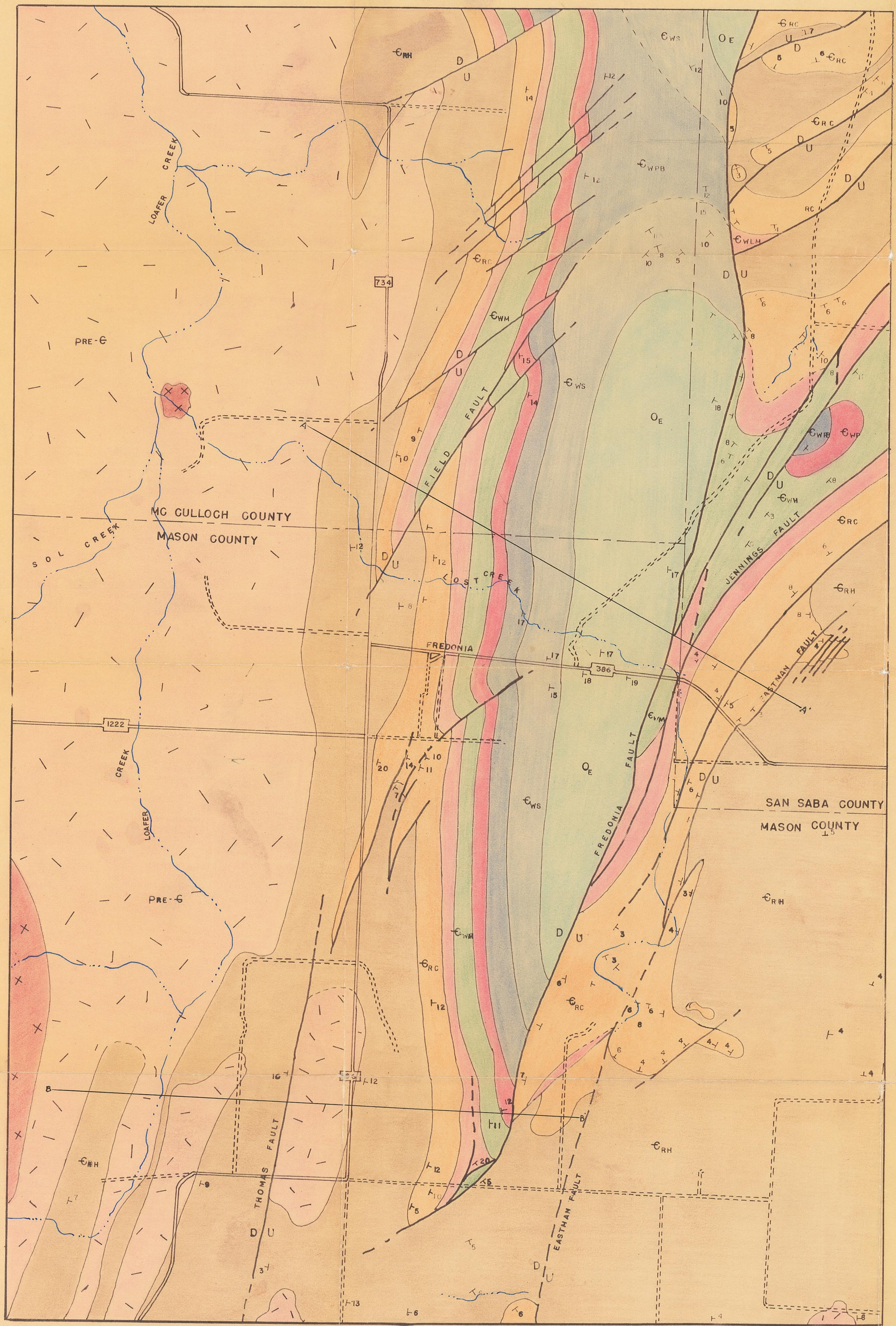
FREDONIA AREA, MASON, SAN SABA, AND MC CULLOCH COUNTIES, TEXAS



STRUCTURAL CROSS-SECTION

FREDONIA AREA, MASON, SAN SABA, AND MC CULLOCH COUNTIES, TEXAS





GEOLOGIC MAP

FREDONIA AREA
MC CULLOCH, MASON, AND SAN SABA COUNTIES, TEXAS

PALEOZOIC

ORDOVICIAN — ELLENBURGER GROUP

- O_E — ELLENBURGER: GREY LIMESTONE & DOLOMITE

CAMBRIAN — WILBERNS FM.

- $Є_{WS}$ — SAN SABA: GREY, SUBLITHOGRAPHIC TO GRANULÁR LIMESTONE
- $Є_{WPB}$ — POINT PEAK: REEF STRUCTURES
- $Є_{WP}$ — POINT PEAK: GREEN SHALE & FLAT-PEBBLED CONGLOMERATE
- $Є_{WM}$ — MORGAN CREEK: WHITE, GLAUCONITIC LIMESTONE
- $Є_{WLM}$ — WELGE, LION MOUNTAIN: RED TO GREEN SANDSTONE

CAMBRIAN — RILEY FM.

- $Є_{RC}$ — CAP MOUNTAIN: SANDY, BROWN LIMESTONE
- $Є_{RH}$ — HICKORY: RED, YELLOW, PURPLE SANDSTONE

UNCONFORMITY

PRE-CAMBRIAN

- PRE-Є — VALLEY SPRINGS: PINK, FINE-GRAINED & COARSE-GRAINED GRANITE GNEISS; PACKSADDLE: BLACK, BIOTITE SCHIST
- PRE-Є (x) — INTRUSIONS OF PINK, FINE- TO COARSE-GRAINED GRANITE

PAVED ROADS — STRIKE & DIP SYMBOL
GOOD DIRT ROADS — INTERMITTENT STREAM
CONFORMABLE CONTACT — PERMANENT STREAM
FAULT — COUNTY LINE
PROBABLE FAULT — 734 FARM HIGHWAY NUMBERS

1" = 1/3 MI

0 1/4 1/2 3/4 1

MILES

10°

MAGNETIC DECLINATION

B. D. MC GRATH 1952