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THE GEOLOGY OF HENRYS CHAPEL QUADRANGLE, NORTHEASTERN CHEROKEE COUNTY, TEXAS

By

H. B. Stenzel

Bureau of Economic Geology
John T. Lonsdale, Director

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of Democracy, and while guided and controlled by virtue, the noblest attribute of man. It is the only dictator that freemen acknowledge, and the only security which freemen desire.

Mirabeau B. Lamar

CONTENTS

	Page
Introduction	5
General geologic information	6
Stratigraphy	11
Wilcox group	11
Wilcox group undivided, uppermost beds	11
Claiborne group	19
Carrizo formation	19
Reklaw formation	34
Newby glauconitic sand member	34
Marquez shale member	78
Queen City formation	83
Arp member	83
Omen glauconitic sandstone member	95
Unnamed upper sand member	99
Upland gravels	100
Lower terrace deposits	101
Alluvium	104
Geomorphology	105
Structural geology	108
Regional setting	108
Economic geology	112
Ball clay	112
Description of clay pits	112
Thermo Fire Brick Company	112
General Refractories Company	112
Reliance Brick Company	113
Placing sand	113
Road metal	113
Sand	114
Stone	114
Lignite	114
Bibliography	115
Index	116

ILLUSTRATIONS

Figures—	Page
1. Map of Texas showing location of the Henrys Chapel quadrangle	6
2. Major topographic features of the Henrys Chapel quadrangle	9
3. Columnar section of the strata cropping out in the Henrys Chapel quadrangle	10
4. Block diagram showing the ground water perched in the Carrizo sand above the beds of the Wilcox group	13
5. Stratigraphic column of the Henrys Chapel ball clay and the beds adjoining it	14
6. Tongues of black ball clay (bed c) risen into gray ball clay (bed d) in the Henrys Chapel ball clay of the Wilcox group	16
7. Exposure of the Wilcox group at the small waterfall (locality 11), northeastern Cherokee County, Texas	18
8. Soil profile of lower part of Carrizo formation on east-west county road, 0.35 mile west of Beaver Run and 1.07 mile north of Farm Road 13	20
9. Soil profile of upper part of Carrizo formation in gullied field road at right-angle turn of county road which crosses Beaver Run, 0.55 mile west of Beaver Run and 1.07 mile north of Farm Road 13	21
10. Contorted sand bed in upper part of Carrizo formation	23
11. Stratigraphic position of the contorted sand bed in the Carrizo formation near Henrys Chapel, Cherokee County, Texas	24
12. Geologic map of the Bridge Creek area southwest of Griffin, Cherokee County, Texas	26
13. Oblique and hollow silty clay-ironstone concretion in the upper glauconitic part of the Carrizo formation	27
14. Location of measured thicknesses of the Carrizo formation in the vicinity of the Henrys Chapel quadrangle	29
15. Vertical and plane section through the Wilcox-Carrizo contact on the west wall of the clay pit of General Refractories Company near Henrys Chapel	30
16. Vertical, but not plane, section through the Wilcox-Carrizo contact on the west wall of the clay pit of General Refractories Company near Henrys Chapel	31

FIGURES— PAGE

17. Perspective block diagram of the Wilcox-Carrizo contact showing the shape of the funnel-shaped pits and their relation to the fossil plant roots in the Henrys Chapel ball clay of the Wilcox group 32
18. Cross section through the buried hill composed of strata of the Wilcox group and covered by Carrizo sand, silt, and shale 33
19. Black diagram of the cuesta formed by the Newby member of the Reklaw formation, showing the distribution of rock-strewn slopes at the points of the lobes 36
20. Soil profile of the Newby member of the Reklaw formation in the north-side cut of the county road at the descent to Grissom Creek, 0.12 mile west of the first bridge northeast of Henrys Chapel community 37
21. Location of measured sections and thicknesses of the Newby member of the Reklaw formation in the vicinity of the Henrys Chapel quadrangle 39
22. Profile of section 1 ..... Facing p. 41
23. Profile of section 2 43
24. Profile of section 3 45
25. Stratigraphic column of sections 4 and 5 47
26. Profile of section 6 49
27. Profile of section 7 51
28. Profile of section 9 53
29. Profile of section 10 57
30. Profile of section 11 59
31. Profile of section 12 ..... Facing p. 60
32. Profile of section 13 63
33. Profile of section 14 65
34. Profile of section 15 67
35. Profile of section 16 69
36. Profile of section 17 70
37. Profile of section 18 73
38. Angular unconformity between the Carrizo formation and the Newby member of the Reklaw formation at roadside cut and ditch on north side of U. S. highway No. 84 (Reklaw-Rusk road) on descent to flood plain of Mud Creek 74
39. Map showing the distribution of the three facies of the Newby member of the Reklaw formation in Cherokee, Nacogdoches, and Rusk counties, eastern Texas 76
40. Cross section of the three facies of the Newby member of the Reklaw formation in Cherokee, Nacogdoches, and Rusk counties, eastern Texas 77
41. Soil profile of Marquez member of Reklaw formation in north ditch of Farm Road 13 at the entrance to Henrys Chapel and graveyard 79
42. Contorted bed in Marquez shale member, bed n of section 3 81
43. The pteropod *Spiratella* from the Marquez shale member 82
44. Soil profile of the northern and central facies of the Arp sand member of the Queen City formation 84
45. Soil profile of the southern facies of the Arp member of the Queen City formation on east side of State highway No. 110 (Troup—New Summerfield road) 85
46. Crumpled and disrupted sand beds of the Arp member on county road leading from Griffin to Bell Church ..... Facing p. 86
47. Location of measured thicknesses of the Arp and Omen members of the Queen City formation in the Henrys Chapel quadrangle 89
48. Profile of Marquez-Arp transition ..... Facing p. 90
49. Distribution of the three facies of the Arp member of the Queen City formation in the Henrys Chapel quadrangle 92
50. Cross section of the three facies of the Arp member of the Queen City formation in the Henrys Chapel quadrangle 93
51. Block diagram of a Queen City outlier capped with the Omen member showing the winding and twisting hill spurs characteristic of the larger Omen caps, caused by the lenticular indurated parts of the Omen member 94
52. Soil profile of Omen member 96
53. Profile of exposure in the meander-scar cove, 1,250 feet south of Farm Road 13 and 1,700 feet east of Farm Road 856, on north margin of flood plain of Hampton Creek 102
54. Profile of terrace exposure in abandoned road cut, on hill spur between Hampton and Grissom creeks, 600 feet south of Farm Road 13 and 3,300 feet southeast of Henrys Chapel Church 103
55. Stream capture among the branches of Campground Creek 106–107
56. Regional geological setting of the Tyler basin and Sabine uplift in the Gulf of Mexico basin 109
57. Structure contour map of the vicinity of the Henrys Chapel quadrangle 110

Plate I. Geologic map of the Henrys Chapel quadrangle, Cherokee and Smith counties, Texas ..... In pocket

THE GEOLOGY OF HENRYS CHAPEL QUADRANGLE, NORTHEASTERN CHEROKEE COUNTY, TEXAS

H. B. Stenzel

INTRODUCTION

The purpose of this publication is to present a detailed geologic map and report covering the strata exposed in the area, elucidating their stratigraphic relationships, and giving information concerning useful geologic deposits.

Among the useful deposits found here, the one of the greatest interest at present is the ball clay, which is now being exploited by three companies. Originally, the geological relationships and stratigraphic position of the ball clay were not known except in a most general way. Hence it was desirable to investigate the deposit so that more reliable geologic information about it might be obtained. The results of the investigation were published in a report specifically devoted to the clay (Stenzel, 1950; Pence, 1950).

In addition to the results obtained by that investigation which have a specific bearing on the ball clay only, many other geologic data were obtained in the general vicinity, and a somewhat larger area had to be mapped in order to obtain information needed for the understanding of the ball-clay deposit. The area covered by the present report and the work done to map it geologically were, for that reason, an outgrowth of the ball-clay report. However, it was thought advisable to present this work separately because it summarizes the geology of an interesting area containing some stratigraphic problems and several geologic materials of practical importance besides the ball clay.

The area covered by detailed geologic mapping undertaken for the present paper (Pl. I) is about 8.0 miles long in a north-south direction and about 6.6 miles wide in an east-west direction. The area is in the northeastern corner of Cherokee County and reaches with its northwestern end to within 1 mile of the town of Troup (fig. 1).

In order to clarify the stratigraphy of the area, reconnaissance geologic mapping was extended to the vicinity of Reklaw in Cherokee County, near the southwest corner of Rusk County, about 12 miles from the area of the geologic map. There the type section of the Reklaw formation was studied in detail. Other reconnaissance geologic mapping was carried southeastward from the area for the purpose of clarifying the stratigraphy of the uppermost Carrizo beds.

Field work was intermittent from February 1946 to October 1948. The writer was assisted in the field at various times by H. C. Fountain, Dan E. Feray, Jr., A. L. Lyth, Jr., C. O. Durham, Jr., and a few additional days were spent in the fall of 1950 when the writer was accompanied by T. M. Anderson. The microscopic descriptions were made by Mrs. Kathryn O'Neill Dickson.

GENERAL GEOLOGIC INFORMATION

Location.—The northern margin of the area mapped nearly coincides with the Cherokee-Smith County boundary line, and its eastern margin is parallel to and about 0.9 mile west of the Cherokee-Rusk County boundary line. The area is slightly more than one-fifth of the Troup quadrangle, in the southeastern part of which it is located (Pl. I). Troup, the nearest incorporated town, is about 1 mile northwest of the northwestern corner of the mapped area; it is a town in southern Smith County, about half a mile north of the Cherokee-Smith County boundary and 8 miles west of the Smith-Rusk County boundary.

Nearest railroad connections are the main line of the Missouri Pacific Railroad, going through Jacksonville and Troup. This line is a short distance west of the mapped area and approaches the west margin of the area at one point to within about half a mile.

The area is traversed by numerous well-kept county roads, some of which are hard surfaced, and three hard-surfaced highways, Farm Road 13 (Troup to Henderson), Farm Road 856 (Henrys Chapel to Emmaus), and State highway No. 110 (Troup to New Summerfield).

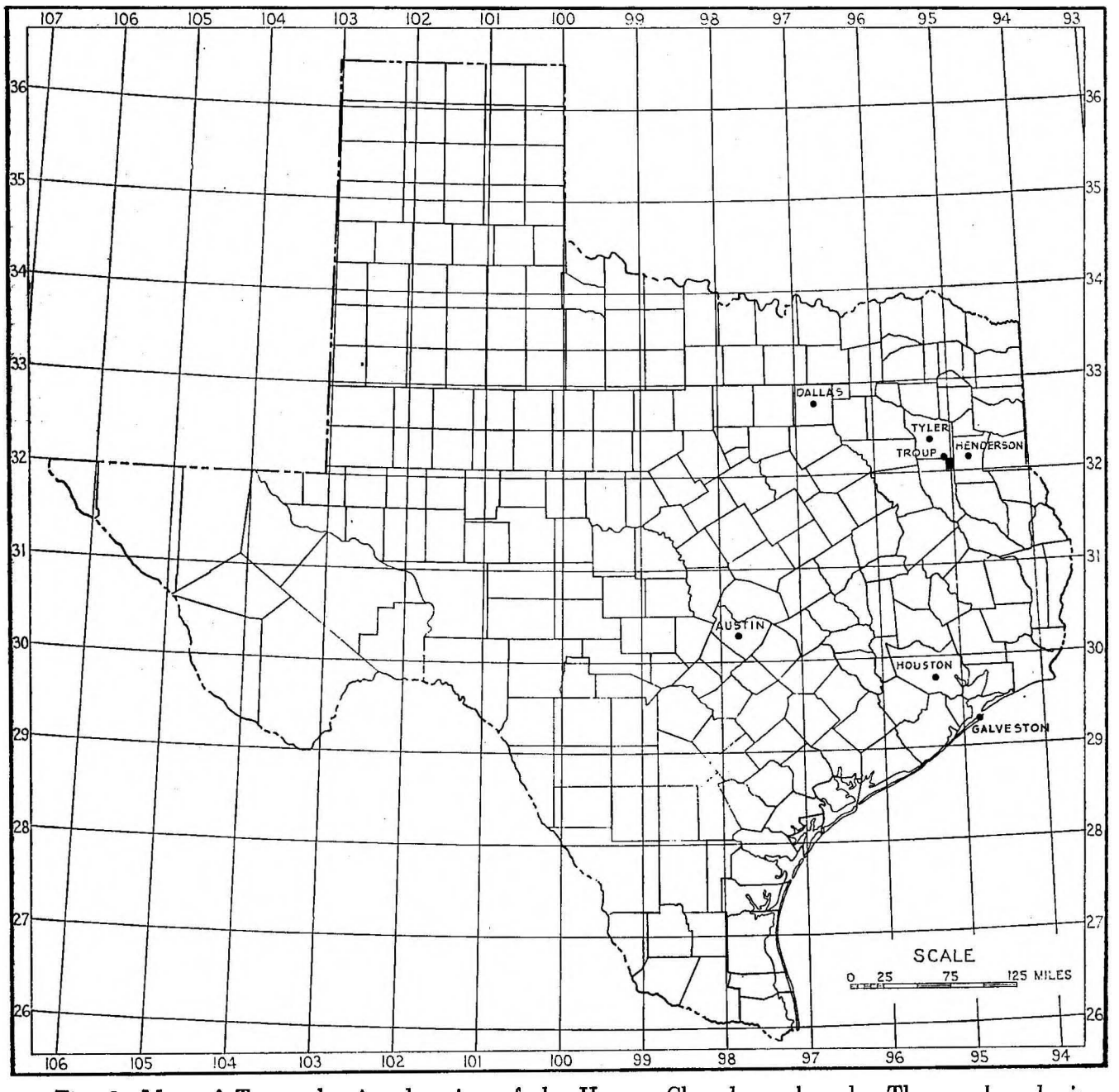


Fig. 1. Map of Texas showing location of the Henrys Chapel quadrangle. The quadrangle is indicated by the black rectangle.

There is also a comparatively dense network of electric high-tension lines and gas and oil pipe-lines in this region, many of which originate in the great East Texas oil field located about 8 miles east of Troup. The mapped area includes in its northeast corner a small part of the western edge of this oil field.

Topographic maps. — Excellent topographic maps of various kinds covering the area of Plate I are available. Aerial photographs may be obtained from the Eastern Aerial Photographic Laboratory, Field Service Branch, Production and Marketing Administration, U. S. Department of Agriculture, Washington 25, D. C. These photographs are available either as contact prints of the scale of 1:20,000 or as enlargements to any desired scale. For geologic field work prints enlarged to a scale of 8 inches to the mile were used. The photographs used in mapping the area of Plate I are dated and index numbered as follows:

CFV–7–28 to CFV–7–36 inclusive, dated 7–16–39,
CFV–8–34 to CFV–8–40 inclusive, dated 7–16–39,
CFV–13–38 to CFV–13–45 inclusive, dated 9–22–39.

Newer photographs, dating from 4–18–49, are now available from the same source.

The area is also covered by the Troup quadrangle, 1:62,500, U. S. Geological Survey, edition of 1943, contour interval 20 feet. This quadrangle was originally printed as the Troupe[1] quadrangle, 1:48,000, U. S. Geological Survey, unedited advance sheet subject to correction, surveyed in 1936 and 1937, which has a more convenient scale.

In addition, the area is covered by maps showing ownerships and land surveys. Land surveys are shown on the following maps:

Map of Cherokee County, 1879, scale 4,000 varas to 1 inch: General Land Office, State of Texas, Nov. 1879.
Map of Cherokee County [no scale indicated, 1 inch to 2,000 varas]: General Land Office, Austin, Texas, June 1902.
Map of Cherokee County, 1 inch equal 2,000 varas: General Land Office, Austin, Texas, July 1933.
Ownership map of Cherokee County, Texas, 1 inch equal 4,000 feet: S. W. Ray, Jacksonville, Texas, January 1931.

Bench marks and altitudes.—Descriptions, latitudes, and longitudes of stations along traverses and descriptions and elevations of bench marks of the Troup quadrangle are obtainable from the U. S. Geological Survey, Washington 25, D. C., on multilithed sheets.

Summary of previous geological work.—Geological field work done in eastern Texas prior to 1920 was insufficient to cope with the great geographic extent of the area and with the great extent and complexity of the formations outcropping in the area. Hence prior to that time the beds and their succession were known merely in a very generalized and often insecure or even erroneous way. The geologic map accompanying Dumble's report on east Texas (Dumble, 1920, pl. 1), for instance, showed the Henrys Chapel area as the outcrop of only one formation, the "Marine" of the Claiborne group, without any more detailed breakdown of that formation, although a previously published report by Alexander Deussen (1914, pl. 1) showed the "Wilcox formation" and the Mount Selman formation sharing the outcrops in the same region. In this respect Deussen's map, although it was exceedingly generalized, was more advanced than Dumble's and depicted in a very general way geologic conditions correctly. Deussen's map showed the Wilcox occupying the valleys of the various headwater branches of the Angelina River and the Mount Selman formation occupying the intervening uplands. In retrospect this arrangement was roughly correct only if one included, as Deussen did in this region, the Reklaw and Carrizo formations, as they are known today, in his "Wilcox formation."

The great increase in geologic field work done in the 1920's by petroleum geologists resulted in the clearing up of most of these uncertainties and old misconceptions of the stratigraphy in eastern Texas. Toward the end of the 1920's a nearly complete and in all essential major features correct knowledge of the outcropping beds was attained by these geologists working in eastern Texas. Publications by B. C. Renick (1928), A. C. Ellisor (1929), E. A. Wendlandt and G. M. Knebel (1929), and C. L.

[1] The town's name is Troup. Troupe is a misprint or error.

Moody (1931) resulted from this work. The most important of these for the present work was the one by Wendlandt and Knebel. The geology of the area was later summarized, chiefly from available published accounts, by F. B. Plummer (1933). These authors elucidated the succession of the beds, described the chief characteristic features of the formations, and established a firm foundation for future work in this area.

Maps submitted by geologists working in Texas were compiled between the years 1924 and 1935 into a geologic map of the State (Darton et al., 1937) at a scale of 1:500,000. This map was a great step forward in the geologic mapping of the area under consideration but had to be rather generalized because of its small scale and the lack of suitable accurate topographic bases. The region around Henrys Chapel was depicted in a correct but generalized way, and the Queen City, Reklaw, and Carrizo formations and the Wilcox group were shown. In retrospective criticism it may be said that the Queen City formation was depicted as occupying too much territory in the region under consideration at the expense of the really much larger Reklaw outcrops and that the Wilcox outcrops were not shown. Similarly the Carrizo formation was omitted in the vicinity of Reklaw and in the channel of Bridge Creek west of Griffin.

With the appearance of this Geologic Map of Texas, an era of active geologic mapping and publication of several fundamental reports came to an end. Much less geologic surface mapping is being done now and very little of it is being published. Only two of the later publications have a bearing on the surface geology of the quadrangle. Additional new information concerning finer subdivision of the formations exposed in east Texas and concerning the contacts between successive formations was contributed by H. B. Stenzel (1939). A report on the ball-clay deposit near Henrys Chapel was published in 1950 (Stenzel, 1950; Pence, 1950).

Outline of topographic features.—The highest point of the area mapped is between 560 and 580 feet above sea level; it is the hill 1,000 feet north of Farm Road 13, about halfway between Troup and Henrys Chapel (fig. 2). To the north of this hill are several high hills stretching for three-quarters of a mile from the Cherokee-Smith County boundary line northward to Union Grove Church in southern Smith County. Another group of three hilltops, between 500 and 580 feet above sea level, is between Bell Church and Concord, about 1.35 miles southeast of Bell Church. All these high hills and many others of lesser height form a stream divide extending in north-south direction. To the east of this divide, creeks drain southeastward into Bowles Creek, which is a short distance east of the margin of the map and runs southward into Striker Creek, a right headwaters branch of the Angelina River. To the west of the divide, creeks drain south-southwestward into Mud Creek, a right tributary of the river. The creeks draining westward from the divide have as a whole a gentler gradient than those draining eastward.

This stream divide is the remnants of a cuesta formed by the ferruginous Omen sandstone, which is quite resistant to erosion. As the gentle dip of the strata is westward the east side of the divide is the inface of the cuesta and the west side its dip slope. However, the cuesta is so greatly dissected by erosion that it is divided into separate outliers of the Omen sandstone, and only the lower strata, for instance, the indurated ferruginous sandstone of the Newby member, form a continuous cuesta front along the east side of the divide.

The whole topography of the area is a series of cuestas of the Coastal Plain type, that is, cuestas that are much dissected into lobes, valley notches, and outliers. The general trend of the cuestas is north-south, and the infaces are on their east sides because the area lies on the east flank of the Tyler basin, toward the center of which the strata dip.

The lowest point of the mapped area, slightly below 300 feet, is the channel of Campground Creek in the southeast corner. Similarly all the creek valleys on the east margin of the area are the lowest places of the area. These valleys have unusually broad flood plains, which are impenetrable bogs in many places.

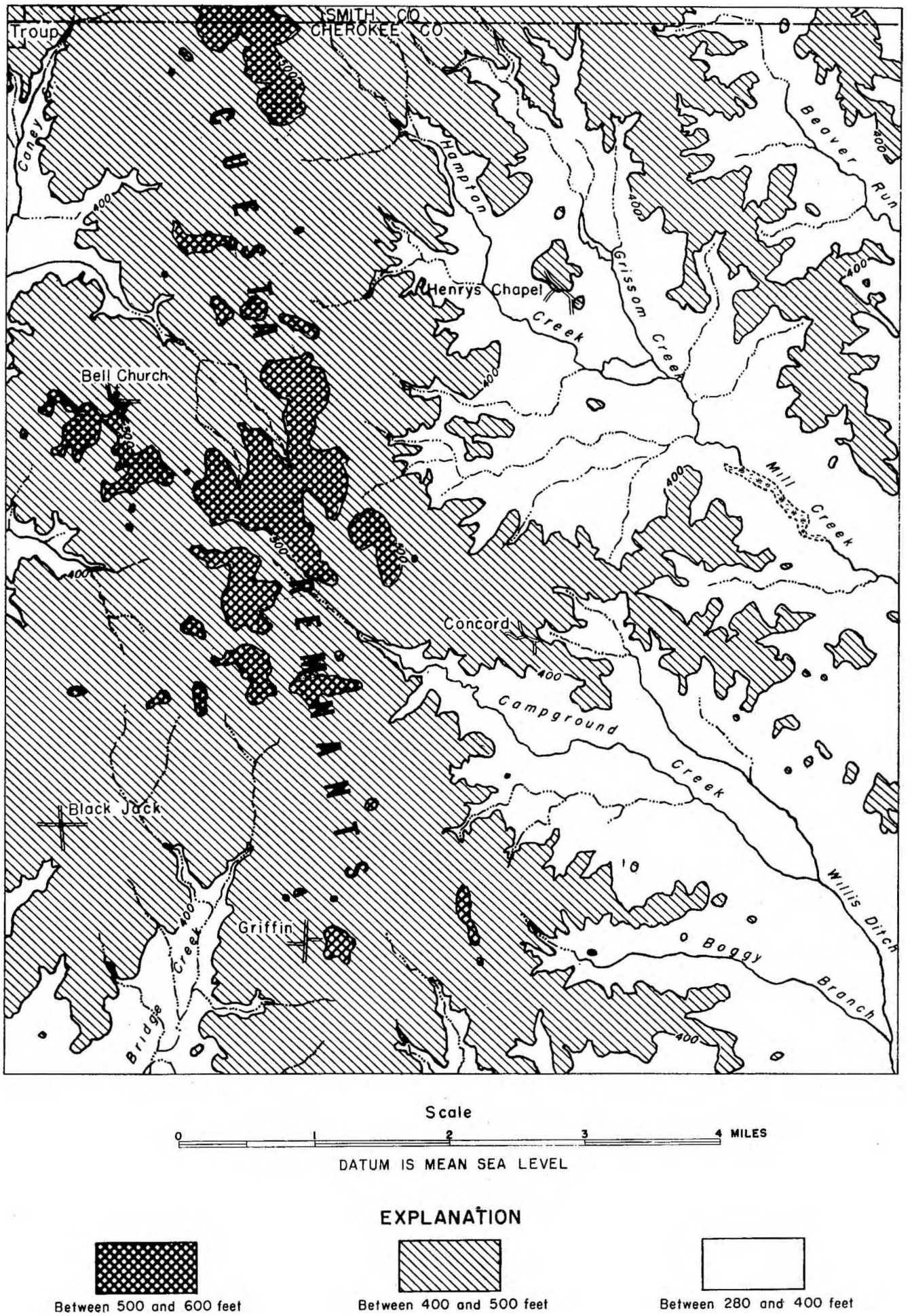


Fig. 2. Major topographic features of the Henrys Chapel quadrangle.

COLUMNAR SECTION OF THE STRATA EXPOSED IN THE HENRYS CHAPEL QUADRANGLE

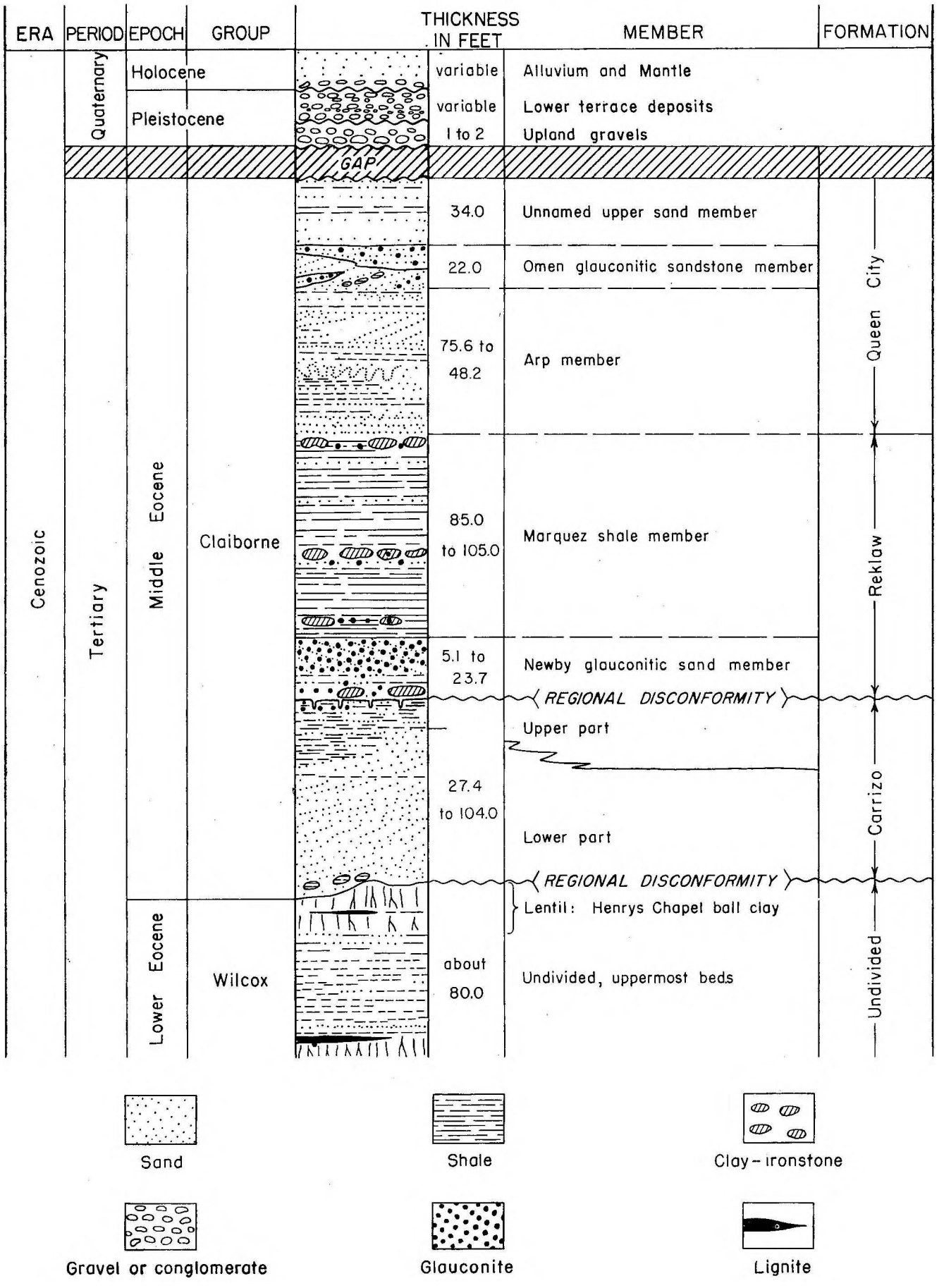


Fig. 3. Columnar section of the strata cropping out in the Henrys Chapel quadrangle.

STRATIGRAPHY

The strata cropping out in the quadrangle (fig. 3) naturally fall into two divisions, those that do and those that do not participate in the forming of the Tyler basin. Those that do are much older than those that do not.

The oldest strata that crop out in the quadrangle are the uppermost beds of the Lower Eocene Wilcox group. The youngest strata that participate in the basin-forming are the beds of the Queen City formation in the Middle Eocene Claiborne group that lie stratigraphically above the Omen member of that formation. Hence, only small parts of the Wilcox and Claiborne groups are involved.

In addition there are outcrops of Pleistocene and Holocene deposits, such as creek-terrace, flood-plain, and swamp deposits. These do not participate in the basin-forming and are quite young; some of them are still forming. Also mentioned should be the mantle of soils, subsoils, weathered rock fragments, and slope wash, which covers nearly all the area. Some of these mantle deposits are as old as Pleistocene, possibly even Pliocene, and some are forming today.

Wilcox Group

In other areas, notably the south flank of the Sabine uplift, the Wilcox group has beds of marine or at least brackish water origin and hence can be divided into formations on that basis. But in the Henrys Chapel quadrangle and immediately east of it, the Wilcox group, as exposed, is strictly nonmarine. Hence the formations recognizable farther away cannot be segregated in the quadrangle, and the group remains undivided.

The Wilcox group is several hundred feet thick in this general region and forms extensive outcrops to the east, in the Sabine uplift. However, in the area under consideration only limited and isolated portions of the uppermost 80 feet are visible and need be discussed. Nevertheless, these few feet are of great importance economically for they contain ball clay. The recognition of the ball clay as part of the Wilcox group is a result of this study.

WILCOX GROUP UNDIVIDED, UPPERMOST BEDS

Surface distribution.—Natural and artificial exposures of the Wilcox group in the quadrangle were found in small isolated places only. These are as follows, listed progressing from north to south.

(1) In the bottom and dump of an auger hole, in the woods of a 98-acre tract 20 feet east and 100 feet south of the southeast corner of a 50-acre tract, 1,130 feet west of Sanders Cemetery, 1,200 feet north of the center of location 3, 1,580 feet south of the north line and 6,850 feet west of the east line of the James Hamilton survey.

(2) In the bottom of the channel, at a sharp right-hand turn of the channel and 150 feet farther downstream, in a straight, 200-foot long stretch of the channel of that right tributary of Hampton Creek that flows southeastward past the dump heaps of the General Refractories Company clay pit, 2,400 to 2,350 feet airline distance from Sanders Cemetery in S. 80° W. direction, 1,400 to 1,600 feet northwest of the center of location 3, 220 to 450 feet south of the south fence of a 50-acre tract, in James Hamilton survey.

(3) In the clay pit of the Troup Works, General Refractories Company, located 3,275 feet in S. 81° W. direction from the church at Henrys Chapel and 850 feet north of the east-west running county road (Henrys Chapel to Bell Church), 2,850 feet south of the north line and 7,000 feet west of the east line of the James Hamilton survey.

(4) In the clay pit of the Reliance Brick Company, 1,000 feet due west of location 3 and 750 feet north of the east-west running county road, in James Hamilton survey.

(5) In the bottom and on dumps of a test well, on the slope leading northward down to the flood plain, about 100 feet north-northeast of a house 1,000 feet southwest of the center of location 3, and 200 feet north of the east-west running county road.

(6) In the clay pit of the Thermo Fire Brick Company, 3,150 feet in S. 50° W. direction from the church at Henrys Chapel, 600 feet south of the east-west running county road, 4,350 feet south of the north line and 6,100 feet west of the east line of the James Hamilton survey.

(7) Banks of a small left tributary of Mill Creek, which crosses the east-west road 300 feet east of the county road forks at elevation 356, 300 feet northeast of an abandoned saw mill, and

1,400 feet in N. 64° E. direction from location 8.

(8) In the west side ditch of the county road, which goes in a general northeast direction from Martin Chapel, at the bottom of the slope south of the swampy flood plain of Mill Creek, near Chinkapin Lake, 0.24 to 0.25 mile by road from the road fork at elevation 356, about 1.7 miles southeast of the church at Henrys Chapel, 2,750 feet east of the west line and 6,000 feet north of the south line of the Wesley Dikes survey.

(9) For about 100 feet in the channel of a nearly straight eastward-flowing right tributary of Mill Creek, which rises 0.2 mile northeast of Martin Chapel, about 1,200 feet upstream (or west) of its confluence with Mill Creek and 750 feet downstream from the pipe-line crossing, 900 feet in N. 22° E. direction from location 11, 500 feet north of the south line and 7,700 feet east of the west line of the Wesley Dikes survey.

(10) At the lower end of the slope just north of the swampy flood plain of the nearly straight eastward-flowing right tributary of Mill Creek, which rises 0.2 mile northeast of Martin Chapel, where the Pure Oil—Liberty pipe-line crosses this tributary, 1,900 feet upstream from its confluence with Mill Creek, 800 feet in N. 27° W. direction from location 11, 350 feet north of the south line and 7,000 feet east of the west line of the Wesley Dikes survey.

(11) At a place where a north-south fence crosses the channel of a lively, spring-fed, northeast and north-flowing right tributary to the nearly straight eastward-flowing branch mentioned under locations 9 and 10, 650 feet south of their confluence and 850 feet in N. 16° W. direction from an abandoned house place, 320 feet south of the north line and 250 feet west of the east line of the A. J. Wait survey, 1.71 miles due east of Martin Chapel.

(12) In two places, for 100 and 150 feet respectively, in the channel of Campground Creek, where this creek crosses the east-west boundary between the Daniel Parker and F. J. Vallanova surveys, 3,000 to 3,300 feet east of the west line of the Daniel Parker survey and from 200 feet north to 150 feet south of the east-west running boundary between the two surveys, 2.18 miles directly east of the crossroads on Farm Road 856 that has an elevation of 423 feet and is 1.85 miles south of Concord and 1.17 miles north of Emmaus Church.

It is readily noted from this list that the exposures and outcrops of the Wilcox group in this quadrangle are confined to the lowest places in the country, that is, to the creek channels or the flood plains or the immediately adjoining lowermost parts of the valley slopes. This is the effect of the very low dip of the entire Tertiary section here and of the position of this area at the westernmost end of the Wilcox outcrops, where the Wilcox group through its low dip gradually disappears under the surface of the ground.

The locations listed above readily fall into four groups: one group of exposures (1 to 6 inclusive) is in the vicinity of the clay pits; the second group (7 and 8) is on Mill Creek about 1.8 miles southeast of Henrys Chapel; the third group (9 to 11 inclusive) is on the nearly straight eastward-flowing branch about 1.7 miles east of Martin Chapel; and the last group (12) is on Campground Creek 2.75 miles southeast of Martin Chapel.

This restriction of the exposures in four small areas is in part misleading, and it is believed that much more extensive outcrops of the Wilcox group exist but are under thin but effective cover by swamps in the creek bottoms, by thin alluvial silt, sand, and clay deposits in creek flood plains, and by fairly thick slope wash that clothes the base of the adjoining hills. This effective cover is there because the outcrops of the Wilcox group are restricted to the lowest places in the country, and the lowest places are naturally those that are apt to receive a covering veneer of this kind. This condition is aggravated by the lower sands of the Carrizo formation, which overlies the Wilcox group. These sands are loose and porous and produce a deep, light gray, loose sand soil that washes readily. In addition there is perched ground water in the porous Carrizo sand where it rests on the impervious Wilcox group. The resulting outflow of the ground water in springs, seeps, and swamps increases the slope wash and gives rise to swamp vegetation, both of which make an effective cover over the Wilcox strata. The twelve exposures listed above are then only those places at which either vigorous erosion by channel-cutting creeks or excavation by machinery removed this covering veneer so that the bed-rock became visible. It is obvious that in many low places a small amount of excavating would expose strata of the Wilcox group, if these places were expertly selected.

Vegetation.—The beds of the Wilcox group in the area are largely impervious to water, but the overlying Carrizo formation, particularly the lower sands, is highly

pervious. Hence there is perched ground water above their common boundary. This water issues in many low places as seeps, as swamps, and as springs, some of which boil up strongly. Therefore the usual vegetative cover of the Wilcox group in this district is swamps and bogs. Many of the creek bottoms in the east half of the quadrangle are impenetrable swamps and bogs with interspersed small lakes extending from one side of the alluvial valley to the other. Such swamps are indicative of the presence of the Wilcox group at shallow depth below the bottom of the swamp.

The relationship of the Wilcox group, the perched ground water, and the issuing springs feeding into swamps are particularly clear at location 8. Here innumerable springs and seeps issue near the Wilcox-Carrizo contact at the foot of the hill and slightly above the level of the Mill Creek bottom for more than 1,000 feet (fig. 4). This issuing ground water produces a narrow curved strip of morass that hugs the foot of the hill at the edge of the flood plain. A spring, which boils up, and many other less vigorous springs and seeps are in the bed of a short tributary to the north; many swamps and peat bogs exist in the short northern tributaries of Mill Creek for 3,500 feet southeast of the county road bridge. However, the Wilcox group is visible only in the road ditch (location 8) and in the banks of a gully (location 7); the remainder of the Wilcox is effectively hidden by the swamps, bogs, thin alluvial cover, and slope wash of Carrizo sand soil.

Composition.—The composition of the uppermost Wilcox beds in the area is different from place to place; this condition is due to both the discontinuous nature of the beds and the erosional effect of the overlying Carrizo sand, which is discussed on pages 30–34. The best exposure, hence the best place to study the composition, is the clay pit of the Reliance Brick Company, which has been excavated deeply into a hill spur and has uncovered fresh, unweathered beds and is the deepest of the clay pits.

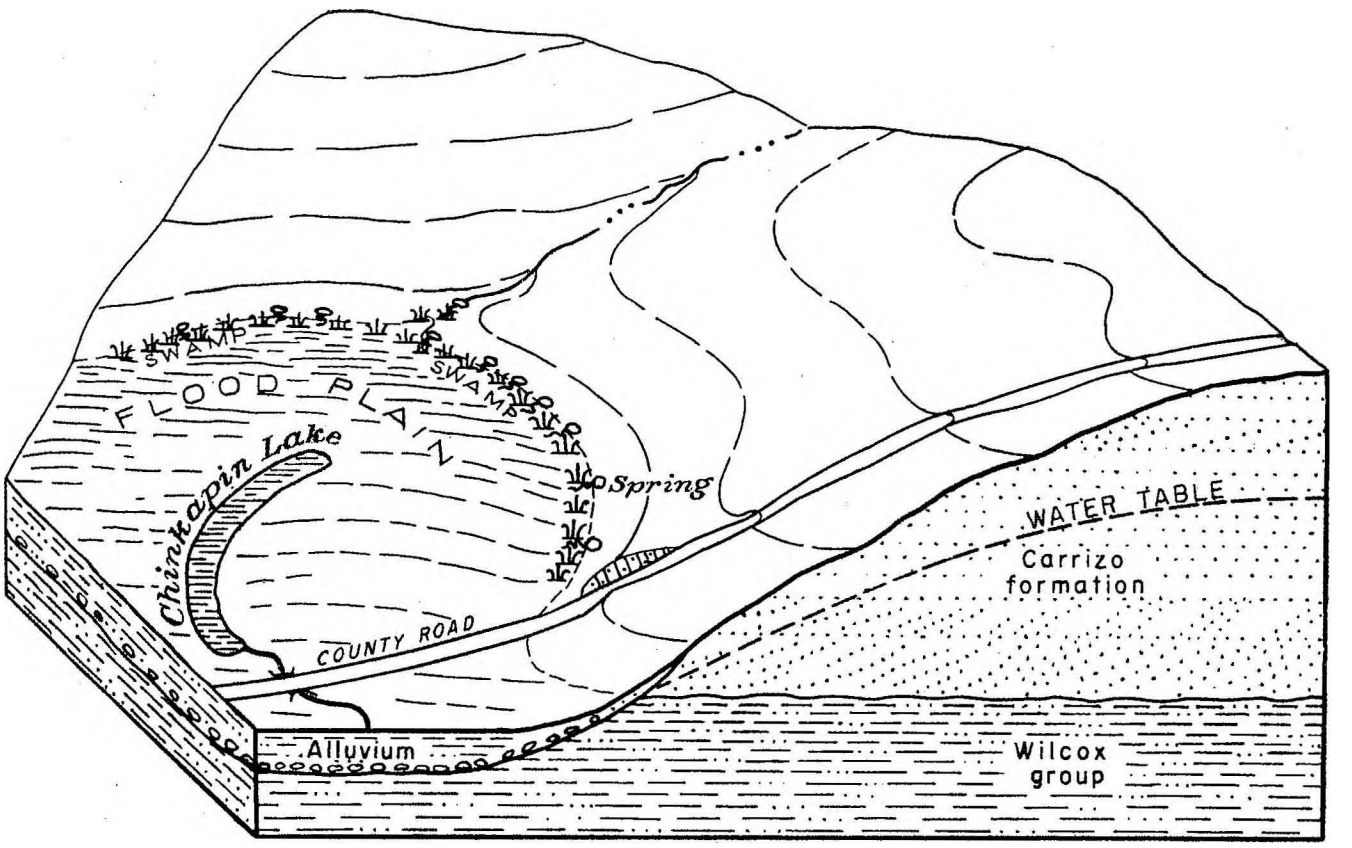


Fig. 4. Block diagram showing the ground water perched in the Carrizo sand above the beds of the Wilcox group. South side of Mill Creek at Chinkapin Lake.

In the clay pits and their vicinity, the uppermost Wilcox beds consist of the following sequence (fig. 5):

Top	Thickness *Feet*
(d) Gray ball clay	8.8 to 8.2
(c) Black ball clay grading locally into lignitic clay containing xyloid lignite	4.1 to 0.7
(b) Gray ball clay	10.6
(a) Silty clay, exposed for only 2 feet in the bottom of the Reliance Brick Company pit	2.0+

For the layers (b), (c), and (d) the name Henrys Chapel ball clay is proposed herewith. In the Reliance Brick Company pit, where the entire Henrys Chapel ball clay is exposed, it is 20.1 feet thick. This pit was opened in 1949, that is, after the work for the clay report (Stenzel, 1950) had been finished. Hence the section exposed there now was not available to the writer, and the thickness of the Henrys Chapel ball clay given in 1950 was erroneous.

The ball clay (layer (d) of the sequence) is very tough and harder than the ordinary Eocene clays, fractures usually hackly and irregular and occasionally subconchoidal, has a uniform color of light bluish gray where it is fresh but bleaches to almost white on prolonged exposure to the sun, and is devoid of any bedding or bedding parting planes. In the clay are countless vertical or nearly vertical, dark brown to black, thin but very long, lignitic tubes; their average and common diameter is 2.5 mm, although they vary from 1 to 3 mm in diameter. The tubes are composed of a central core of clay encased by one or several nearly parallel concentric outer films of lignite. Individual tubes can be traced downward for several feet at least. On tracing the tubes

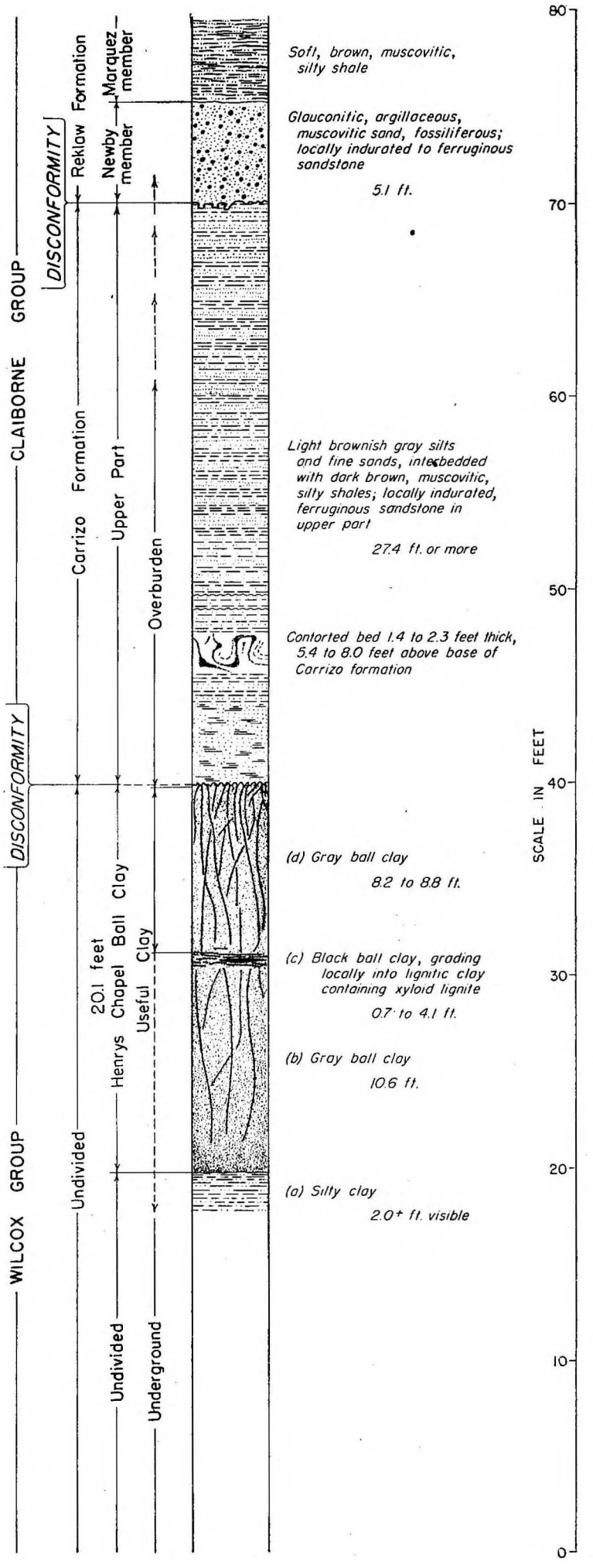


Fig. 5. Stratigraphic column of the Henrys Chapel ball clay and the beds adjoining it.

downward they are found to fork downward at acute angles of divergence, but these forks are rare. The tubes are the fossilized remains of roots of ancient plants that grew in Wilcox time upon the ball clay as a soil. Because their cores are filled with the same clay that surrounds them, the plants responsible for them must have grown and decayed during the time the clay was deposited, and the roots were filled with the clay after their decay. The clay is cut and separated into irregular, angular blocks by numerous gently inclined slippage planes. These planes are covered with glossy and finely grooved, wavy slickensides. The slippage planes dip up to 43° in various directions so that the blocks of clay that they separate have various wedge or lens shapes. The slippage planes branch here and there and some intersect each other. The amount of slippage that each one has undergone is evidently very small, and in those that could be checked by the offset of the vertical fossil roots, it does not exceed 1 or 2 mm.

A rare impurity of the clay stratum is siderite balls. These balls are heavy and up to 5 inches in diameter. They consist of many small grains of spherulitic siderite surrounded and held together by the clay. The grains are 1 to 3 mm in size and roughly spherical in shape; but where they are crowded they have small facets of contact, yet are separated by a thin film of clay. Each grain is composed of lamellar and fibrous crystals of siderite radiating from the center of the grain; individual crystals are up to 0.02 mm wide. Under the microscope the freshest of the crystals are colorless to yellowish brown, but most of them are opaque due to alteration products. In the clay matrix surrounding the siderite balls and on the boundary between clay and siderite grains and less commonly in the interior of the grains are small crystals of pyrite and possibly marcasite. The recognizable crystals are pyritohedra. The grains weather readily to a rust-brown opaque color and give the siderite balls a brown-speckled appearance. Most of the grains are weathered.

The second stratum (c of above) is 0.7 to 4.1 feet thick and similar to the overlying stratum (d). However, it is blackish from finely divided lignitic matter and lacks the fossil roots to a large extent. It too is devoid of bedding planes and grades well into the gray ball clay above and below. It is ill defined and only roughly horizontal. In the Reliance Brick Company pit the black layer is 0.7 foot thick, nearly black, and cut by many slickensided slippage planes, so that it crumbles into small angular pieces. In the General Refractories Company pit the stratum is 4.1 feet thick and consists of three roughly parallel layers: a nearly black, 0.8-foot thick layer at the top; a gray, 2.5-foot thick layer in the middle; and a black, 0.8-foot thick layer at the base. The three layers fluctuate up and down a little. The lower of the two black layers encloses lenses of xyloid lignite several feet long but only a few inches thick. This lignite is very light and fairly hard, when dry, and splintery; it breaks easily with the grain into horizontal sheets, but the cross-grain break is subconchoidal to splintery; the long-grain vertical break is similar but more splintery. The color is sooty black with a silky sheen, and the grain of the wood shows in very fine parallel streaks of silky sheen. Each lignite lens is one piece of lignitized wood flattened by compaction. Associated with the lignite is a great deal of pyrite or marcasite. Hence the lower part of the 4.1-foot thick stratum where the lignite is found in this pit cannot be used as a ball clay. No lignite has been found in the other two clay pits. In the Thermo Fire Brick Company pit the black layer fluctuates up and down considerably and extends in tongues irregularly upward into the main body of the ball clay (fig. 6). The base of the Carrizo sand, which is about 10.4 feet above the black layer in this clay pit, is flat and horizontal and entirely unaffected by the flame-like tongues in the Wilcox group be-

low. The tongues are evidence of interior motion and intermixing of the gray and black clay layers. This motion must have taken place before the Carrizo formation was laid on the ball clay, because the Carrizo is entirely unaffected by it. The tongues are evidence of ancient soil creep of the ball clay during the time the clay was deposited as an ancient soil.

The third stratum (b of above) is best seen in the Reliance Brick Company pit. There it is 10.6 feet thick and quite similar to the upper gray ball clay (d), but it lacks the slickensided slippage planes, and many of the fossil roots are filled with microscopic crystals of pyrite or marcasite producing a yellow metallic sheen. Here the downward branching of the roots is particularly well observable; but it is also seen that many of the roots in growing down into the clay and on striking an older root followed the older root for some

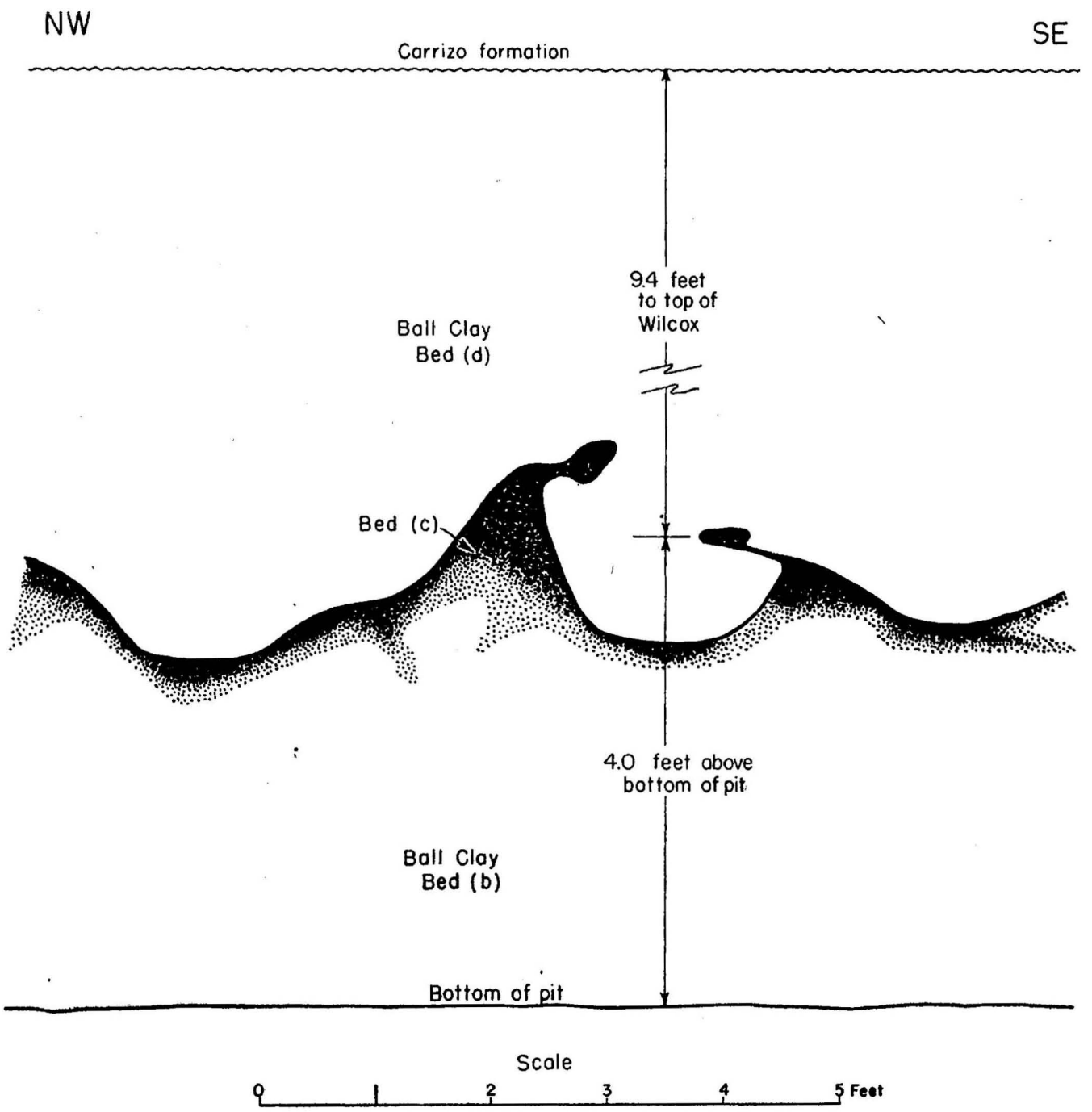


Fig. 6. Tongues of black ball clay (bed c) risen into gray ball clay (bed d) in the Henrys Chapel ball clay of the Wilcox group. Clay pit of the Thermo Fire Brick Company, near Henrys Chapel, Cherokee County, Texas.

distance. Such root junctions look as if the roots branched both upward and downward.

The fourth stratum (a of above) is visible only in the bottom of the Reliance Brick Company pit, and only the uppermost 2 feet of the stratum show. The stratum is a soft, tough, grayish-black, massive, subconchoidally fracturing, muscovitic, very argillaceous, carbonaceous silt with a few fossil rootlets, which are mostly filled with finely crystalline pyrite or marcasite.

Description of individual Wilcox exposures.—The following are local details of the Wilcox strata. The listing is by locations given on pages 11–12.

(1) The cuttings near this auger hole indicate that the whitish-gray ball clay was encountered below the Carrizo sand, which crops out at the surface. Depth and thickness data are not available.

(2) The ball clay is exposed in the bottom of the creek channel, which has cut into the clay to a depth of about 2 feet. The clay is overlain by Carrizo sand. The exposures are restricted to the channel and left bank; the right bank is composed of flood-plain deposits of the creek.

(3) In the General Refractories Company clay pit the Wilcox strata exposed by excavation are:

Top	Thickness *Feet*
(d) Ball clay, uniformly gray	8.2
(c) Ball clay, grading into lignitic clay (dark colored, 0.8 foot; gray colored, 2.5 feet; black colored and with lignite lenses, 0.8 foot)	4.1

(4) In the new pit of the Reliance Brick Company the Wilcox strata are exposed to a greater depth than anywhere else. The section exposed is:

Top	Thickness *Feet*
(d) Gray ball clay	8.8
(c) Black clay, top and bottom of bed ill defined, crumbling into small pieces along the many small slippage planes	0.7
(b) Gray ball clay	10.6
(a) Silty clay, only top part of bed visible	2.0+

(5) The dumps of the test well have ball clay. No information is available as to depth or thickness here.

(6) In the Thermo Fire Brick Company pit the Wilcox strata exposed by excavation are:

Top	Thickness *Feet*
(d) Ball clay, uniform gray	10.4
(c) Black clay, extends in flame-like tongues for 1.8 feet upward into the overlying gray clay	0.3
(b) Gray ball clay grading upward into the next layer; bottom of layer is not exposed	2.7+

(7) In the banks of an intermittent creek branch, plastic, very light greenish-brown to gray, massive clay with many rusty yellow and red stain spots, visible for a depth of about 8 feet, lies under alluvial sands and sandy clays. Down this creek branch, south of the boiling spring, weathered, light brownish-gray mottled with small orange-yellow spots, hackly fracturing, massive, slightly silty clay shows in the channel. This clay may be the weathered exposure of a fire clay, but this clay is probably not the same stratum as the Henrys Chapel ball clay.

(8) The exposures in the ditch made by the road-grading machinery are obscure, and a great deal of water is seeping out. Most of the material is a tough, light gray to nearly white, massive or obscurely thin-bedded, argillaceous silt with some tiny muscovite flakes, which has a few rusty yellow-brown and orange stains along porous channels that were made by roots of vegetation growing upon it. Some of the layers are composed of porous, less argillaceous fine sands and silts. As only 5 feet of section are visible one could not really gain a good concept of the composition of the Wilcox group at this place. True ball clay was not seen but may be present nevertheless; if present it is not the same stratum as the Henrys Chapel ball clay of the clay pits. The Wilcox strata exposed here are estimated to be 75 to 80 feet lower stratigraphically in the Wilcox group than the Henrys Chapel ball clay (compare fig. 4).

(9) A leached clay, soft, tough and gummy, almost white, is visible here to a depth of about 1 foot.

(10) In the small cut made by the pipe-line a 9-foot high exposure shows the following:

Top	Thickness *Feet*
(c) Carrizo sand soil: Loose, white to light gray, sandy soil	2.0
(b) Weathered Carrizo sand: Firm to coherent, rusty brown, muscovitic, fine-grained sand	2.0
(a) Wilcox group: Firm, dark grayish brown where freshest, light grayish-brown where less fresh, massive, muscovitic, silty clay	5.0

(11) A small, but well exposed section of the uppermost Wilcox beds is visible here. This locality is at a small waterfall, 0.6 foot high, directly under a fence. The waterfall is caused by the superior resistance of the exposed lignite bed. Here the following sequence is exposed for about 20 feet each way from the waterfall in the stream channel and is covered at the sides by various alluvial sands derived from the Carrizo sand, which is exposed farther upstream (fig. 7).

Section at waterfall at locality 11.

Top	Thickness *Feet*
Wilcox group, undivided, uppermost beds	
(d) Topmost beds not exposed	?
(c) Indurated, brittle, fracturing flat, black to brown-black, thinly bedded, shaly, impure, earthy lignite with flat pieces of black xyloid lignite (twigs?), small round pieces of highly lustrous, clear, greenish-brown resin, and countless tiny flakes (muscovite?) on bedding planes; contains thin, small, gray-brown silt lenses; cut by subparallel, vertical, closely spaced joints	0.6
(b) Firm, black, thinly bedded, muscovitic, very lignitic underclay with short slickensided parting planes and pieces of lignite	0.3
(a) Soft but very tough, plastic, massive, medium gray-brown when fresh but leaching to a light gray color, very silty underclay with vertical lignitized root imprints up to 6 mm in diameter. Bottom not visible	0.8

Downstream from this place to the mouth of this branch there are no exposures, except those of coherent, dirty rust-orange, clayey, alluvial sands at the banks of the channel. Upstream there are several steep banks showing loose, dark brown when fresh, fine-grained sands with a few chocolate-brown, thin shale partings that are exposures of the Carrizo formation. The clay here is not the same stratum as the Henrys Chapel ball clay.

(12) Exposed to a depth of about 1 foot is a firm and tough, slightly plastic, whitish-gray to very light brownish-gray with orange-yellow and orange-red stains, massive, slightly muscovitic, very argillaceous silt and argillaceous very fine-grained sand.

Subsurface distribution.—In June 1947 a geophysical crew drilled 53 shot holes in the region to the north of the clay pits. The area covered by them begins in the south along Farm Road 13 and extends northward to the county line. All holes were drilled rapidly with a fishtail bit. No notes were kept by the drillers during the drilling, but driller's logs were written at the end of the day from memory alone. Hence too much reliance was placed on their memories, and errors were unavoidable particularly because drilling was very rapid. Also the drillers were not trained in the recognition of the strata through which they were drilling nor were they familiar with the area. Therefore the records of these shot holes are not too reliable. However, these shot holes and their driller's logs are the only subsurface information available and are useful to some extent.

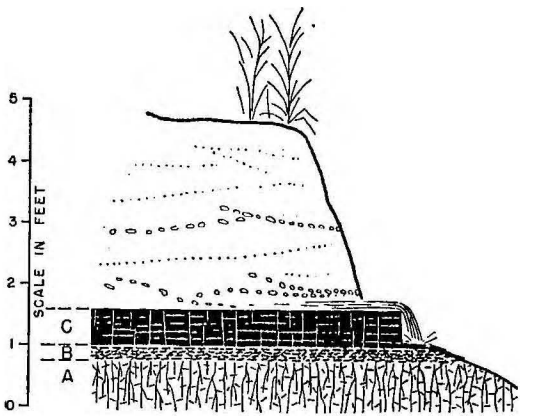


Fig. 7. Exposure of the Wilcox group at the small waterfall (locality 11), northeastern Cherokee County, Texas.

A few of the holes were drilled while the writer was present and were recorded reliably at that time. The cuttings of the other holes were inspected too and afforded some observations as to the nature of the strata drilled through. All data concerning these shot holes are contained in a previous paper on the ball clay (Stenzel, 1950, pp. 31–37).

The shot holes prove the great underground extent of the Henrys Chapel ball clay or of ball clay-like silty clays north of the clay pits. For instance, shot hole 50 located 1.81 miles north of the church at Henrys Chapel encountered an almost white ball clay with small slippage planes at a depth of 49 feet. It is rather important to know that the Henrys Chapel ball clay extends that far underground, because this fact indicates that the ball clay or similar clays may have a large distribution and hence may be available elsewhere.

Paleontology.—The only fossils found in the Wilcox group of this area are plant remains, such as the lignitized root traces in the Henrys Chapel ball clay and pieces of xyloid lignite in the middle part of the ball clay. Interesting are the small lustrous pieces of resin associated with lignite found at locality 11. The Wilcox group of this area is evidently nonmarine.

Under the microscope thin sections of the Henrys Chapel ball clay show longitudinal sections of the fossil roots, which are about 7 mm long and are 3.2 mm wide at one end and 1.6 mm at the other. The walls are made up of 3 rings or layers of organic remains, in which are several rows of cells, from 4 to 14 microns across. The central vascular tissue which is fossilized was torn in making the thin section. The core is about 4 mm across with about 6 or 7 rows of cells or cell walls on either side of the center line. The cell wall bands of the core are of the same general width as the above except for a resin(?)-filled tube about 0.3 mm wide. In cross sections of the root tube the clay particles filling the center are arranged in a radiating spherulitic pattern in wedge-shaped areas of simultaneous extinction under crossed nicols.

The microscopic study confirms the vegetal nature of these bodies and the presence of clay fillings. The roots are apparently roots of herbaceous rather than woody plants. (Description by Mrs. Kathryn O'Neill Dickson.)

Claiborne Group

CARRIZO FORMATION

Distribution.—Outcrops of this formation are extensive and occupy the eastern half of the area mapped roughly east of a north-south line going through Henrys Chapel and Concord. East of the mapped area Carrizo outcrops extend for many miles and form large outliers around Henderson in Rusk County. The westernmost exposures of the Carrizo are found in the mapped area in the creek bottoms and their channels and are listed below in sequence going south (Pl. I).

In the channel of Grissom Creek the northwesternmost exposure is in a meander, convex to the north, 1,500 feet south of the Smith-Cherokee County line, 5,550 feet northeast of the nearest point on Farm Road 13, and 6,100 feet due north of the Hampton Creek bridge on that road. Interbedded silts and shales of the upper Carrizo are exposed in the channel for about 250 feet and are overlain by flood-plain alluvium.

In the channel of Hampton Creek the northwesternmost exposure of Carrizo is on the right bank where the creek swings against the western edge of its valley to form a small bluff, just below a wagon road ford, 1,100 feet northeast of a farm house, 1,800 feet northeast of the nearest point on Farm Road 13, and 2,850 feet upstream from the bridge of that road over Hampton Creek. Here the Carrizo formation consists of 3.4 feet of carbonaceous shale with fine silt partings and is overlain by 2.8 to 4.0 feet of glauconitic sands of the Newby member; this in turn is overlain by alluvial gravel and clay.

In the creek which flows past the north end of the General Refractories Company clay pit, the westernmost Carrizo is exposed in the channel and a small bluff on the left side of the creek, 5,050 feet west of the church at Henrys Chapel and 2,150 feet south of the nearest point on Farm Road 13.

In the branch that flows eastward between the two clay pits, the westernmost Carrizo is exposed in two bluffs, one on each side of the branch, 2,250 and 1,950 feet west of bench mark 357.

In Campground Creek the westernmost exposure of the Carrizo formation is in a bluff on the left bank, 3,000 feet southwest of the church at Concord and 2,650 feet west of Farm Road 856. Thin-bedded brown very fine-grained sands with shale partings are visible here.

In a right tributary of Campground Creek the westernmost Carrizo is exposed for 500 feet in the deeply cut meandering channel below a waterfall with a deep pool, 5,950 to 5,600 feet south-southwest of the church at Concord and 3,000 to 2,500 feet west of Farm Road 856.

On Boggy Branch, in the southeast corner of the area, the westernmost clear exposure of the Carrizo sand is a 10-foot high bluff on the left bank at a meander convex to the north, 2,250 feet south and 1,900 feet east of the rectangular crossroads at elevation 423. The bluff is 200 feet southwest of an abandoned house site on top of a small Newby outlier. The Carrizo sand extends farther up the creek from this bluff for about 1,400 feet, that is, nearly to Farm Road 856 but shows only by soils and topographic features.

The westernmost exposures of the Carrizo sand in the southwest part of the area mapped are in the channel of Bridge Creek and one of its left tributaries beginning at a place 3,000 feet west-southwest of the cemetery at Griffin and 1,100 feet south of the bridge over the creek on the county road that goes west from Griffin to State highway No. 110 and extending slightly beyond the south margin of the map (fig. 12). Here in the meandering channel of the creek and its left tributary the uppermost beds of the Carrizo formation are cut into below the Newby member of the Reklaw in six separate places; the exposures are clearly inliers of the Carrizo. The first of these inliers in the channel of Bridge Creek is only about 60 feet long, the second about 100 feet, the third

is curved in the form of a reverse S-curve and about 250 feet long, the fourth is winding and the longest, extending for about 600 feet; the fifth is south of the south margin of Plate I. The sixth inlier is about 60 feet long and is in the bottom of the channel of the left tributary of Bridge Creek, at the base of a high bluff on the south bank of the tributary, 1,300 feet airline distance east of the entry of the tributary into the creek. The width of the exposures is the width of the channel. The exposures are particularly important because they are the westernmost of all the Carrizo exposures in the mapped area and are of a different facies than all other Carrizo exposures. They are also the only known inliers of the formation in the mapped area. The section exposed here is described on pages 44–45 (fig. 24).

Topography.—By virtue of the high porosity of the deep loose sand soils developed on the Carrizo formation and the high porosity of the formation itself, the resistance to erosion is high, and steep slopes are maintained by the Carrizo sand, or rather were maintained as long as the land was not plowed or excessively grazed.

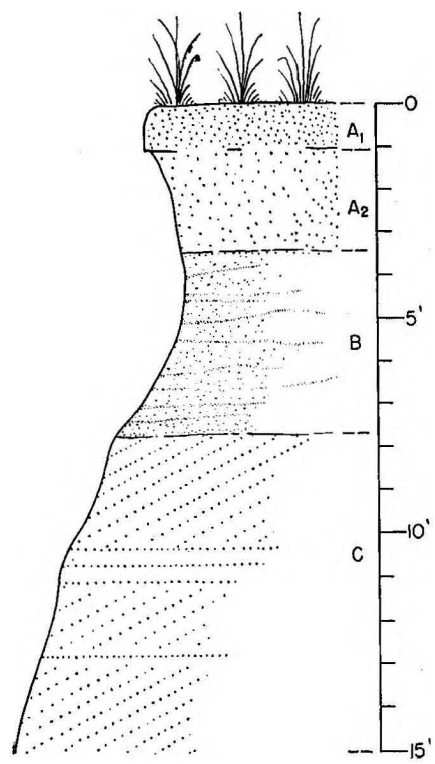


Fig. 8. Soil profile of lower part of Carrizo formation on east-west county road, 0.35 mile west of Beaver Run and 1.07 mile north of Farm Road 13.

As a whole the upland underlain by the Carrizo formation is a gently rolling dry hill country with low broad hills of an average slope of 90 feet per mile and broad, dry drains between them. Near the creeks the slopes quicken and become on an average 350 feet per mile along the deeper creeks. The major creeks in the Carrizo outcrop area have flat, swampy flood plains 0.1 to 0.2 mile wide.

Soils and vegetation.—Soils developed on the Carrizo formation are excellent examples of the podsol series. This series is characteristic of temperate humid climate and porous substrata.

The major part of the Carrizo formation is composed of porous, medium to fine-grained sands. On these sands the soil cover consists of a deep loose sand soil, ashy gray when dry or light brownish-gray when wet, which is the top soil or zone A of the soil profile. The subsoil or zone B is light gray-brown and only slightly clayey. Road cuts or other exposures of this soil profile are exceedingly rare, because few of the cuts extend through the deep loose top soil, which in places is from 3.5 to 5.0 feet or more in thickness and washes readily. A typical soil profile is exposed in the deep cut of the east-west county road, 0.35 mile west of Beaver Run and 1.07 miles north of Farm Road 13 (fig. 8).

Soil profile of lower part of Carrizo formation.

	Thickness *Feet*
(A_1) Loose, light brownish gray when wet, ashy gray when dry, unstratified, very porous, fine-grained sand. pH = 6.5	1.1
(A_2) Loose, light grayish yellow-brown unstratified, very porous, fine-grained sand. pH = 6.0	2.4
(B) Loose, light gray-brown with darker brown streaks, unstratified, porous, fine-grained sand; the streaks are ¼ to 1 inch thick, medium rusty brown and slightly clayey. pH = 5.5	4.3
(C) Coherent, pale rusty orange-brown, cross-bedded, porous, clean, medium to fine-grained sand, exposed down to level of road. pH = 5.0	7.3

This soil profile was measured in the road cut at the south side of the road. However, on the other side of the road, both the A and B horizons are much thicker; horizon A is 4.8 and B is more than 7.9 feet thick but its base is not visible. Hence in some places the top soil, horizon A, and the subsoil, horizon B, of the Carrizo sand are more than 12.7 feet thick. The soils of the Carrizo sand probably are the thickest of all the sand soils developed on the Eocene formations in this area.

The smaller, upper part of the Carrizo formation consists of interbedded porous silts and very silty shales. Because of the greater content of clay in this part the sandy top soil is very much thinner. Hence road cuts commonly reveal the subsoil and weathered rock beneath.

The soil profile given below is exposed in a gullied field road that ascends a hill of 440 to 420 feet elevation above sea level, at the right angle turn of the county road that crosses Beaver Run, 0.55 mile west of Beaver Run and 1.07 miles north of Farm Road 13. The hilltop bears a cap of Newby glauconitic sandstone, which was used as road metal. Hence the soil developed on the upper Carrizo formation here is strongly influenced by slope wash from the Newby sandstone and is not typical for the upper Carrizo formation. However, in the area investigated every other visible soil profile of the upper Carrizo was similarly influenced by remnants of the Newby sandstone or terrace and slope wash materials derived from that sandstone. In this sense the profile given below is characteristic if not typical (fig. 9).

Soil profile of upper part of Carrizo formation.

	Thickness *Feet*
(A) Loose to friable, brownish-gray, slightly clayey sand soil without bedding, containing very many irregular and subangular residual boulders and pebbles of brown, weathered, glauconitic Newby sandstone, mostly ¼ inch in diameter but ranging up to 3 inches. pH = 6.5	0.9
(B) Crumbly, dirty orange-yellow to dirty red-brown, clayey silt with desiccation cracks and without bedding, containing some very small residual fragments of the Newby. pH = 5.5	0.8
(C) Coherent, striped dirty orange-red and gray, silty shales and silts, falling into crumbly blocks of 2 to 3 inches size, bottom not visible. pH = 5.0	4.2

The original vegetation of the Carrizo formation was a nearly continuous cover of oak forest with sparse underbrush or of a mixed oak and pine forest. The individual trees were widely enough spaced to leave small bare sand flats between them. Remnants of this forest cover are not extensive because most of the land has been cleared for plowing. In the last two decades some of the cleared fields have reverted to pasture. Much of the cleared area has been terraced, and contour plowing is practiced fairly commonly.

Composition.—The Carrizo formation can be divided into two parts for convenience of description. The major, lower part consists of cross-bedded or lenticular, chiefly fine-grained, occasionally medium to fine-grained, clean, very porous sands. Their color when fresh is very light brownish-gray due to an admixture of finely divided carbonaceous or lignitic matter. The weathered cross-bedded sands assume various iron-stained colors, among which pinkish or flesh colors predominate. The bedding is water-laid cross-bedding; the cross-bedding makes angles of up to 24 degrees with the horizontal. The horizontal bedding planes separating the cross-bedded

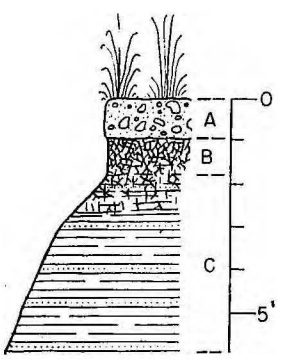


Fig. 9. Soil profile of upper part of Carrizo formation in gullied field road at right-angle turn of county road which crosses Beaver Run, 0.55 mile west of Beaver Run and 1.07 mile north of Farm Road 13.

layers are from 0.3 to 1.7 feet apart, averaging mainly 0.7 foot. Porosity is high; the sands are loose, and cementing material is lacking in most places. Only through weathering, a weak ferruginous cement is produced, which discolors the weathered sands and may turn them into friable sandstone. Because this part of the Carrizo sand is so lacking in coherence, it washes very readily as soon as the protective cover of vegetation is destroyed; hence exposures of it are very rare and do not stand up long.

Near the base of the lower cross-bedded Carrizo sands, shale-pebble conglomerates are locally abundant. Such shale-pebble conglomerates were seen (1) in the ditch on the south side of Farm Road 13 (Troup—Henderson road) 1.22 miles east of the church at Henrys Chapel and in gullies cutting the base of the southeast slope of the hill spur 350 to 500 feet northwest of the road ditch, in the east corner between Farm Road 13 and the north-south county road that branches off there; (2) in gullies cutting the base of the west slope of the Carrizo hill of 420 to 440 feet elevation, on the east side of Grissom Creek, 1,650 feet north of Farm Road 13; and (3) in the cove-like bluff made by a former meander of Hampton Creek at the base of the south slope of the hill spur, separating Hampton from Grissom Creek, 1,300 feet south of Farm Road 13 and 1,750 feet east of Farm Road 856 (see fig. 53 on p. 102). The three localities are within three-fourths of a mile from each other and outline an area of basal Carrizo sand that has abundant shale pebbles. The shale pebbles are flattish and their edges are well rounded. Most pebbles are less than an inch in length, but such cross sections as 2 by 3, 2½ by 4½, 3 by 7, 2 by 15, 1½ by 16, 4 by 19, 5 by 27, and 7 by 13 inches have been measured. Arrangement is either regular following the cross-bedding or highly confused. The shale pebbles are derived from the Wilcox group and are mostly composed of gray or brown, laminated, silty, slightly muscovitic clay shales, which change to whitish-gray or more rarely purplish-red on weathering; some are probably pieces of the Henrys Chapel clay. Such shale-pebble conglomerates are much rarer in the upper Carrizo, and their pebbles are smaller.

Toward the top of the Carrizo formation the grain size decreases, and silty shales make their appearance. This change is, however, gradual and does not take place at the same stratigraphic level in different localities. Hence there is no sharp demarcation between the upper and the lower part of the formation.

The upper part of the Carrizo formation consists of an interbedded sequence of porous very fine-grained sands and silts, clayey or shaly silts, and silty shales, all carbonaceous to some extent and level bedded. Induration and cementation are variable, but owing to the argillaceous cement and the abundance of shale, the sequence as a whole is normally firm, although many of the silt beds are loose, porous, and free of cement; hence it stands up comparatively well under active erosion. This is the reason for the abundance of excellent exposures of this upper part in ditches and roadcuts; such ditches and cuts stand up fairly well and exposures remain visible for a long time. Coherence of the upper part of the Carrizo in the ball clay pits is such that chunks and even large blocks of it may fall down from the walls and retain largely their coherence and shape. Locally the sandy beds in the upper Carrizo are cemented by limonite into hard, harsh, black-maroon to blackish-brown to rusty brown or yellow to variously orange-red, usually massive or irregularly bedded, ferruginous sandstone of variable thickness. Such rock is important as road metal and building stone and as an objectionably hard part of the overburden of the ball clay.

Color of the upper part of the Carrizo formation is dependent on the amount of carbonaceous or lignitic matter present.

The freshest unweathered upper Carrizo has a medium to dark gray to brownish-black color, streaked according to the bedding. The darker layers may grade even into sooty black if finely divided lignitic matter is abundant. The darker layers are usually the more shaly ones and weather at first to a chocolate-brown, which gradually bleaches on exposure to the sun, and weather finally to a light gray. The freshest silty layers have a grayish color from finely divided lignitic particles; there is also a slight bluish cast to this color perhaps due to finely divided marcasite or pyrite. Weathering is very rapid, as can be seen in freshly excavated walls of the clay pits where the sand layers soon become discolored by limonite to a depth of a few millimeters. The weathered colors of the silts vary from dirty rust yellow-brown to orange-red and dark rusty red-brown, the most common color. These colors produced by weathering of the upper Carrizo are usually bright and thinly banded in gray and dark rusty red-brown due to the interbedding of shales and sands.

Bedding is even, level, extensive, and thin in the upper Carrizo. Most of the silt beds are less than half an inch thick. Individual layers no more than 2 inches thick can be traced in the General Refractories Company clay pit nearly through the whole excavation, that is, for at least 400 feet. The bases of some of the thicker sand layers show a slight amount of bulging caused by channeling. Ripple-mark bedding is present and can be recognized in vertical section by the small lenses of sand, half an inch thick and 2½ inches long, that are strung up in a horizontal continuous layer and are bounded on top and bottom by wavy shale partings. One grayish-black, more lignitic shaly layer visible in the General Refractories Company pit is penetrated by countless gray, silt-filled fossil burrows of 3 to 8 mm diameter.

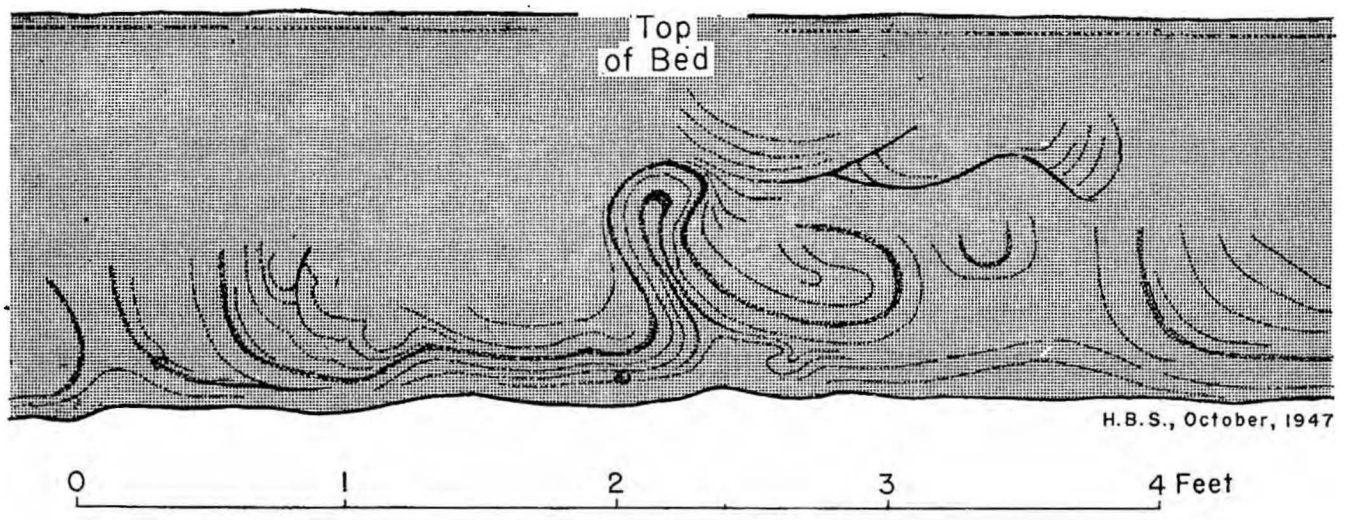


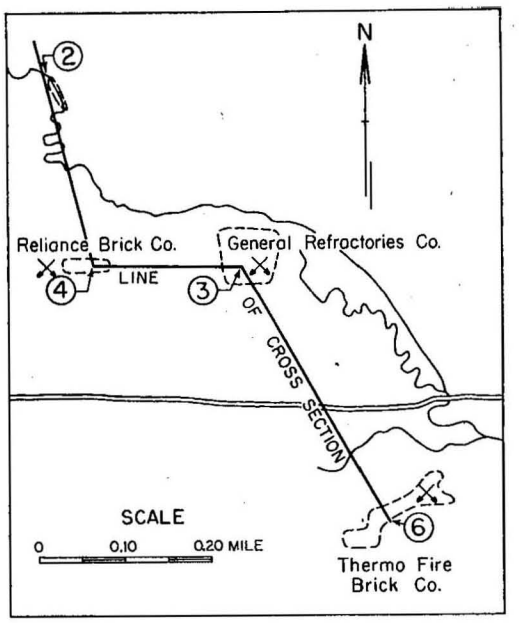
Fig. 10. Contorted sand bed in upper part of Carrizo formation. Clay pit of General Refractories Company near Henrys Chapel, Cherokee County, Texas.

Contorted bedding is present in only one layer, one of the thicker sand layers of the upper Carrizo (figs. 5, 10, 11, and 18). The layer is present only in the immediate vicinity of the clay pits where it is visible in the three clay pits (locations 3, 4, and 6) and in the channel of the creek to the northwest (location 2 of p. 11). The distribution proves that it is traceable for at least 3,500 feet from the northwest to the southeast, although its maximal observed thickness, in the Reliance Brick Company pit, is only 2.3 feet. In all three places it occupies the same stratigraphic position, 5.4 to 8.0 feet above the Carrizo-Wilcox contact (fig. 11).

Thickness and stratigraphic position of the contorted layer in the upper part of the Carrizo formation.

Location	Thickness of contorted layer, *in feet*	Distance from top of contorted layer to base of Carrizo, *in feet*
(2)	1.4 to 1.7	7.4
(3)	1.5	5.4
(4)	2.3	8.0
(6)	1.5	5.9

The contorted bedding is apparently caused by subaqueous sliding that took place shortly after deposition of the layer but before the succeeding bed was laid down, because all succeeding beds are undisturbed and level bedded. At no other place in Texas has contorted bedding been observed in the Carrizo formation.



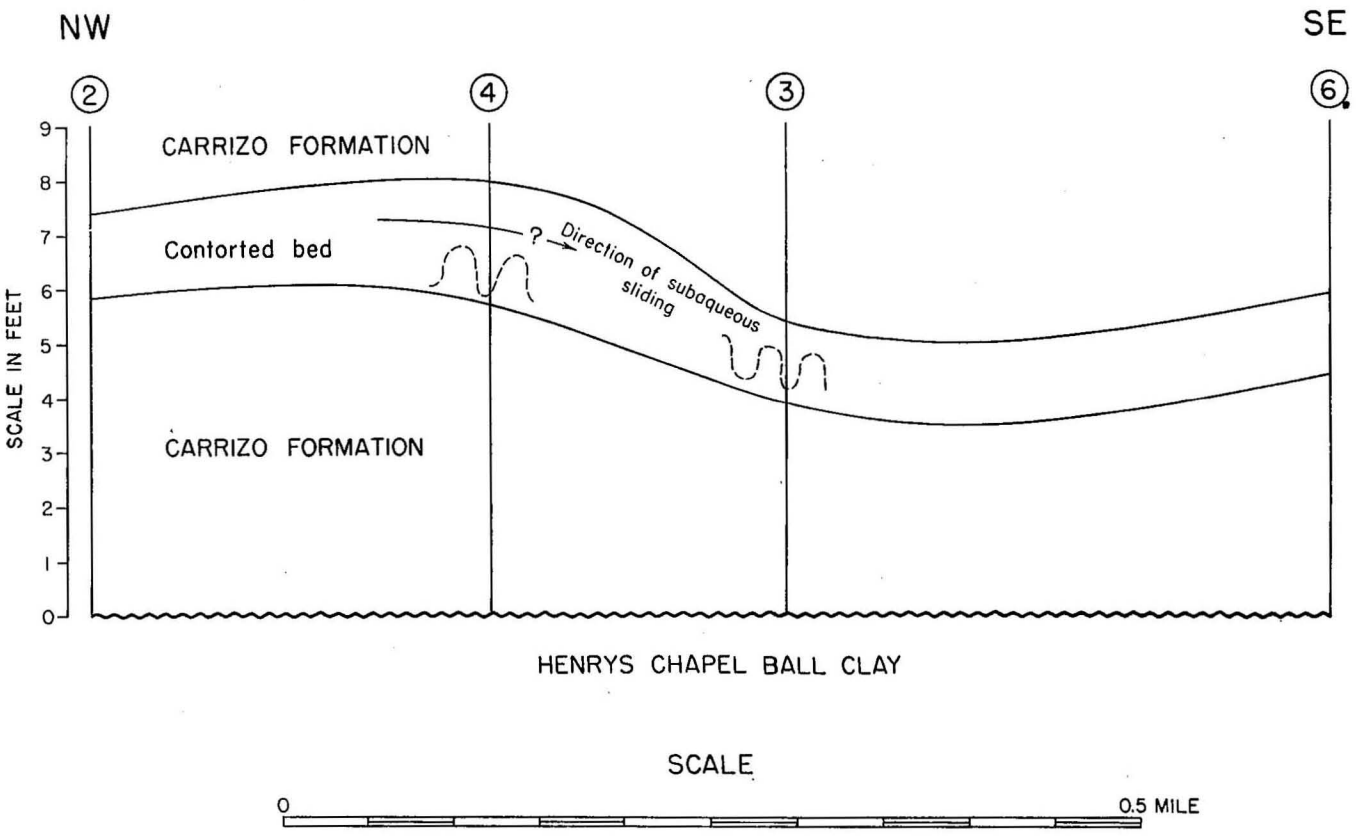


Fig. 11. Stratigraphic position of the contorted sand bed in the Carrizo formation near Henrys Chapel, Cherokee County, Texas. Compare also figs. 3, 10, and 18.

Massive bedding is rare in the upper Carrizo section; it was found only in a few places. One of these is the bottom layer of the Carrizo in the three clay pits and the creek channel (location 2). The layer is 2.5 to 2.8 feet thick, massive to indistinctly bedded; its more argillaceous, darker, and more lignitic parts are discontinuous clouds extending rarely for more than 1 inch laterally; the more sandy, lighter colored, less lignitic parts have obscure sandy pipes or burrows(?) that weld the whole into a massive indistinctly bedded unit. The bed is a slightly muscovitic, argillaceous, lignitic silt or very fine-grained sand with lenses of xyloid lignite.

Another place showing massive bedding is a 6-foot high bluff on the right bank of a right tributary of Campground Creek, at a meander convex to the southeast, 1,200 feet west of Farm Road 856 and 5,150 feet south of the crossroads at Concord. The upper Carrizo here is a blocky, indurated, brownish-black, massive, argillaceous and carbonaceous siltstone or silty claystone with conchoidal fracture cut by vertical joints.

Under the microscope this claystone consists of about 22 percent angular fragments of quartz and muscovite plates with a few grains of zircon, tourmaline, biotite, rutile, hematite, and limonite in a matrix of brownish color probably composed of clay and lignitic matter but unresolved by the microscope. The quartz grains are 0.02 to 0.14 mm in diameter; their average diameter is 0.05 mm. Bedding is indicated in the thin section by the parallel arrangement of quartz and mica fragments. (Description by Mrs. Kathryn O'Neill Dickson.)

In these interbedded sands and silty shales of the upper Carrizo, muscovite is fairly abundant on most bedding planes, perhaps slightly more abundant than in the overlying Newby member of the Reklaw formation but definitely much less abundant than in the Marquez shale member. Lignitic matter finely divided is present everywhere and may become abundant in some thin layers. The shales generally have more of it than the sands. Small pieces of black lignite are not uncommon on bedding planes, and some fossil leaf imprints were seen. Slightly larger lenses of brittle, sooty black, silkily lustrous, xyloid lignite are frequent in the base of the massive, 2.5-foot thick basal layer of the Carrizo in the General Refractories Company pit, where they occur in the basal 0.1 foot right above the Wilcox contact (fig. 15). They are up to 3 mm thick and up to 3 cm long and taper out to very thin ends at their margins. These feather-edge margins prove that this lignite is syngenetic lignite and not lignite pebbles derived from the underlying Wilcox deposits. Marcasite dust is probably present in all layers, contributes to the bluish cast of the sand layers where they are fresh and unweathered, and is the cause of some of the rapid weathering. Marcasite concretions are the only concretions present but are nonetheless rare. They are silty and up to 2 inches in diameter; they were found only in fresh excavations, in the contorted bed, and in the basal, 2.5-foot thick, massive layer of the Carrizo in the General Refractories Company clay pit.

Tectonic joints are present at a few places, notably in the more sandy layers of the Carrizo in the Thermo Fire Brick Company clay pit, where the parallel and vertical joints stop at the more shaly breaks of the sequence. Also the silty claystone mentioned above is cut by joints. Coherence of these strata is just strong enough to allow jointing to develop.

Ferruginous sandstones.—Locally sandy portions of the upper part of the Carrizo formation are highly indurated through infiltration of limonite into the pore spaces between the sand grains. Such ferruginous sandstones are hard and harsh and black-maroon to blackish-brown to rusty dark brown to ocher-yellow in color but do not tend to orange-red or other reddish colors. Bedding is variable from place to place; massive as well as well-bedded or ripple-marked sandstones are present. Some layers have abundant muscovite flakes. In some of these sandstones are layers of small flat shale pebbles; usually these pebbles have been altered by weathering to an earthy ocher-yellow or brown limonitized clay or the pebbles have been partially or wholly removed leaving cavities.

Under the microscope, bedding is indicated in the thin sections by the long axes of the quartz grains and mica flakes being largely parallel, also by those of the limonitized clay pebbles, and to a lesser extent by areas or streaks of greater concentration of quartz grains or limonitized clay pebbles. The detrital grains of quartz are angular to subangular; many are flat or lenticular in cross section. They range in size from 0.08 to 0.36 mm and average about 0.15 mm in greatest dimension. The largest grains are no more rounded than the average-sized ones. Each grain has a coating of garnet-red iron oxide at least 0.01 mm thick. The detrital flakes of muscovite are 0.2 by 0.02 mm

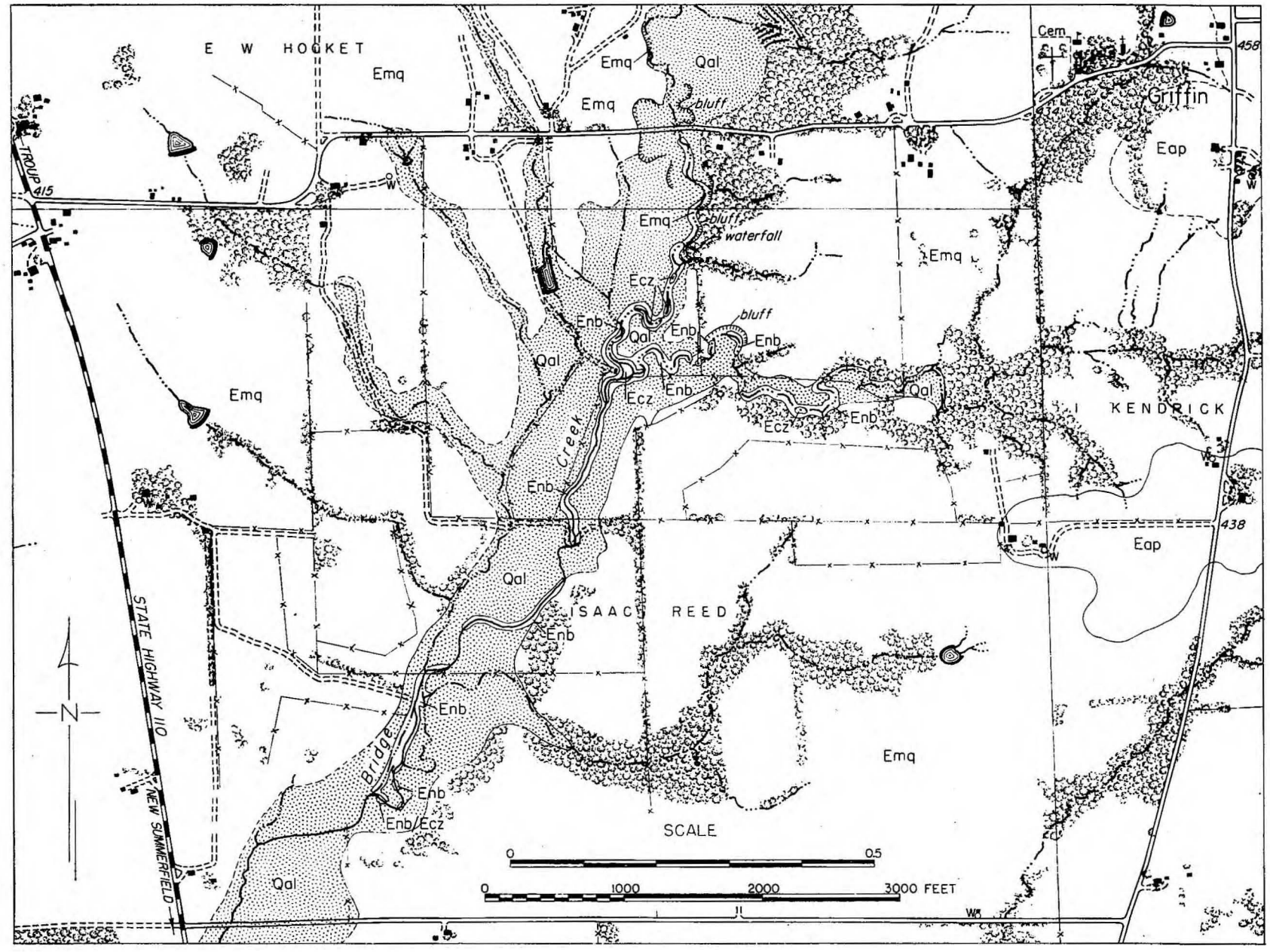


Fig. 12. Geologic map of the Bridge Creek area southwest of Griffin, Cherokee County, Texas.

The major, northern part of the area represented on this figure is also shown on Plate I, but at a smaller scale. On Plate I the colored patterns of the exposures of the Emq and the Ecz in the channel of Bridge Creek are wrong; however, the letter symbols Emq and Ecz are correctly applied.

in size as an average and are also coated. Some flakes have limonite (or hematite?) intercalated between the laminae. Several of the iron oxide grains suggest by their appearance that they may have originally been muscovite flakes. There is a trace of hematite in grains smaller than the average quartz; they too are coated with garnet-red iron oxide. There are two kinds of limonite pebbles or granules. The larger are flattish pebbles (up to 6 by 5 by 2 mm) which include fine grains of quartz and muscovite, 0.02 to 0.04 mm in size, and were probably originally shale pebbles which are now thoroughly impregnated with limonite. The smaller limonite granules are of the size of the quartz grains, roundish, contain no inclusions, and show no particular structure. Because of their lack of structure it is unlikely that these granules be weathered glauconite. There is a trace of detrital grains of dark minerals and of alkali feldspar, but none of plagioclase. The matrix is a red ferruginous cement which may also contain an unrecognizable amount of clay. The dark red portions of the cement matrix have visible interstitial voids, but the lighter, yellow-orange portions do not and fill the pore space between the detrital grains completely. The average volume relations of the constituents are 69 percent (90 to 52 percent) for the limonite and clay, 28 percent (41 to 10 percent) for the detrital grains, chiefly quartz, and 4 percent (7 to 0 percent) for the unfilled pore spaces. (Microscopic description by Mrs. Kathryn O'Neill Dickson.)

Less strongly indurated portions of the upper Carrizo are hard to friable, dirty orange-red or rusty yellow and brown, massive or thinly bedded, muscovitic fine-grained sandstones.

These indurated portions of the Carrizo formation are not extensive. One lens that is particularly well exposed is 450 to 1,050 feet north of Farm Road 13, in Wesley Dikes survey just outside of the southwest corner of the T. A. Pratt survey, 2.35 to 2.5 miles east of the church at Henrys Chapel. The size of this lens is 850 by 400 feet, and it is about 10 feet thick (Pl. I). Such a size is probably about the maximum attained by the indurated portions of the Carrizo formation. In the General Refractories Company clay pit, at the top of the south face of the pit, a 2.1-foot thick, very hard and harsh, black-maroon to rusty dark brown, massive, ferruginous sandstone ledge was uncovered in October 1948. This ledge was lenticular and wedged out northward; it was uncovered only when the south face of the pit had been moved far enough back into the hill spur. In other places the entire indurated portion of the upper Carrizo consists of a few large blocks that have been freed by weathering. Thicknesses of such indurated portions are from 1 to 10 feet only. These ferruginous sandstones are important as sources of road metal and local building stone. Hence they are shown by a special symbol on the map (Pl. I).

Glauconitic upper part of Carrizo formation.—In the channel of Bridge Creek and one of its left tributaries near the southwest corner of the mapped area (see description of locality under "Distribution" and fig. 12) are several inliers of upper Carrizo of a facies not found elsewhere in the area mapped. Here only 5.4 feet of uppermost Carrizo is exposed; the upper bed, 2.3 feet thick, is a muscovitic, silty, carbonaceous shale and the lower bed, exposed to a depth of 3.1 feet, is a peculiar dark grayish chocolate-brown, massive, slightly glauconitic, very argillaceous, fine sand containing a few imprints of mollusks. A few hard, rusty yellow-brown concretions having a hard, ½-inch thick shell and a soft core of very silty clay-ironstone are present in the upper bed and stand obliquely or vertically in the bedding (fig. 13). The section exposed at this place is described in detail on pages 44–45 (fig. 24).[2]

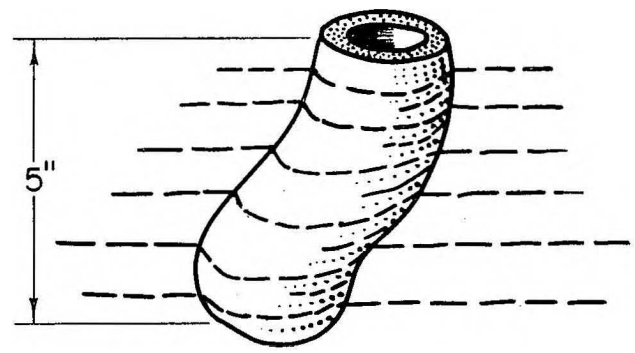


Fig. 13. Oblique and hollow silty clay-ironstone concretion in the upper glauconitic part of the Carrizo formation. Channel of Bridge Creek southwest of Griffin, Cherokee County, Texas. The concretion is broken open at the top.

Thickness.—Thickness data were obtained from favorable exposures and outcrops by alidade or hand level and from geophysical shot holes. These data demonstrate the formation to be highly variable in thickness.

The smallest thickness recorded is 24 feet in geophysical shot hole 50. As this figure is unusually small and from a geophysical shot hole, some doubt might be entertained as to its reliability were it not that nearly the same figure can be obtained

[2] Very little progress has been made by mineralogists in Texas in identifying the minerals here called glauconite. It is suspected that these minerals may be chamosite or other greenish iron-silicates of a general megascopic appearance similar to glauconite. Hence the term glauconite is used in this report to include any of these minerals.

by alidade at the Thermo Fire Brick Company pit, where the smallest thickness measured is 27.4 feet.

At a distance of only 1.85 miles from this pit the greatest thickness was measured in this region. It was measured along the county road that connects Chinkapin Lake with Martin Chapel and rises southwestward from the swampy bottom of Mill Creek to the top of the upland at 420+ feet above sea level. Along this road, at the edge of the swampy bottom, the Wilcox group is exposed at location 8; higher, cuts and road ditches expose the lower, cross-bedded part of the Carrizo and the upper, more level-bedded part, which is quite sandy here; at the top of the hill, road ditches expose upper Carrizo sand and some reworked pebbly sands. There is no trace of the Newby member at the top of the road nor at the top of the 440 to 460-foot high sand hill, 1,300 feet east of the right-angle turn of this road; this high hill is only 3,500 feet south of location 8. Measuring by hand level from the top of the Wilcox at location 8 to the top of the upland along the road gave 104 feet as the thickness of the Carrizo. This is a minimum, but the thickness cannot be much more than 104 feet because Newby outliers are a short distance to the south in the vicinity of Martin Chapel and lie at 420 to 410 feet above sea level.

The following is a tabulation of recorded thickness data in this region (fig. 14):

Location	Thickness *Feet*
(13)[3] Geophysical shot hole 51	50
(14) Geophysical shot hole 50	24
(15) Geophysical shot hole 49	98.3
(16) Geophysical shot hole 46 approximately	50
(3) General Refractories Company pit,	
northeast corner	29.6
southeast corner	31.5
southwest corner	34.8
northwest corner	35.0
(6) Thermo Fire Brick Company pit,	
center of south wall	27.8
west end of south wall	27.4
(8) Hill slope rising southwestward from Chinkapin Lake	104.0+
(17) On north side of U. S. highway No. 84 (Reklaw-Rusk road) on descent to Mud Creek flood plain, on west side of the valley, 1.7 miles west of underpass at Reklaw village, east-central Cherokee County [Rusk quadrangle, U. S. Geol. Survey]; in part from a geophysical shot hole record	57.5?
(18) Along north-south county road, starting from Farm Road 13 (Troup-Henderson road) and extending southward to a hill about one-third mile north of Goldsberry School (Negro), about 2.5 miles airline distance east of Carlisle, western Rusk County [Henderson quadrangle, U. S. Geol. Survey]; obtained by alidade and plane-table and corrected for local dip; of the total thickness 13.8 feet is upper shaly Carrizo and 43.0 feet is lower cross-bedded sands	56.8
(19) National Geophysical Company, shot hole 15, elevation 253.4 feet, 94 feet deep, all in Carrizo formation; elevation of top of Carrizo formation is 297 feet in road cut 950 feet northwest of the shot hole; located on east-west county road 0.82 mile due east of Woodville Church, Cherokee County [Cushing quadrangle, U. S. Geol. Survey]	138+

[3]The locations in parentheses are the same as those indicated on text figure 14, which gives the various thickness data of the Carrizo formation.

The reason for the rapid and apparently erratic change in thickness from place to place is to be found in the nature of the basal contact of the Carrizo formation, which is discussed below.

Paleontology.—Molluscan fossils and glauconite had hitherto not been known to occur in the Carrizo sand of Texas. They are found only in the uppermost 10 feet of the Carrizo formation and only south of a certain line.

Their northernmost known occurrence is in the Carrizo inliers in the channel of Bridge Creek and one of its tributaries (fig. 12), and this is the only place they are found in the area represented on Plate I. The fossils are leached, and only imprints can be seen; they are scarce. They appear to be a small *Corbula* (pelecypod) and a small *Natica* (gastropod).

Outside of the mapped area fossiliferous upper Carrizo is fairly widely distributed in a belt about 11 miles long beginning in the general vicinity of Reklaw village in Cherokee and adjoining southwestern Rusk County and extending southeastward to exposures along State highway No. 204 (Cushing—Nacogdoches road) about 2 to 4 miles southeast of Cushing. The west end of the belt is about 11 miles south of the

southeast corner of the mapped area. The upper Carrizo of this belt is very similar in lithologic composition and fossil content to that of the Carrizo inliers in the channel of Bridge Creek so that these inliers appear to be the north end of the belt.

Glauconitic and fossiliferous upper Carrizo of a somewhat different character has been discovered in the excavation behind two 10,000-barrel oil storage tanks on the west-facing bluff overlooking the flood plain of Striker Creek at the Gulf Pipe Line Company pump station, 0.25 mile east of the west line of Rusk County and 0.75 mile north of U. S. highway No. 79 (Jacksonville—Henderson road). Here imprints of large valves of *Venericardia planicosta* Lamarck are found in muscovitic, slightly glauconitic, very fine-grained sandstone 9.2 feet below the top of the Carrizo formation. In addition to the *Venericardia*, imprints of *Corbula* and *Turritella* are found in the upper Carrizo here. The locality is about 1.25 miles southeast of the southeast corner of the mapped area, and the section exposed there is described in detail on pages 66–67 (fig. 34).

The Carrizo inliers in the channel of Bridge Creek and the pump station locality define the north limit of glauconitic

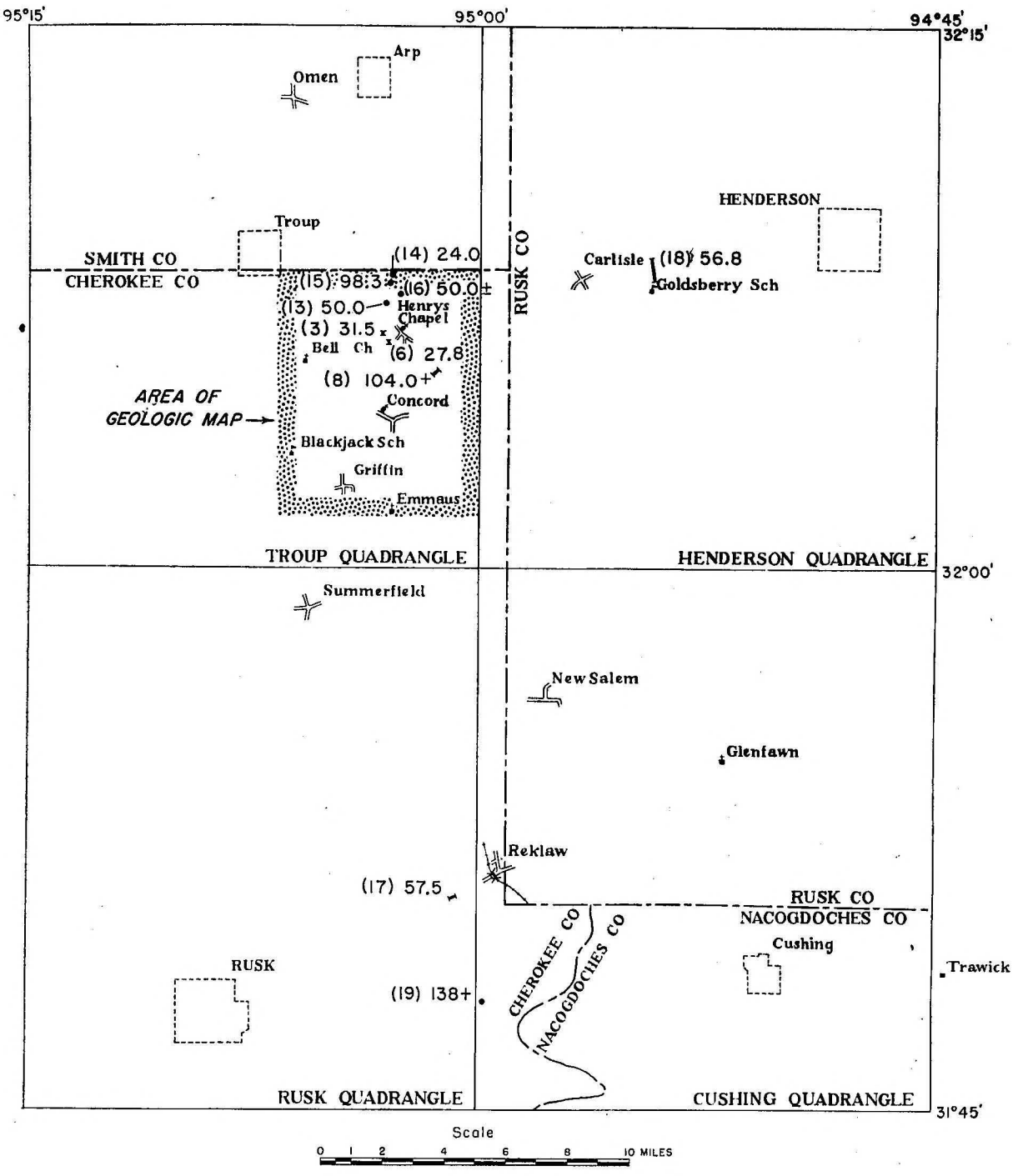


Fig. 14. Location of measured thicknesses of the Carrizo formation in the vicinity of the Henrys Chapel quadrangle. Location numbers are given in parentheses and correspond to those given in the text on p. 28; each heavy line indicates the position and direction in which the sections were measured. The thicknesses are given in feet.

and fossiliferous Carrizo. North of this limit all the Carrizo section is free of molluscan fossils and glauconite; south of the limit the major part of the Carrizo formation, except the uppermost 10 feet, is similarly free.

Wilcox - Carrizo contact. — The stratigraphic problem which this contact presents is of economic importance in this area, because the extent of the Henrys Chapel ball clay is directly affected by the nature of the contact, and correct geologic interpretation is essential to any further exploration for the clay. There are also certain scientific implications dependent upon the interpretation of the contact presented here (compare Stenzel, 1941, 1951).

In the Henrys Chapel quadrangle, observations can be made that prove in more than one way the presence of an erosional disconformity at the Wilcox-Carrizo contact. These observations disclose also features peculiar to this area and hitherto not described or recognized at the Wilcox-Carrizo boundary.

Detailed observations of minute features of the contact between the two can be made easily in the three clay pits (locations 3, 4, and 6) and in the channel of the creek near by (location 2). As at these three places features of the contact are the same, only observations made in the General Refractories Company pit (location 3) need be given here.

The contact is abrupt without any transition between the Wilcox and the Carrizo. The ball clay is abruptly overlain by shaly silts of the Carrizo.

Taken over the entire clay pit, that is, for a maximum distance of about 430 feet, the attitude of the contact is even and nearly level, and maximum differences in elevation of the contact amount to only 5.4 feet and are mainly due to regional dip of the Carrizo and Wilcox. Elevations above sea level of the contact are 359.7 feet in the northwest corner, 359.9 feet in the southwest corner, 365.1 feet in the northeast corner, and 363.2 feet in the southeast corner of the pit.

In detail the base of the Carrizo sand is irregular. Countless small extensions of the Carrizo go 2.5 to 5 cm into the ball clay; a few have been found to go as much as 10 cm (figs. 15, 16, 17). These extensions are usually highly irregular in shape, but they are wider at the top and become narrower downward, ending in a bluntly rounded tip. Their lower ends are approximately circular in horizontal section. Hence the extensions can be regarded as highly irregular funnels narrowing

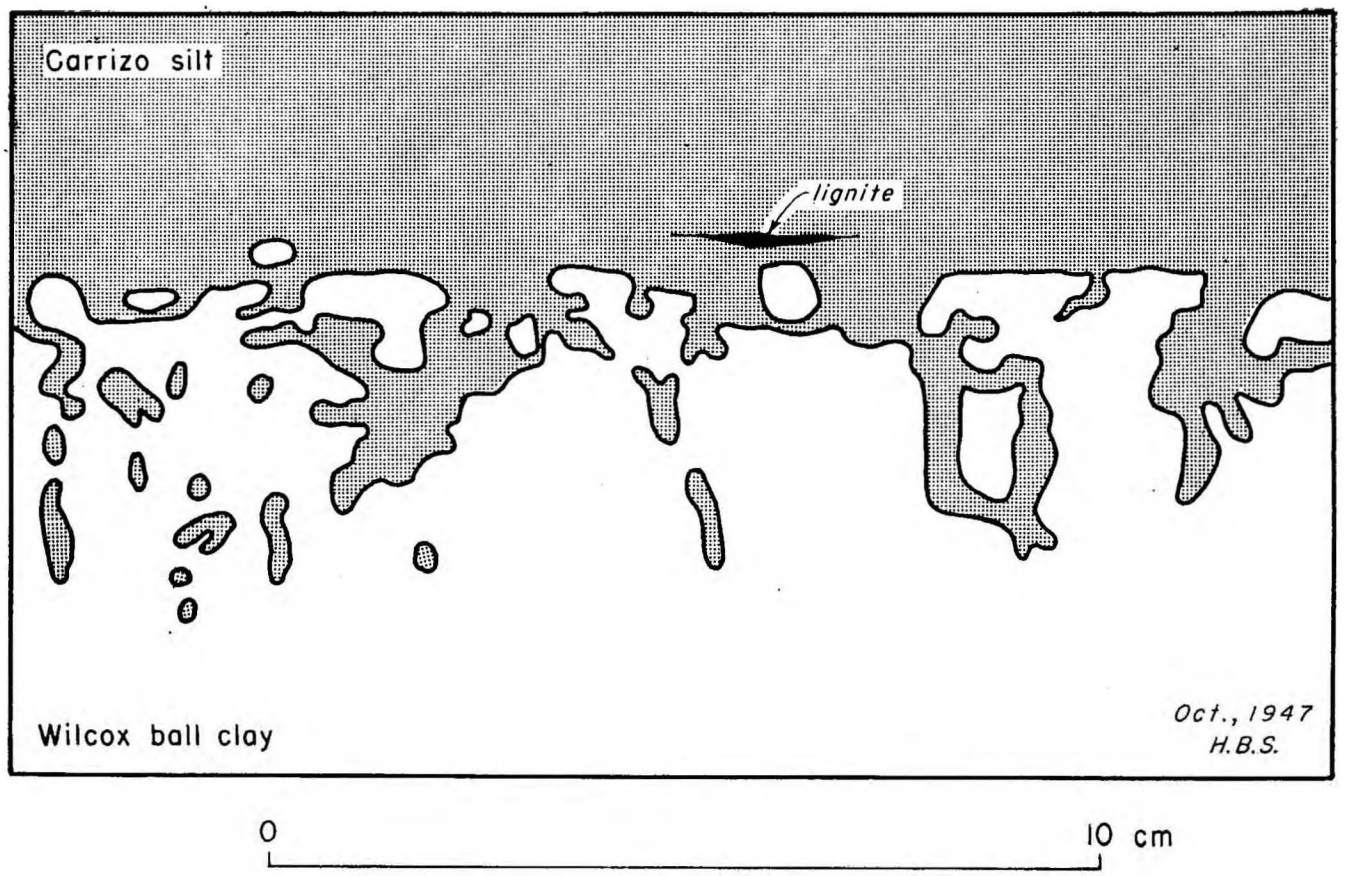


Fig. 15. Vertical and plane section through the Wilcox-Carrizo contact on the west wall of the clay pit of General Refractories Company near Henrys Chapel.

downwards. If one excavates carefully with a small knife into the ball clay below the bluntly rounded tips of these silt-filled funnels in the direction in which they point, one finds always one of the fossil lignitized roots in the clay. Evidently the root tracks were less resistant to erosion than the surrounding ball clay, and erosion preceding Carrizo deposition excavated more easily the root tracks than the surrounding clay and produced irregular funnel-shaped pits above each exposed root track (fig. 17).

Other kinds of extensions of the Carrizo sand into the Wilcox ball clay are rare, but a few were found which wedged out downward with an acute angle ending in a sharp point. Their horizontal section is not rounded but elongate, ending sharply both ways. Some extensions of this kind do not go down straight but are offset as a dog leg (fig. 16). This kind of extension is apparently the filling of a shrinkage crack in the Wilcox clay, and the shrinkage must have occurred shortly before the deposition of the overlying Carrizo silts which simply washed or sifted into the crack without destroying its sharp features.

There are so many of these irregularities and extensions at the contact that it is minutely and exceedingly irregular. Nevertheless there are no boulders or pebbles of ball clay enclosed in the base of the Carrizo sand. Shale-pebble conglomerates, which are so common in the basal cross-bedded sands of the Carrizo encircling the area of the clay pits, are wanting at the base of the shaly Carrizo silt sequence of the clay pits.

Another proof of the presence of an erosional surface separating the Carrizo formation from the Wilcox group is the

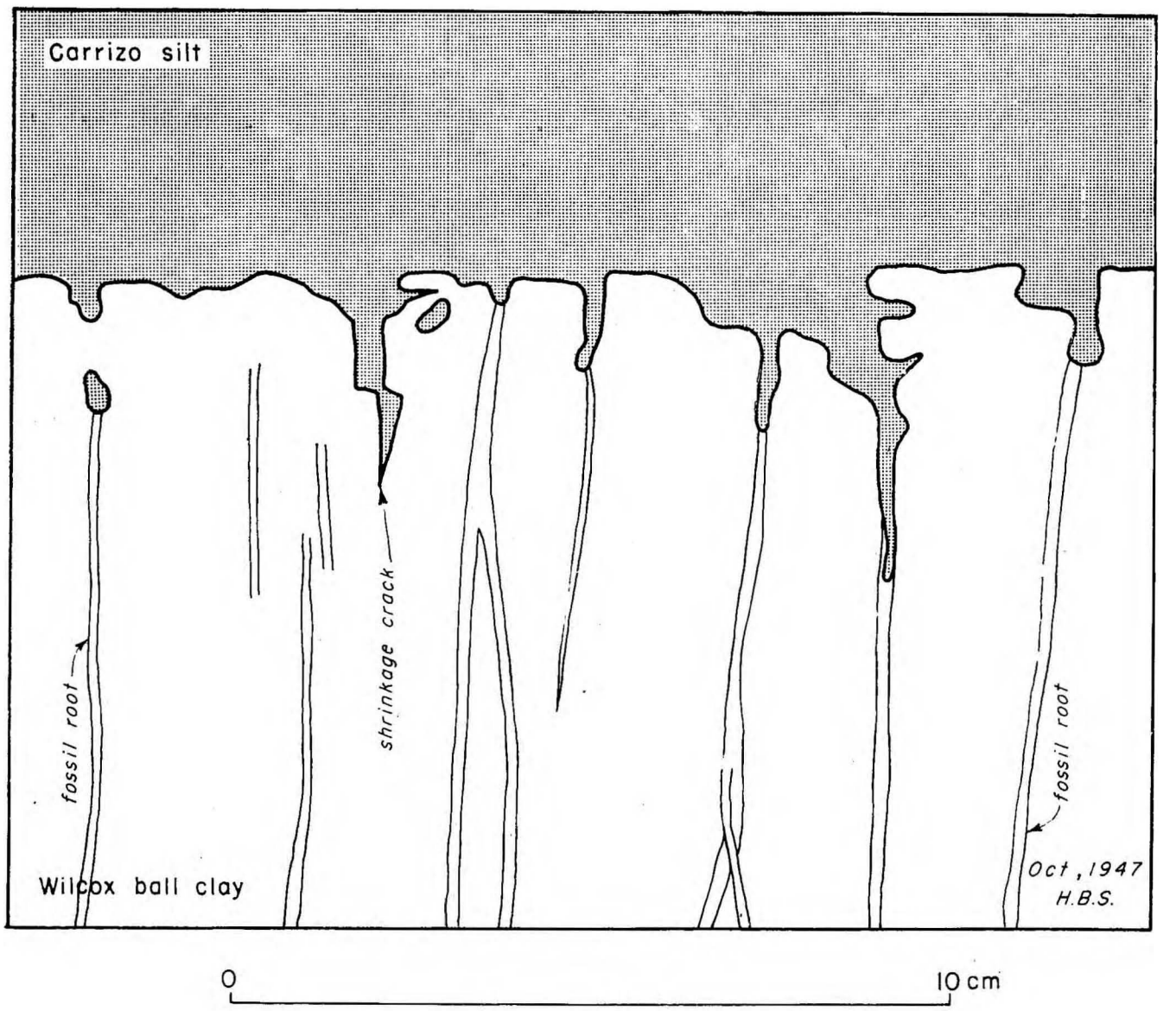


Fig. 16. Vertical, but not plane, section through the Wilcox-Carrizo contact on the west wall of the clay pit of General Refractories Company near Henrys Chapel.

One shrinkage crack and several funnel-shaped holes, filled with Carrizo silt, are dug out to show the relation of the latter to the fossil plant roots in the ball clay.

erratic change in thickness of the Carrizo. At the clay pits the following thicknesses were measured: 27.4 to 28.7 feet at Thermo Fire Brick Company pit and 29.6 to 35.0 feet at General Refractories Company pit. At short distances from the clay pits the thickness of the formation is much larger. For instance, at a distance of 1.85 miles southeast from the nearest pit, a thickness of at least 104 feet is indicated for the Carrizo formation. At a distance of 1.55 miles to the north-northeast (N. 16° E.) of the nearest clay pit two geophysical shot holes, 49 and 49-B, with elevations of 383 and 388 feet above sea level, respectively, afford reliable thickness data. The holes were within a few feet of each other; 49 was on the left bank of a headwater branch of Grissom Creek, 0.49 mile south of the north line of the county and 1.12 miles west-southwest of the county road fork of 403 feet altitude; at that place the Newby member crops out on the slope leading down to the flood plain at an elevation of 393.3 feet. The holes were drilled in the presence of the writer; both drilling characteristics and cuttings were excellent so that the top of the Wilcox could be determined accurately. The top of the Wilcox group was at a depth of 93 feet in hole 49-B; hole 49 was lost in the loose sand of the Carrizo at 75 feet depth. Hence the thickness of the Carrizo formation here is 98.3 feet. Similar thickness data can be given for the region east of the clay pits but would be merely needless repetition. To the west of the clay pits regional dip carries the Wilcox, Carrizo, and Reklaw rapidly underground so that information is unobtainable.

These data demonstrate a buried hill (fig. 18) composed of Wilcox strata with its peak near the Thermo Fire Brick Company clay pit. The hill is at least 77 feet high; it slopes at least 41 feet per mile to the southeast and 44 feet per mile to the north-northeast. Considering that the hill was composed of such soft and noncoherent rocks as loose fine sands, silty clay-shales, and lignite seams, the slopes of the hill are fairly impressive. The present-day hills in this area are, however, about three to four times as steep, although they are composed of the same kinds of soft rocks.

The peak of the hill is occupied by the 20.1-foot thick Henrys Chapel ball clay forming the top of the Wilcox group at this place. The clay is slightly harder than the average Eocene clay-shale and is tough, blocky, devoid of bedding planes so that it does not break down readily but forms large blocks. It should be somewhat more resistant to erosion than the average Eocene clay and certainly very resistant to chemical weathering because of its composition. The clay cap may have been responsible for resistance to erosion and survival of the hill at the beginning of Carrizo deposition.

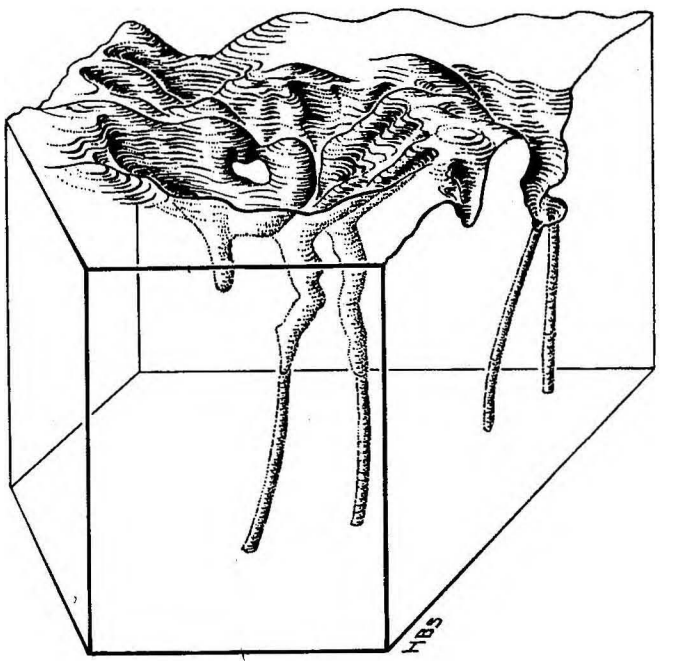


Fig. 17. Perspective block diagram of the Wilcox-Carrizo contact showing the shape of the funnel-shaped pits and their relation to the fossil plant roots in the Henrys Chapel ball clay of the Wilcox group.

The erosion disconformity at the base of the Carrizo and the buried Wilcox hill explains the fact that in the vicinity of the clay pits only the upper shaly and silty part of the Carrizo is present and the lower cross-bedded sands are missing.

Facies.—The Carrizo formation shows facies changes in two directions, vertically from the bottom to the top of the formation and horizontally from north to south.

The vertical facies change is essentially one of decreasing grain size of the individual components of the strata. Hand in hand with the decrease in grain size goes an increase in the admixture of lignitic material and the change from prevailing cross-bedded sands to prevailing level-bedded silts and shales. These changes are due to progressive decrease of carrying power in the waters that deposited the formation.

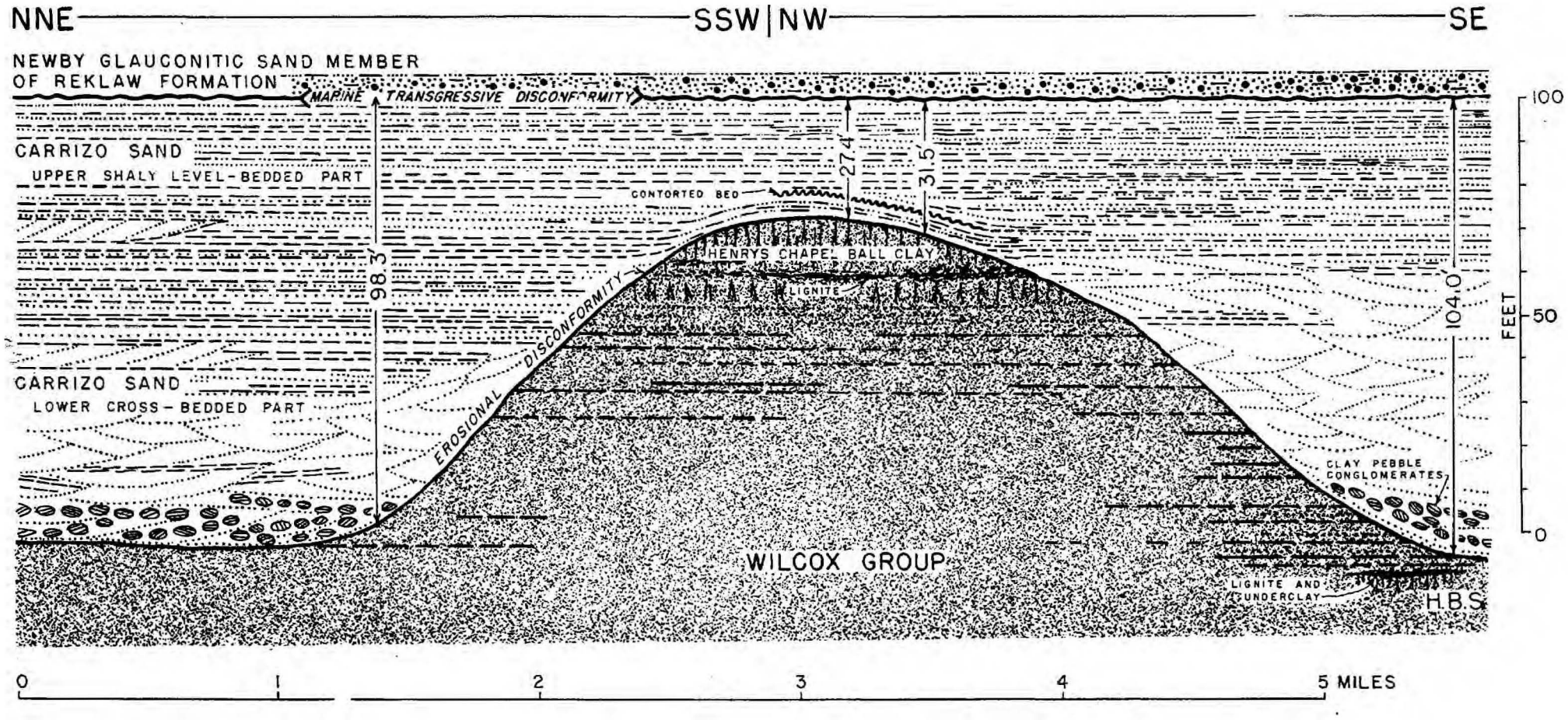


Fig. 18. Cross section through the buried hill composed of strata of the Wilcox group and covered by Carrizo sand, silt, and shale. Near Henrys Chapel, Cherokee County, Texas.

In summarizing the conditions believed to have existed at the time the lower part of the formation was deposited one might say the lower Carrizo was deposited as channel fills or sand bars by streams between hills that were composed of Wilcox strata and rose above the level of deposition of the stream sands at least in one place. Toward the south the streams may have been more or less confluent, and deltaic conditions may have prevailed. As the streams dropped their load and built up their bed-load deposits, they gradually slackened and brought in finer and finer materials.

Toward the end of deposition, only nonmarine, deltaic, fine-grained sediments were deposited in the north. Toward the south these sediments merged into slightly glauconitic, slightly fossiliferous, carbonaceous, very fine-grained sands, silts, and shales deposited in brackish, lagoonal waters. The line delimiting the north end of this slightly glauconitic facies is probably the northern limit of brackish waters existing during the deposition of uppermost Carrizo sediments; in other words, it is approximately the ancient lagoonal shore line.

REKLAW FORMATION

Local exposures of the Reklaw formation were noted by geologists of the Geological Survey of Texas directed by E. T. Dumble. Even a few fossils from this formation were described by G. D. Harris from exposures in Bastrop County. Alexander Deussen (1914, pp. 45–46) recognized at Marshall, Harrison County, in east Texas "a red ferruginous sandstone (probably an altered glauconitic sand)" with "casts of *Venericardia planicosta* Lamarck, indicating marine origin." This is the now well-known *Venericardia* rock in the Newby member of the Reklaw formation of east Texas. Deussen recognized also that this sandstone "constitutes the country rock," that is, that it has a wide distribution in the vicinity of Marshall, and gave descriptions of several localities near Marshall. But this is as far as the recognition of the formation went before the 1920's.

The Reklaw formation was first recognized as a separate traceable and mappable unit and described by Wendlandt and Knebel (1929, pp. 1352–1355). The type locality of the formation was given by them as the railroad cut in northwestern Nacogdoches County 2 miles southeast of the village of Reklaw in Cherokee County. These authors described the formation as consisting of 20 to 40 feet of brown to dark blue, micaceous, sandy clay at the base, a 4- to 15-foot thick, rather pure, clayey glauconite containing plentiful fossils in the middle, and a brown clay with streaks of sand and greensand and clay-ironstone concretions, up to 100 feet thick, at the top.

Detailed stratigraphic work done recently by the writer at and near the type locality of the formation near Reklaw village (compare Section 14 on pp. 64–65) and similar work in the area of the Henrys Chapel quadrangle have shown, however, that the lowest of the three division of the Reklaw formation as described by Wendlandt and Knebel, that is, the 20 to 40 feet of brown to dark blue, micaceous, sandy clay, does not belong in the Reklaw formation, because it interfingers with and grades laterally into the Carrizo sand and is separated on top from the Reklaw glauconitic beds by a regionally continuous disconformity. This lower division of the Reklaw of Wendlandt and Knebel is in fact the upper shaly and silty part of the Carrizo as described on preceding pages of this paper. Hence, the restricted Reklaw formation consists of two divisions, a lower glauconitic sand of 4 to 15 feet thickness and an upper brown shale up to 100 feet thick. These two divisions are precisely the two members of the Reklaw which were descibed from Leon County (Stenzel, 1939, pp. 65–78). In Leon County the two members, the Newby at the base and the Marquez above, can be segregated and mapped, and their type localities are in that county. Later work has shown these members to be useful divisions recognizable in central Texas and over most of eastern Texas.

NEWBY GLAUCONITIC SAND MEMBER

Distribution.—The outcrop band of this formation, continuous except for local alluvial cover, extends from north to south through the middle of the mapped area. To the west of this band the member dips and lies under younger formations, but to the east it forms numerous outliers that cap some of the high hills of the undu-

lating Carrizo outcrop. Such Newby outliers continue eastward far beyond the mapped area at least as far as Henderson in Rusk County.

The continuous outcrop band is commonly only 100 to 200 feet wide, is deeply dissected into lobes of various sizes by the numerous creeks originating in the area, and enters the county from the north at a place 1.1 miles west of Red Oak Flat church. Southward it follows roughly a curve that is convex to the west past Henrys Chapel and through Concord to a place about 1.8 miles east of Emmaus Church at the south end of the mapped area. This convex curve is a result of the structural attitude of the Eocene beds (fig. 57).

There are 41 outliers of the Newby member and 2 outliers of the Newby member capped by the Marquez member in the quadrangle. The outliers range in size from 0.6 mile long to 50 by 150 feet in size. Their distribution is irregular because the regional homoclinal dip varies from place to place.

Only one inlier of the Newby member is found west of the continuous outcrop band in the area mapped. This inlier is in the channel of Bridge Creek and one of its left tributaries, downstream from the bridge on the county road that goes westward from Griffin to the Troup—Summerfield highway. This is the same place at which the inliers of the Carrizo formation occur, which were described in preceding pages (fig. 12).

Topography.—Weathering oxidizes the glauconitic sands of the Reklaw readily and transforms them into hard ferruginous sandstones. Thus weathering increases their resistance to erosion greatly, at least at first. These ferruginous sandstones form a cuesta which commonly faces eastward and is inconspicuous over most of the quadrangle, because the Newby member is thin (fig. 19). In many places the Newby scarp rises only 5 to 10 feet above the general level of the country and is easily overlooked. However, in those places where active erosion by running water has enhanced the general topographic relief the Newby cuesta is fairly impressive and steep. It is so along Farm Road 13 east of Henrys Chapel where the southeastward-projecting lobe of the Newby cuesta is enhanced by the deep valleys of Grissom and Hampton Creeks, and the vertical topographic relief is 65 feet. At the southern end of the mapped area, about 1.5 miles east of Emmaus Church, the Newby cuesta is more conspicuous, because there the thickness of the Newby member is more than three times as large as farther north and the various branches of Boggy Branch have enhanced the topographic expression of the cuesta.

In spite of its being inconspicuous in many places, the cuesta made by the Newby glauconitic sand member influences profoundly the distribution and development of topographic features in the whole area. A glance at the geologic map (Pl. I) shows creek valleys as more abundant, or at least more conspicuous, in the eastern half, that is, east of the cuesta, than in the western half. Also broad alluvial flats, composed of flood plains and alluvial fans, are common east of the cuesta and comparatively rare west of it. In many places the broad alluvial flats of the eastern creeks reach westward right up to the base of the cuesta and either stop there abruptly or at least become much narrower; compare the heads of the right tributaries to Campground Creek or the heads of the right tributaries to Hampton and Grissom Creeks. The cuesta determines the rate of slope of the creek profiles; the rate of slope is low east of the cuesta and comparatively high where the creeks descend the cuesta. The distribution of the alluvial flats is caused by differences in the rate of erosion effective in the various formations across which the creek branches flow. The lower part of the Carrizo sand evidently offers little resistance to the lateral widening of creek valleys, but the Newby member offers more resistance.

In the northern part of the quadrangle where the Newby cuesta is inconspicuous and the Newby member is thin, the inface of the cuesta slopes at an average rate of about 225 feet per mile. At the south end of the mapped area the average rate has risen to 750 feet per mile.

Lobes of the cuesta have a tendency to extend out in finger-like points on the divides between minor drainages. These finger-like points are common from Concord on northward to the margin of the mapped area.

Soils and vegetation.—Soils of the Newby member are of the podsol type. There is a whitish-gray to medium dark

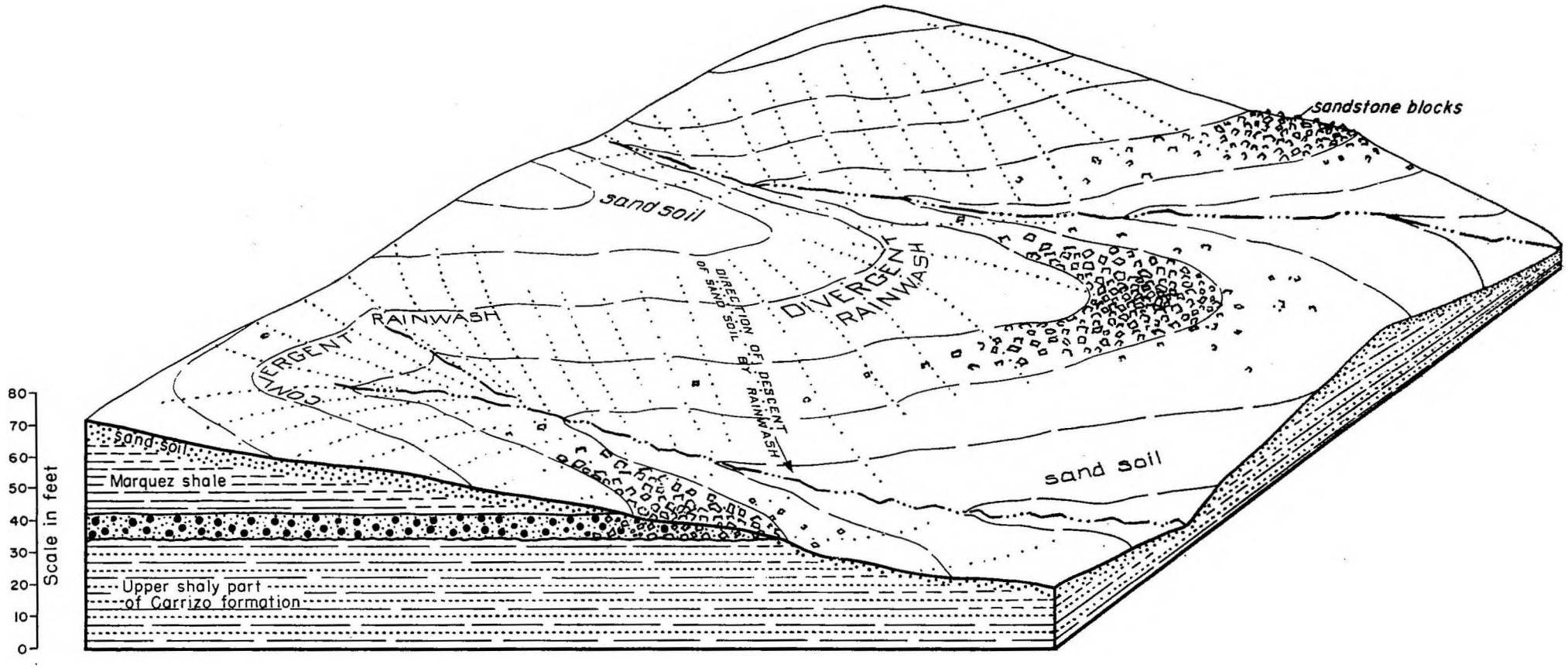


Fig. 19. Block diagram of the cuesta formed by the Newby member of the Reklaw formation, showing the distribution of rock-strewn slopes at the points of the lobes.

Rainwash of sand soil from above seems to be the controlling factor of rock-strewn and sand-soil-covered slopes of the cuesta. Where rainwash tends to converge in its descent down the slope, sand soil is washed down faster than it is removed. Where it tends to spread in its descent, the sand soil that is washed down is spread out thinly enough to let the underlying Newby sandstone blocks protrude.

grayish-brown, leached, sandy top soil, and beneath it is a grayish yellow-brown sand soil with sandstone rock fragments. The ease with which the Newby member can be mapped in this area is dependent on the thickness of the sandy top soil. Where it is thick, no rock fragments reach the surface, and mapping becomes very difficult. Where the sandy top soil is thin, the sandstone rock fragments reach the surface and they lie on the surface of the ground in great numbers and large size in some places. Such rock-strewn slopes are easy to map. The rock-strewn Newby outcrop is usually steep and commonly occurs at the tip of eastward-projecting lobes; at the flanks of the lobes there is usually a deep sandy soil cover. Where sandstone rocks are not visible and road ditches do not penetrate deep enough to expose fresher, recognizable Newby materials, a peculiar pale dirty yellow to dirty rust-orange rather than bright orange-colored subsoil indicates the presence of the Newby outcrop. Colors of subsoils are to some extent distinctive of the various mappable units in this area.

A soil profile, regarded as typical of the Newby glauconitic sand member, was measured in the north-side cut of the county road going northeastward from Henrys Chapel community at the descent to Grissom Creek, 0.12 mile west of the first bridge (fig. 20).

Soil profile of the Newby member.

	Thickness *Feet*
(A_1) Loose, medium dark grayish-brown, fine-grained sand without stratification. pH = 7.0	0.8
(A_2) Loose, grayish yellow-brown, unstratified fine-grained sand soil with many subangular fragments and blocks, up to 5 inches in size, of hard, rusty brown, ferruginous, fossiliferous, fine-grained sandstone containing weathered glauconite. pH = 7.0	1.1
(B) Coherent dirty rust-orange-yellow, unstratified, clayey, fine-grained sand with blocks and fragments of weathered Newby sandstone. pH = 4.5	1.7
(C) Indurated, dirty rust-orange to dirty rust-yellow, poorly bedded, muscovitic, argillaceous, fine-grained sandstone with weathered glauconite grains. pH = 5.0. To bottom of ditch	2.6

Like the Carrizo formation the Newby member was originally covered by an oak and pine forest, but this forest probably was denser on the Newby member because its soils are more fertile. Where the Newby cuesta is low and inconspicuous the land has been cleared, but where the cuesta is steeper it is still wooded. In such places it is not uncommon that the Newby is wooded, but the Carrizo below and the Marquez above have been cleared, so that a narrow strip of woodland occupies approximately the steep slope of the Newby outcrop.

Composition.—The fresh, unweathered Newby member cannot be seen in any of the exposures of the area except in the channel of Bridge Creek and one of its tributaries; the common Newby exposures are oxidized, weathered, and thoroughly discolored. The fresh, unweathered material is a coherent, gray-green, massive to poorly bedded, glauconitic, muscovitic, argillaceous, fossiliferous, fine-grained and very fine-grained sand. More richly glauconitic parts are better called sandy glauconite rock and are commonly firm. The presence of glauconite, the massive or poorly developed bedding, and the large fossils, are diagnostic features serving to segregate the member from the beds below and above. Siderite as interstitial cement is present in some layers, and these may pass into impure clay-ironstone layers containing quartz sand and glauconite grains.

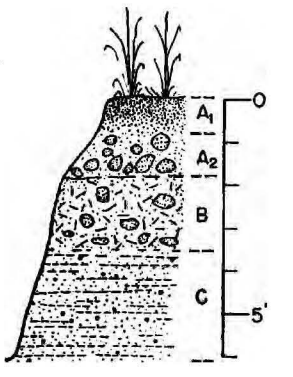


Fig. 20. Soil profile of the Newby member of the Reklaw formation in the north-side cut of the county road at the descent to Grissom Creek, 0.12 mile west of the first bridge northeast of Henrys Chapel community.

The beds of the weathered Newby member have varying hardness; they range from friable to hard; induration may be uniform or confined to knobby irregular portions of a bed. However, induration is

so common in this member that it serves to distinguish it from the very soft immediately overlying section of the Marquez and the commonly merely firm or coherent upper Carrizo shales and silts. Indurated ferruginous sandstone of the upper Carrizo is similar in hardness to the Newby sandstone layers but is distinctly harsher under the hammer.

Colors of the weathered Newby are rusty, ranging from grayish-yellow to yellow to orange-red and brown. The harder layers are commonly rust-brown. Maroon-black, so characteristic of the ferruginous sandstone ledges in the upper Carrizo, was not seen. Many of the rust colors of the Newby have a faint olive undertone, which is probably the effect of partly fresh glauconite grains. Surprisingly, some glauconite grains stay green in the otherwise oxidized and weathered sandstones of the Newby.

Bedding is commonly poor, crude, or even absent; knobby and irregular bedding is common in some layers. Cross-bedding is found only in the southernmost part of the mapped area: in the Newby inlier of Bridge Creek and in exposures south of Boggy Branch, where it is very well developed in some beds at the top of the Newby section.

A structure common in many layers and distinctive of the Newby member is a kind of swirly bedding reminiscent of the grain of birds-eye maple wood. In vertical sections the structure consists of ill-defined rings or swirls of light greenish-gray clay poor in glauconite but filled with and surrounded by a matrix of argillaceous glauconitic fine-grained quartz sand. These rings or swirls can be traced by careful excavation and seem to be the cross sections of long pipes in the glauconitic sand. Originally the glauconitic sand matrix was riddled by burrow holes, the walls of which were lined with irregular thicknesses of the light greenish-gray clay; later the cavities were filled in with material similar to the surrounding matrix. Similar clay-lined burrow holes up to 60 inches deep are known today from many beaches and shallows, which are riddled by these holes (Lunz, 1937). The burrowing animal responsible for the present-day holes is the mud shrimp *Callianassa*, the several species of which have a world-wide distribution. As the genus *Callianassa* is well represented in Tertiary deposits of the Gulf Coastal Plain, it seems probable that the peculiar structure in the Newby member was made by these animals. Whatever its origin may be, the structure is distinctive; for brevity of description it is called birds-eye structure in the description of stratigraphic sections.

The prevailing component of the Newby member is fine or very fine-grained quartz sand. Glauconite is rare in some layers and more abundant in others but was found in every bed. It is more abundant in the extreme south of the mapped area and beyond where it composes thick (6 feet or more) beds of medium-sized glauconite grains. Weathered glauconite grains consisting of limonite usually can be detected with the hand lens; they are rounded, pellet-shaped, and have a shrunken appearance having pulled away from their enclosing matrix. Tiny flakes of muscovite are present in all beds but are not as common as they are in the Marquez member. All beds seem to be more or less argillaceous and even the loose sands have enough argillaceous matter to make them stick together after drying. Lignite pieces or carbonaceous matter were not found anywhere in this member in the quadrangle. However, outside of the area represented on Plate I, at the borrow-pit on U. S. highway No. 84 on the right bank of the Angelina River in southwestern Rusk County (Bureau of Economic Geology locality 200-T-1), rounded pieces of lignite up to 2 inches in length were found in the Newby member; most of these pieces had ship-worm bore-holes in them, hence were originally driftwood in the Newby sea.

Thickness.—The Newby member is ordinarily only 5 to 7½ feet thick, but at the southern end of the mapped area, south of Boggy Branch, at Emmaus, and in the Newby inlier of Bridge Creek between the former Black Jack brick schoolhouse and Emmaus Church, the thickness increases rapidly and rises up to nearly 24 feet. This increase is gained in the upper part of the Newby section through the addition of glauconitic quartz sands and sandy glauconite beds, many of which are cross-bedded. From their field relations it is evident that these added beds, rich in glauconite, are lenses that are long in approxi-

mately east-west direction but are comparatively short in a direction transverse to their long axes.

Accurately measured thicknesses in the Henrys Chapel quadrangle and surrounding region are listed below; of these, nos. 3, 4, 5, 6, and 8 are in the quadrangle (fig. 21). Sections exposed at all these localities, except no. 8, are described in detail under "Detailed sections," pages 41–73.

CHEROKEE COUNTY—

(1) Cut and road ditch on north side of U. S. highway No. 84 (Reklaw—Rusk road) on descent to flood plain of Mud Creek, on the west side of the valley, 1.7 miles southwest of underpass at Reklaw village, east-central Cherokee County [Rusk quadrangle, U. S. Geol. Survey]....13.1 feet

(2) North ditch of Farm Road 856, at the settlement of Emmaus, east of the bridge over a left tributary of Sampson Creek and west of the road fork at elevation 377, 0.55 mile south of Emmaus Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey]; this

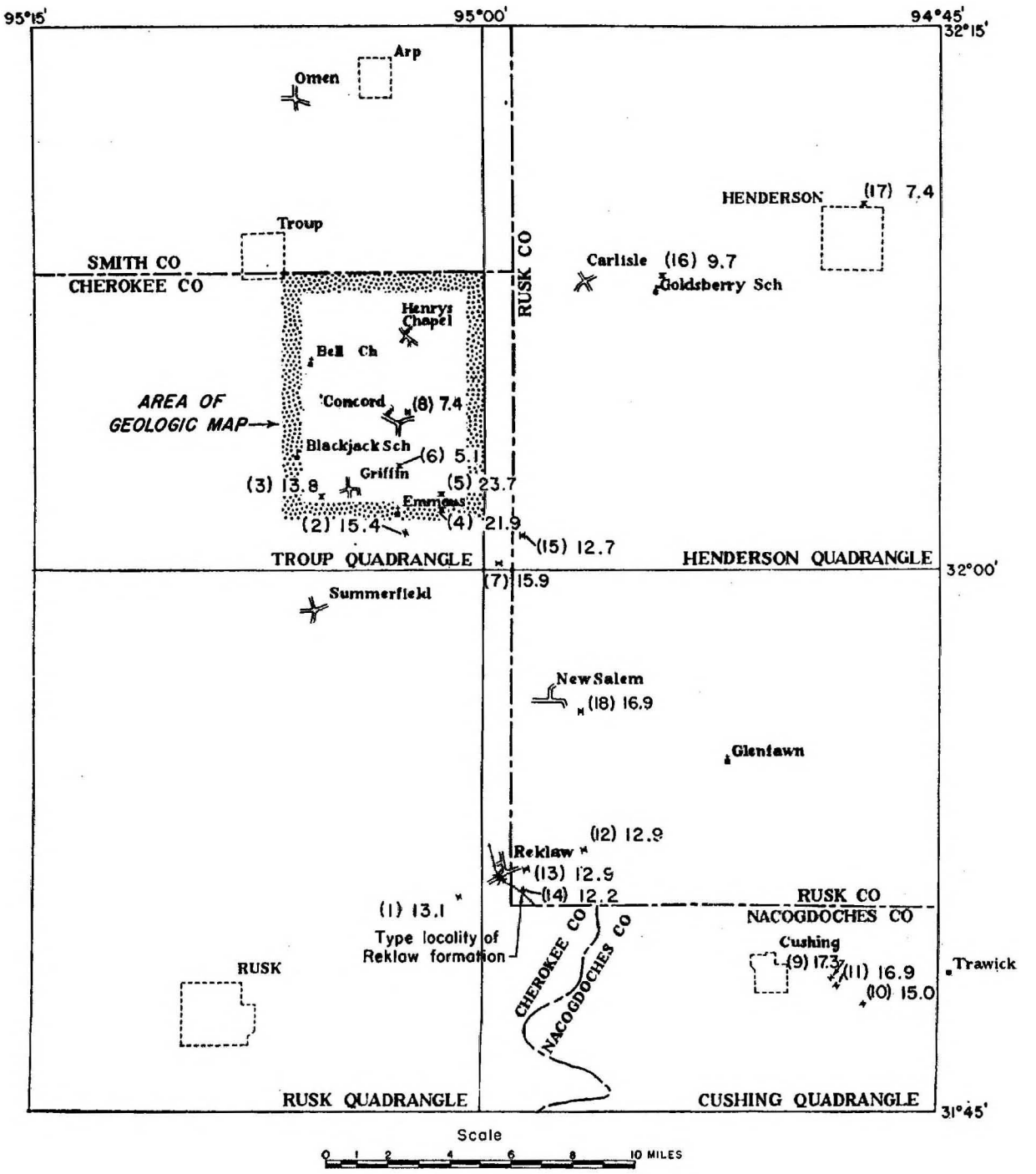


Fig. 21. Location of measured sections and thicknesses of the Newby member of the Reklaw formation in the vicinity of the Henrys Chapel quadrangle. Location numbers are given in parentheses and correspond to those given in the text on pp. 39–40; each heavy line indicates the position and direction in which the sections were measured. The thicknesses are given in feet.

exposure was destroyed when Farm Road 856 was built ..... 15.4 feet

(3) Waterfall, channel, and banks of Bridge Creek, 850 feet and more downstream from the wooden bridge of an east-west county road which connects Griffin with State highway No. 110 (Troup—New Summerfield road), about half a mile west of Griffin Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey] ..... 13.8 feet

(4) Cuts on north-south county road, between the two road forks, the elevations of which are 406 and 404, 0.6 mile south of bridge over Boggy Branch, 1.25 miles airline distance east-northeast of Emmaus Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey] ..... 21.9 feet

(5) Cuts on north-south county road from road metal pit at top of hill to road fork (elevation 406) south of it, 0.3 to 0.46 mile south of Boggy Branch bridge, 1.35 miles east-northeast of Emmaus Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey] ..... 23.7 feet

(6) West ditch of Farm Road 856, on north slope of a hill spur leading down to a right tributary of Campground Creek, 1.46 miles south of Concord and 0.39 mile north of the crossroads at elevation 423, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey] ..... 5.1 feet

(7) Cut on north side of U. S. highway No. 79 (New Summerfield—Henderson road) on right bank of Striker Creek, from flood-plain level to 150 feet west of west end of concrete bridge, about 6.3 miles east of New Summerfield, northeastern Cherokee County [Henderson quadrangle, U. S. Geol. Survey] ..... 15.9 feet

(8) Road ditch on east side of Farm Road 856, due west of Martin Chapel, south of the eastward-flowing tributary branch of Campground Creek, 0.38 mile northeast of the church at Concord, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey] ..... 7.4 feet

NACOGDOCHES COUNTY—

(9) Three bluffs on right bank of Hogpen Branch, 1,700 feet west-southwest of Oak Flat Cemetery, 900 feet north-northeast of State highway No. 204 (Cushing—Nacogdoches road), northwestern Nacogdoches County [Cushing quadrangle, U. S. Geol. Survey] ..... 17.3 feet

(10) Deep cut on State highway No. 204 (Cushing—Nacogdoches road), 0.15 mile west of the channel of Jones Creek, 3.72 miles southeast of crossroads in Cushing or 3.23 miles northwest of crossroads in Trawick, northwestern Nacogdoches County [Cushing quadrangle, U. S. Geol. Survey] ..... 15.0 feet

(11) Road cut on north side of State highway No. 204 (Cushing—Nacogdoches road) on west slope of a hill leading down to the channel of Hogpen Branch, a right tributary of Dill Creek, 0.45 mile west-northwest of Oak Flat Church, where the old highway joins the new one at an acute angle at highway right-of-way concrete marker 455, 2.43 miles southeast of crossroads in Cushing or 4.48 miles northwest of crossroads in Trawick, northwestern Nacogdoches County [Cushing quadrangle, U.S. Geol Survey] ..... 16.9 feet

RUSK COUNTY—

(12) Borrow pit on north side of U. S. highway No. 84 (Rusk—Mt. Enterprise road) on right side of the Angelina River, about 300 feet west of the stream, southwestern corner of Rusk County [Cushing quadrangle, U. S. Geol. Survey], Bureau of Economic Geology locality no. 200-T-1 ..... 12.9 feet

(13) Deep cut on a westward slope along north side of U. S. highway No. 84 (Reklaw—Mt. Enterprise road), 0.65 mile east of underpass at Reklaw village, southwestern Rusk County [Cushing quadrangle, U. S. Geol. Survey] ..... 12.9 feet

(14) Cut on Southern Pacific Railroad, 0.85 mile southeast of highway underpass at Reklaw village, in southwest corner of Rusk County [Cushing quadrangle, U. S. Geol. Survey] 12.2 feet

(15) Excavation in west-facing bluff, behind two 10,000-barrel oil storage tanks, overlooking flood plain of Striker Creek, at Gulf Refining Company pipe-line pump station, 0.25 mile east of west boundary of county and 0.75 mile north of U. S. highway No. 79 (New Summerfield—Henderson road), southwestern Rusk County [Henderson quadrangle, U. S. Geol. Survey], Bureau of Economic Geology locality no. 200-T-2 ..... 12.7 feet

(16) Ditches of north-south county road between Alexander Gin and Goldsberry School (Negro), about one-third mile north of schoolhouse and 2.5 miles airline distance east of Carlisle, west-central Rusk County [Henderson quadrangle, U. S. Geol. Survey] ..... 9.7 feet

(17) Cut on east side of State highway No. 322 (Henderson—Longview road), 150 feet north of intersection with State highway No. 64 (Henderson—Tyler road), 100 feet east of International—Great Northern Railroad tracks and 150 feet north of highway-railroad crossing, in outskirts of Henderson, just north of city limits, central Rusk County [Henderson quadrangle, U. S. Geol. Survey] ..... 7.4 feet

(18) Cut on New Salem—Glenfawn county road, on ascent from and east of Buford Branch, 0.17 mile east of Gulf Refining Company pipeline crossing and 1.1 miles southeast of New Salem, southwestern Rusk County [Cushing quadrangle, U. S. Geol. Survey] ..... 16.9 feet

Detailed sections.—The Newby member, on account of its small thickness and good resistance to erosion, is well exposed in several places so that detailed sections can be obtained. Herein it stands out favorably among the Tertiary stratigraphic units of this region. All well-exposed sections that were found have been measured, and it is not likely that any others can be found in the Henrys Chapel quadrangle. In addition to the sections within the Henrys Chapel quadrangle, several sections located in the vicinity are given below. The sections were measured with hand level and steel tape.

Oversized
page

SECTION 1

Cut and road ditch on north side of U. S. highway No. 84 (Reklaw—Rusk road) on descent to flood plain of Mud Creek, on west side of the valley, 1.7 miles southwest of underpass at Reklaw village, east-central Cherokee County [Rusk quadrangle, U. S. Geol. Survey], figure 22.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 12.2 feet only:	
(s) Poorly exposed brown shale containing beds of clay-ironstone, to top of hill	7.5
(r) Hard, rusty brown, slabby to poorly bedded, glauconitic clay-ironstone	1.0
(q) Same as (o)	2.1
(p) Hard, rusty yellow, platy and thin-layered, glauconitic clay-ironstone in sheets	0.2
(o) Soft and gummy, light greenish-gray, weathering to light rusty brown, thinly bedded, plastic clay enclosing nests of glauconitic sand	1.4
Newby glauconitic sand member of Reklaw formation, 13.1 feet thick:	
(n) Coherent, rusty brown, weathered, cross-bedded, glauconitic sand with coarse glauconite grains and fossil imprints; imprints of bryozoans of *Lunulites* form of growth seen	1.0
(m) Same as (k), concentrically weathering	0.6
(l) Same as (j)	0.9
(k) Hard, rusty red-brown, irregularly nodular, glauconitic clay-ironstone containing fossil imprints, concentrically weathering	1.0
(j) Coherent, light gray-green when fresh, weathering to dirty rust-yellow, massive, porous, glauconitic sand	1.1
(i) Hard, rusty red-brown, nodularly layered, slabby, glauconitic clay-ironstone containing fossil imprints	0.8
(h) Firm, red-orange to dirty rust-yellow, poorly to lenticularly bedded, porous, glauconitic sand containing imprints of fossils and some large grains of glauconite, encloses soft, light gray-green, argillaceous, glauconitic sand layers of irregular boundaries partly extending into narrow burrows, 0.9 foot thick at 3.0 feet above base and 0.3 foot thick at 4.4 feet above base	7.7
Marine transgressive disconformity	
Upper part of Carrizo formation, 16.4 feet thick:	
(g) Soft, chocolate-brown, thinly bedded, carbonaceous, muscovitic, fine-sandy shale containing some nests of sand, thickens westward from 0.0 to	1.5
(f) Loose, light gray-yellow, oxidized, porous, medium-grained sand forming a lens about 15 feet long, up to	1.0
(e) Firm, grayish chocolate-brown, massive and crinkly bedded, carbonaceous, muscovitic, argillaceous, fine-grained sand enclosing some more clayey clouds, becomes medium grained toward top	5.9
(d) Same as (c) but the silts hardly indurated	2.9
(c) Partly indurated, chocolate-brown, laminated to thinly bedded, carbonaceous, muscovitic, silty shale containing indurated, ferruginous silt layers	3.7
(b) Soft, light grayish chocolate-brown, laminated to thinly bedded, carbonaceous, muscovitic, silty shale interbedded with argillaceous silt layers	1.4
Lower part of Carrizo formation, 43.9 feet(?) thick but only upper 10.0 feet exposed:	
(a) Firm, light grayish chocolate-brown, massive to poorly bedded in part, slightly argillaceous, carbonaceous silt having lignitized plant fragments and small leaves. weathers to a dirty light rust-yellow; in some places are short, discontinuous, more shaly portions; exposed to bottom of ditch	10.0
(x) Remainder of Carrizo formation to top of Wilcox group, from log of geophysical shot hole drilled here; (however, such logs are notoriously unreliable)	33.9
Total thickness of Carrizo formation, corrected for lenticularity of beds	57.5(?)

SECTION 2

North ditch of east-west county road, at settlement of Emmaus, east of the bridge over a left tributary of Sampson Creek and west of the road fork at elevation 377, 0.55 mile south of Emmaus Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey], figure 23.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 9.0 feet only:	
(g) Soft, gummy, leached to light greenish-gray or oxidized to red-brown, laminated, unctuous shale containing ellipsoidal concretions of hard, rusty brown, muscovitic, non-glauconitic, earthy clay-ironstone about 0.2 foot above base and of 0.8 by 0.8 by 0.4-foot size; to top of hill	9.0
Newby glauconitic sand member of Reklaw formation, 15.4 feet thick:	
(f) Soft, glauconitic sand similar to (a)	0.1
(e) Hard, rusty red-brown, cross-bedded, sandy glauconite arenite; lower 1.5 feet softer and has many indurated, narrow pipes	4.5
(d) Firm, rusty orange with light greenish-gray blotches, massive, argillaceous, glauconitic sand	4.4
(c) Hard, rusty red-brown, nodular, sandy, glauconitic clay-ironstone	0.4
(b) Similar to (a) but more argillaceous; has rusty red streaks	1.2
(a) Firm, light greenish-gray, indistinctly bedded, argillaceous, glauconitic sand, exposed for only 1.7 feet but augered for 3.1 feet more	4.8
Marine transgressive disconformity	
Upper part of Carrizo formation, in auger hole:	
(x) Soft, blue-gray to brownish, sandy clay	3.5

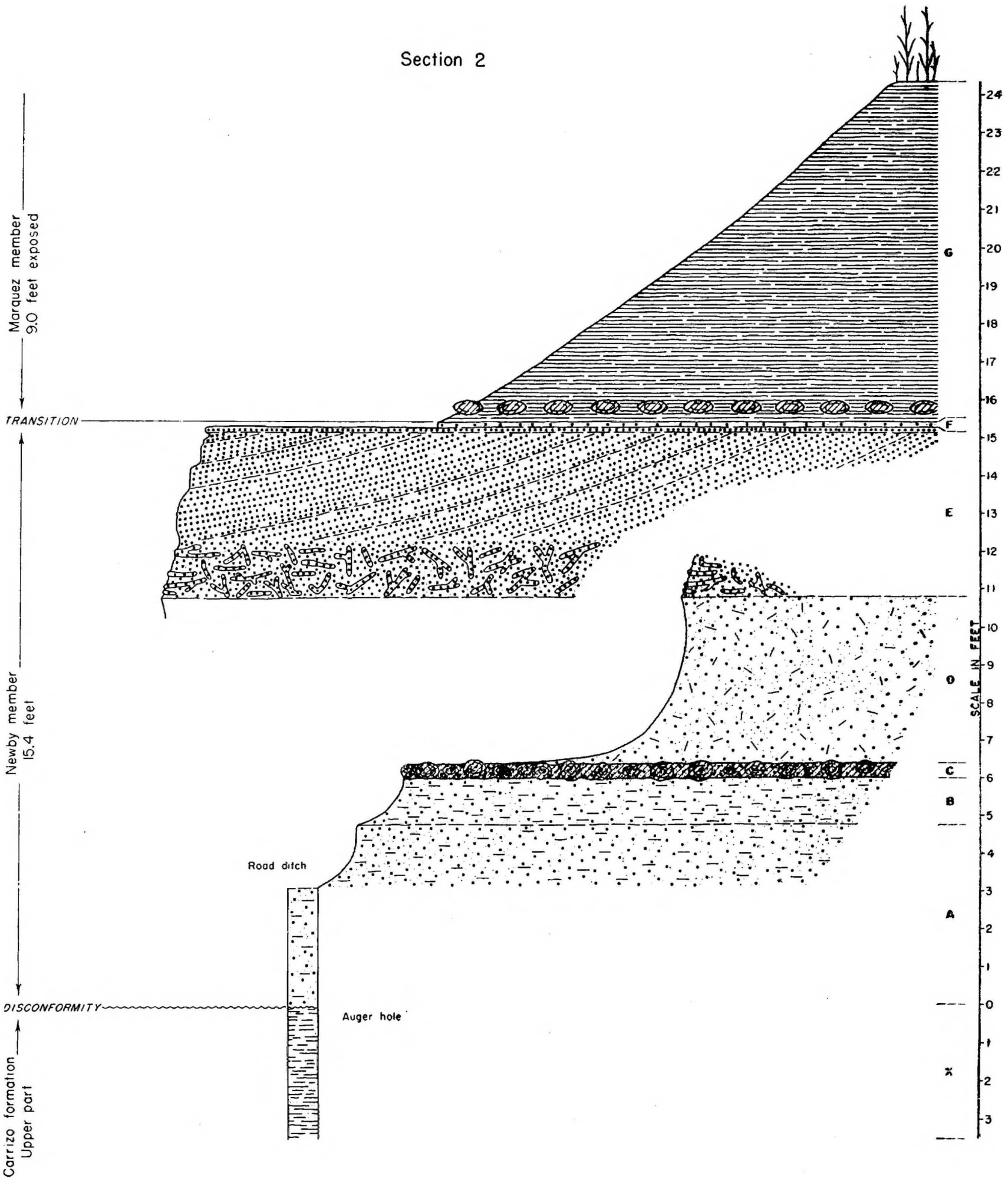


Fig. 23. Profile of section 2.

SECTION 3

Channel and bluffs alongside of Bridge Creek, downstream from wooden bridge of east-west county road, which connects Griffin with State highway No. 110 (Troup—New Summerfield road), about ½ mile west of Griffin Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey], figure 24.

The exposures begin in the north at the first bluff, about 20 feet high, on left side of Bridge Creek, 400 to 600 feet downstream from county road bridge. There is a second 20-foot bluff on the left side, 650 to 800 feet from bridge; then a waterfall over cross-bedded Newby glauconitic sand, 850 feet from the bridge. From this waterfall on there are nearly continuous exposures in the channel of the creek, which were followed to the right-hand turn of the creek, where a 1.25-mile long left tributary enters from the east and a syrup oven stands on the west bank, about 1,800 feet from the county road bridge.

Beds (w) to (p) were measured at the first bluff downstream from bridge. Beds (g) to (k) were measured at the second bluff and form the entire bluff. Bed (j) shows only between the second bluff and the waterfall. Beds (i) to (b) are exposed at and a little below the waterfall. Beds (c) to (a) and the upper Carrizo bed (bb) were measured at a right-hand turn of the creek, 1,500 feet from the county road bridge. The Carrizo beds (aa) and (bb) were measured at the syrup-oven bend. Figure 12 on page 26 is a detailed map of this vicinity.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 28.8 feet only:	
(w) Hard, red-brown, slabby, silty, glauconitic, fossiliferous, earthy clay-ironstone at the top of the first bluff	0.7
(v) Similar to (t) but rusty yellow-orange	0.8
(u) Clay-ironstone	0.2
(t) Similar to (r) but has dirty orange-red streaks in light greenish-gray	1.5
(s) Soft, olive-brown, massive, feldspathic(?), sandy glauconite arenite containing thin branching pipes of reddish earthy clay-ironstone of half an inch diameter	0.9
(r) Soft, rusty brown on outside, greenish-gray where fresh, indistinctly bedded, muscovitic, argillaceous, glauconitic sand containing several thin (0.1 foot) discontinuous clay-ironstone bands	2.3
(q) Hard, rusty red-brown but bright red-maroon in upper half inch, flat to lenticular, muscovitic, silty, earthy clay-ironstone	0.2 to 0.5
(p) Soft, gray to chocolate-brown, massive appearing, but thinly and indistinctly bedded, very silty, muscovitic, carbonaceous shale containing marcasite and silt occupying very fine, 1 to 5 mm-thick, branching burrows; contains large secondary gypsum crystals and copiapite	4.3
(o) Shale like (k), contains many silt lenses	8.7
(n) Silt as (l), discontinuous and crumpled into complicated patterns (fig. 42)	from 0.0 to 1.3
(m) Shale like (k), contains some thin silt lenses	3.1 to 1.8
(l) Soft, coherent, light brownish-gray on outside, gray chocolate-brown where fresh, thinly and lenticularly bedded, muscovitic, argillaceous silt having very many tiny lignitized plant fragments; forms a long lens	0.1 to 0.3
(k) Soft, reddish chocolate-brown where weathered, black-brown where fresh, laminated, richly muscovitic, silty, carbonaceous shale with subconchoidal fracture	5.7
Newby glauconitic sand member of Reklaw formation, 13.8 feet thick:	
(j) Hard and brittle, rusty brown on outside, flat, silty, muscovitic, earthy clay-ironstone containing very few glauconite patches	0.3
(i) Indurated to crumbly, rusty olive-brown, cross-bedded, muscovitic, sandy, porous glauconite arenite containing 3 levels of discontinuous, hard and brittle, bright rust-yellow and red, jointed, concentric, earthy clay-ironstone, up to 0.3 foot thick, lying at the level interfaces of the cross-bedding	5.4
(h) Soft, olive-green, indistinctly bedded, muscovitic, sandy glauconite arenite containing many branching, half-inch thick pipes of sandy, earthy clay-ironstone	0.7
(g) Partly indurated, rusty, brownish-yellow to light greenish-gray, nodular and poorly bedded, muscovitic, glauconitic sand enclosing small, 1-inch long nests of brownish shale and nodules with clay-ironstone matrix	0.6
(f) Glauconitic sand, same as (d)	1.0
(e) Clay-ironstone, similar to (c) but containing some concentric clay-ironstone	0.3
(d) Glauconitic sand as (b) but more weathered, hence light rusty yellow in most places	0.7
(c) Hard, red-maroon, irregularly nodular, muscovitic, fine-sandy, glauconitic clay-ironstone with irregular distribution of chiefly glauconite-free, earthy clay-ironstone nests; forming two indistinct ledges separated by softer material	1.3
(b) Coherent, light orange-yellow where weathered, gray-green where fresh, indistinctly bedded, glauconitic, argillaceous, slightly fossiliferous, muscovitic sand	3.0
(a) Hard, red-maroon in the exposures upstream but gradually losing hardness and red color downstream, indistinctly bedded, slightly fossiliferous, glauconitic sand with slight amount of clay-ironstone matrix	0.5
Marine transgressive disconformity: irregular contact surface with burrows, one of which carefully dug out was 3 cm in diameter and extended 3.4 feet down into bed (aa) of the Carrizo	

	Thickness *Feet*
Upper part of Carrizo formation, upper 5.4 feet only:	
(bb) Soft, light chocolate-brown where weathered, brownish-black where fresh, thinly bedded, muscovitic, silty, carbonaceous shale having light sulfur-yellow efflorescences of copiapite; silt is in small clouds or nests. At the right-hand bend of the creek, 1,500 feet from the county road bridge, this bed contains 0.8 foot below its top, hard, rusty brown, badly weathered, very silty clay-ironstone concretions composed of a half-inch-thick shell and a softer core, up to 0.4 foot high and 0.3 to 0.7 foot in diameter, standing obliquely in the bedding	2.3
(aa) Coherent, dark rusty brown-black on outside, very dark gray-green and dark grayish chocolate-brown where fresh, massive, slightly glauconitic, slightly muscovitic, argillaceous, fine-grained sand containing a few imprints of small fossils (like *Corbula* and *Natica*) and finely divided marcasite; to bottom of water hole in channel	3.1

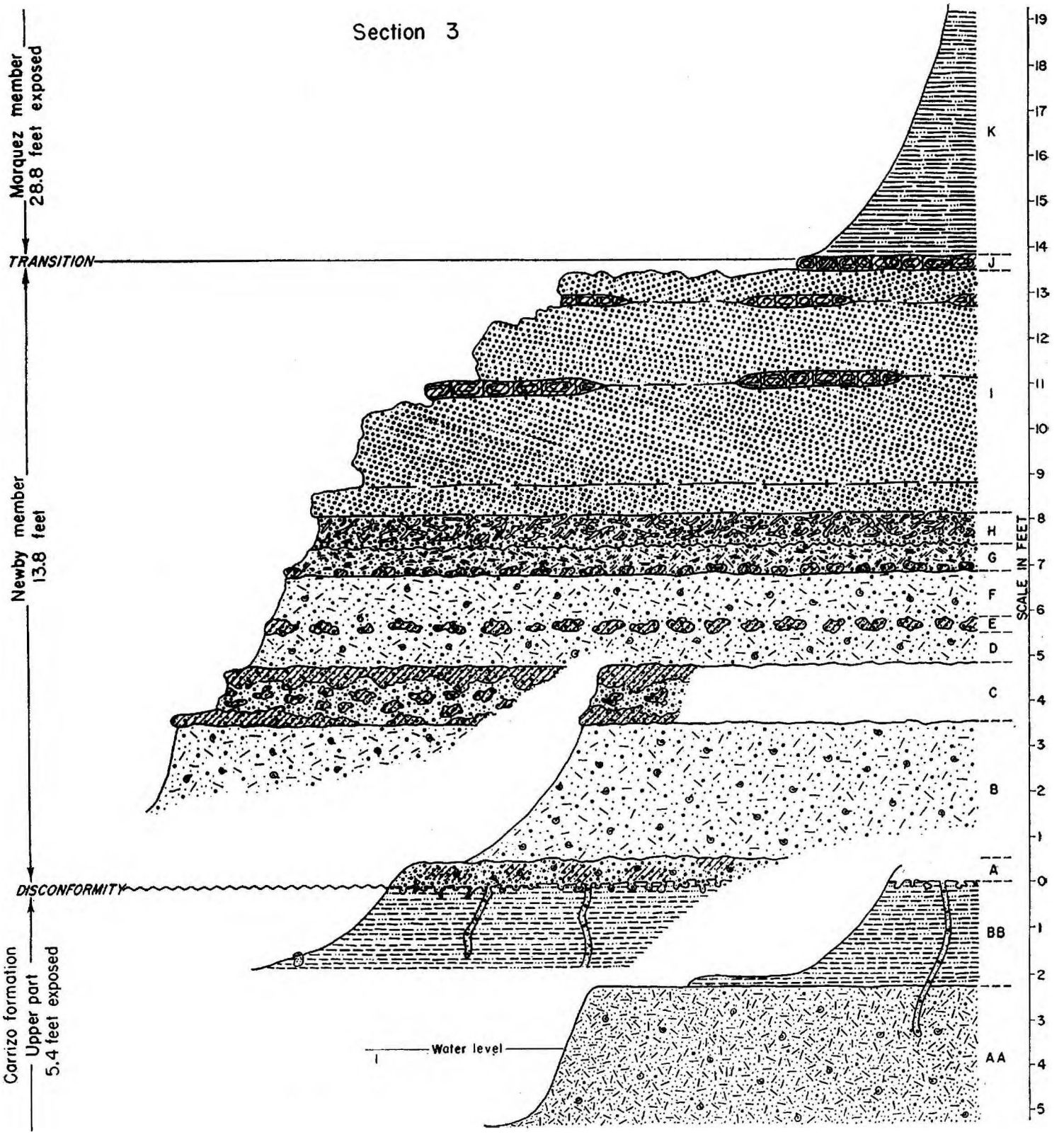


Fig. 24. Profile of section 3.

SECTION 4

Cuts on north-south county road, between the two road forks, one of which is at elevation 404, 0.6 mile south of bridge over Boggy Branch, 1.25 miles airline distance east-northeast of Emmaus Cemetery, northeast Cherokee County [Troup quadrangle, U. S. Geol. Survey], figure 25.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 3.0 feet only:	
(n) Soft, dirty dark red with greenish-gray blotches, badly weathered, unctuous shale cut by dessication cracks; to top of exposure	3.0
Newby glauconitic sand member of Reklaw formation, 21.9 feet thick:	
(m) Crumbly, red-brown to olive, cross-bedded, porous, sandy glauconite arenite, the top half foot thinly and level-bedded and having shale partings	5.7
(l) Hard, red-brown, poorly bedded, sandy glauconite arenite having a clay-ironstone matrix	3.0
(k) Indurated, dirty orange-red, massive to poorly bedded, glauconitic sand with some greenish-gray streaks	1.4
(j) Similar to (i) but more thinly bedded and shaly	1.7
(i) Friable, greenish-gray, poorly bedded, shaly, glauconitic sand	1.7
(h) Hard, brittle, red-brown, irregularly platy, concentric earthy clay-ironstone lacking glauconite	0.1
(g) Similar to (d)	1.1
(f) Hard, brittle, red-brown, irregularly platy, partly glauconitic, concentric, earthy clay-ironstone	0.3
(e) Friable, dirty orange-red, lenticularly bedded, sandy glauconite arenite	1.6
(d) Friable, dirty rust-orange, massive, glauconitic sand	0.7
(c) Soft, greenish-gray and rusty-orange, thinly bedded, glauconitic, shaly sand, some of the glauconite fresh and green	2.7
(b) Friable, dirty rust-orange, massive, fossiliferous, glauconitic sand with some birds-eye structure and burrows extending into the Carrizo shale below; 1 foot at top is locally more indurated and more glauconitic	1.9
Marine transgressive disconformity	
Upper part of Carrizo formation, uppermost 3.3 feet only:	
(a) Soft, gray to chocolate-brown, muscovitic, silty shale containing fine-grained sand partings, toward top it is more orange-red and weathered; base of bed not visible; to bottom of exposure	3.3

SECTION 5

Cuts and ditches on north-south county road from road-metal pit at top of hill to road fork on its south slope, 0.3 to 0.46 mile south of Boggy Branch bridge, 1.35 miles east-northeast of Emmaus Cemetery, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey], figure 25.

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, 23.7 feet thick:	
(i) Hard, red-brown with an olive undertone, massive, fossiliferous, sandy glauconite arenite having a clay-ironstone matrix, to top of hill	9.7
(h) Glauconitic sand as (f)	5.1
(g) Hard, red-brown with an olive undertone and whitish streaks, thinly bedded, sandy glauconite arenite separated by whitish, silty shale partings; one of which has some hard, platy, partly glauconitic, earthy clay-ironstone 1 inch thick	0.8
(f) Indurated, rusty dark orange-red with irregular whitish streaks, massive, glauconitic sand	2.0
(e) Soft, dirty dark orange-red and grayish-white, thinly bedded, shaly, glauconitic sand	2.3
(d) Indurated, deep red-orange, massive, fossiliferous, glauconitic, fine-grained sand	0.9
(c) Hard, olive-greenish-brown tending to rusty red-brown, poorly bedded, sandy glauconite arenite containing many imprints of *Venericardia planicosta* Lamarck	0.9
(b) Indurated, dirty orange-red, massive, fossiliferous, argillaceous, glauconitic sand having birds-eye structure. About 7 imprints of *Venericardia planicosta* Lamarck, about 6 cm in size, were found 1 inch above the base of this bed; one of these had both valves in place	2.0
Marine transgressive disconformity	
Upper part of Carrizo formation:	
(a) Friable, grayish-white with rusty orange-red stripes, thinly bedded, muscovitic, silty shale (white) with thin layers of muscovitic, fine-grained sand (orange-red)	———

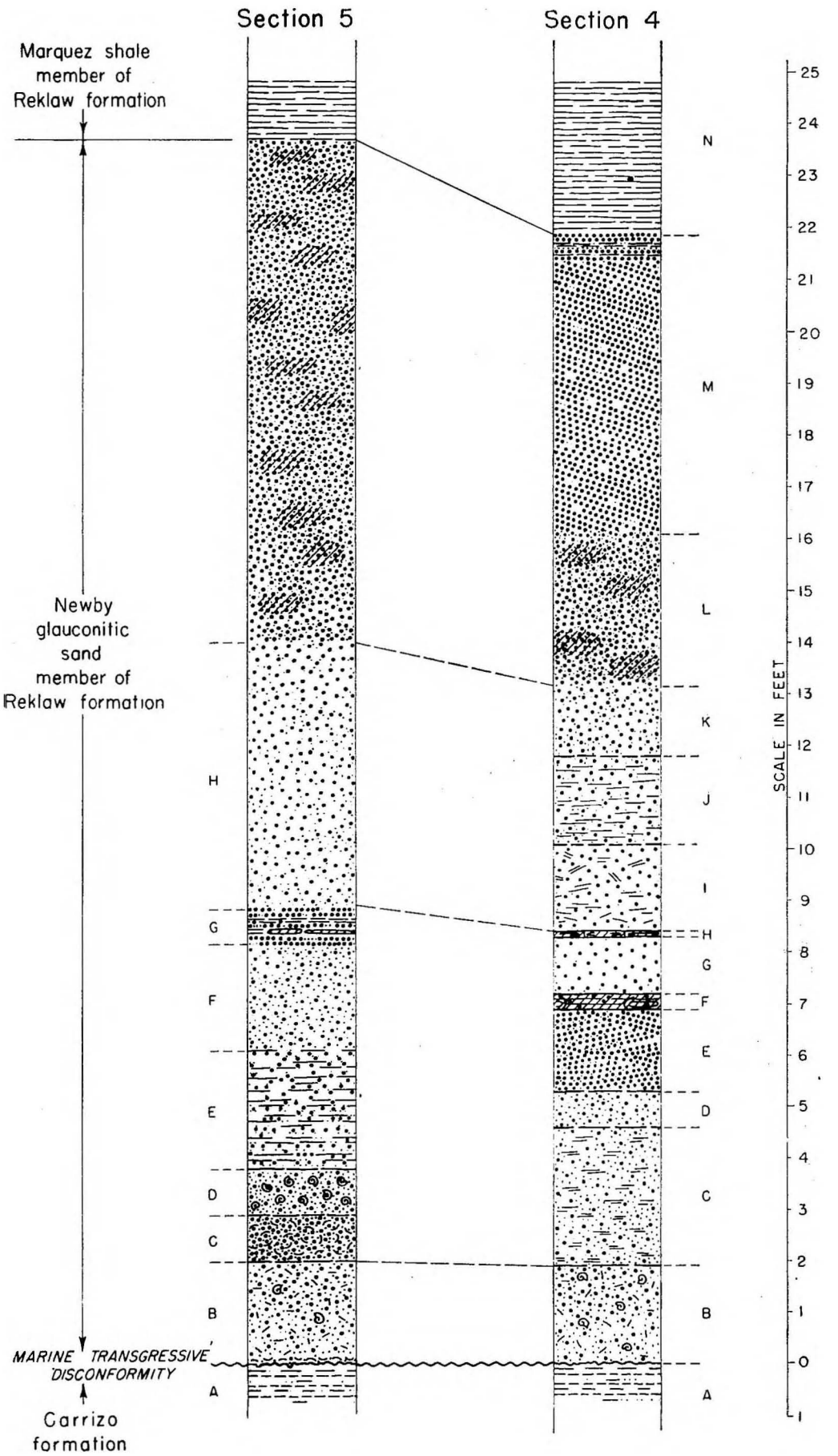


Fig. 25. Stratigraphic column of sections 4 and 5.

SECTION 6

Cuts and ditches of Farm Road 856, on north slope of a hill spur leading down to a right tributary of Campground Creek, 1.46 miles south of Concord and 0.39 mile north of the crossroads at elevation 423, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey], figure 26.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 31.3 feet only:	
(j) Shale as (i), enclosing several nodular clay-ironstone layers, to top of hill	10.0
(i) Soft, gummy, laminated, weathering to nearly brick-red, light greenish-gray in leached portions, chocolate-brown where nearly fresh, conchoidally fracturing, silty, richly muscovitic, carbonaceous shale containing cardboard-thin, limonitic, indurated layers in lower part but lacking clay-ironstones; upper part not well exposed	21.3
Newby glauconitic sand member of Reklaw formation, 5.1 feet thick:	
(h) Glauconitic sand as (f); fresh parts dug out are light greenish-gray	0.8
(g) Glauconitic sand similar to (f), but it is softer and has more clay pieces in birds-eye structure	0.4
(f) Glauconitic sand similar to (e) but lacking indurations and having the clay pieces more conspicuous	1.3
(e) Coherent, rusty yellow-brown with an olive undertone, massive, fossiliferous, glauconitic, slightly muscovitic, slightly argillaceous sand, has many indurated knobs (probably pipes) of 1 to 2 inches diameter and crescent- to ring-shaped, light greenish-gray, more argillaceous portions that produce birds-eye structure	1.1
(d) Glauconitic sand as (c) but indurated, contains imprints of the gastropod *Volutospina* of about 1 inch size	0.7
(c) Coherent, rusty brown with an olive undertone, massive, fossiliferous, glauconitic, slightly muscovitic, slightly argillaceous sand having some irregular indurations; extends in burrows down into the upper part of the Carrizo formation	0.8
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 5.1 feet only:	
(b) Silty shale as bed (a) but increasingly riddled at the top by burrows and pipes filled with Newby glauconitic sand, many of which are indurated, ⅜ of an inch thick and nearly vertical in lower part and up to 2 inches wide and irregular in upper part	1.7
(a) Coherent, grayish chocolate-brown in fresher parts, weathering to dirty rust-yellow in a few places, massive to poorly bedded with very short bedding planes, silty, richly muscovitic, carbonaceous shale containing many small nests of loose fine-grained sand that becomes here and there so abundant that the rock becomes a fine-grained sand rather than a shale; to bottom of exposure	3.4

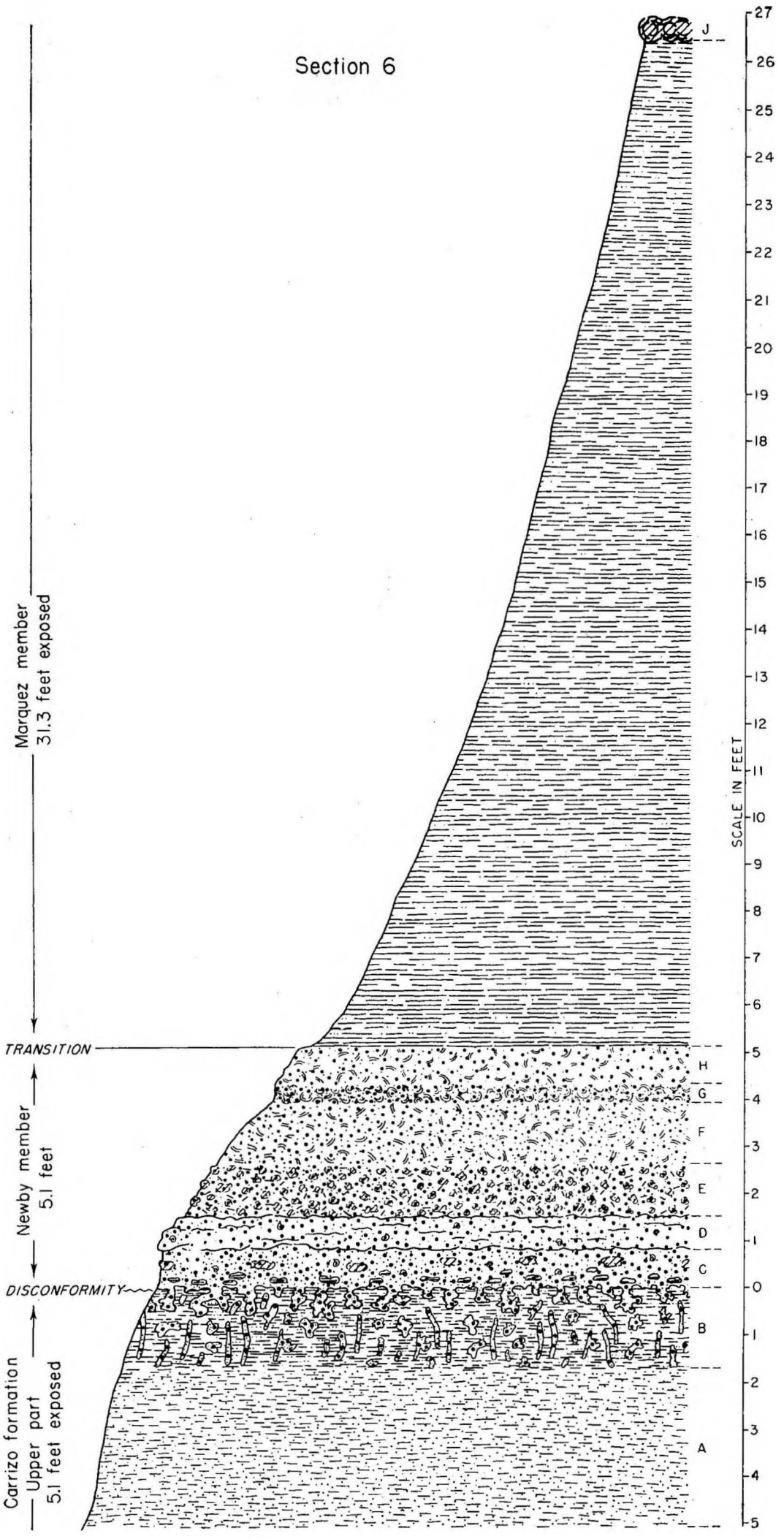


Fig. 26. Profile of section 6.

SECTION 7

Cut on north side of U. S. highway 79 (New Summerfield—Henderson road) on right bank of Striker Creek, starting nearly at flood-plain level and extending 150 feet west of west end of concrete bridge, northeastern Cherokee County, Texas [Henderson quadrangle, U. S. Geol. Survey], figure 27.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 11.0 feet only:	
(q) Similar to (p) but thin bedded	0.8
(p) Coherent, dirty rust-yellow with olive undertone, massive, very argillaceous, muscovitic, glauconitic silt	1.6
(o) Hard, hematite-red, ellipsoidal, discontinuous, earthy clay-ironstone enclosing clouds of muscovite, silt, and glauconite grains	0.9
(n) Indurated, greenish-gray and rusty red-brown streaked, poorly and thinly bedded, muscovitic, glauconitic, very argillaceous, fine-grained sand containing irregular short lenses of brown shale	1.5
(m) Soft, gray and chocolate-brown, irregularly fracturing, thinly short-lenticular, richly muscovitic, carbonaceous shale containing irregular short lenses of muscovitic silt	1.9
(l) Soft, chocolate-brown, conchoidally fracturing, laminated, muscovitic, slightly silty shale; some layers contain small, waxy, brown pellets (glaumonite?); a few thin (0.3 foot), coherent, whitish-gray, laminated, richly muscovitic, carbonaceous, slightly argillaceous silt layers containing plant remains on bedding planes	4.3
Newby glauconitic sand member of Reklaw formation, 15.9 feet thick:	
(k) Hard, rusty yellow-brown, earthy, clay-ironstone having fine-grained sand and glauconite grains well dispersed	0.4
(j) Indurated, rusty olive-brown, cross-bedded, slightly sandy, medium-grained glauconitic arenite having interstitial clay cement	2.7 to 4.1
(i) Friable, rusty olive-yellow-brown, massive, glauconitic, argillaceous, medium-grained sand enclosing hard, hollow pipes of sandy clay-ironstone filled with loose glauconitic sand; at east end this layer is partly hard	2.1
(h) Loose, olive-brown, massive, glauconitic, slightly argillaceous, medium-grained sand	0.6
(g) Hard, olive-brown and rusty yellow, irregularly nodular, glauconitic, medium-grained sand and concentric, very sandy, glauconitic, clay-ironstone having earthy clay-ironstone cores	3.1
(f) Friable, rusty olive-red-brown, massive, glauconitic, argillaceous, fine-grained sand	1.0
(e) Friable, rusty olive-red-brown and greenish-gray sand similar to (f) but containing many greenish-gray shale pieces lying flat	1.2
(d) Friable, rusty olive-yellow-brown, massive, argillaceous, glauconitic, fine-grained sand	0.4
(c) Soft, greenish-gray, laminated, richly muscovitic, silty shale; leached	0.4
(b) Indurated, rusty, dark olive-yellow, knobby, glauconitic, argillaceous, fine-grained sand grading into clay-ironstone matrix; at base are many pipes ¼ inch in diameter	1.5
(a) Friable, rusty red-brown, massive, slightly muscovitic, glauconitic, fine-grained sand, containing a discontinuous layer of indurated, hematite-red, sandy, glauconitic, chiefly earthy clay-ironstone having imprints of *Limacina*, 0.3 foot thick and 0.8 foot above base	2.4
Marine transgressive disconformity	
Upper part of Carrizo formation:	
(x) Soft, greenish-gray and rusty brown splotched, indistinctly bedded, muscovitic, very argillaceous, fine-grained sand in part grading to brown clay; to bottom of exposure	2.5+

SECTION 8

Road ditch on east side of Farm Road 856, due west of Martin Chapel, south of the eastward-flowing tributary branch of Campground Creek, 0.38 mile northeast of the church at Concord, northeastern Cherokee County [Troup quadrangle, U. S. Geol. Survey].

Not detailed, because deeply weathered.

Newby glauconitic sand member of Reklaw formation, 7.4 feet thick.

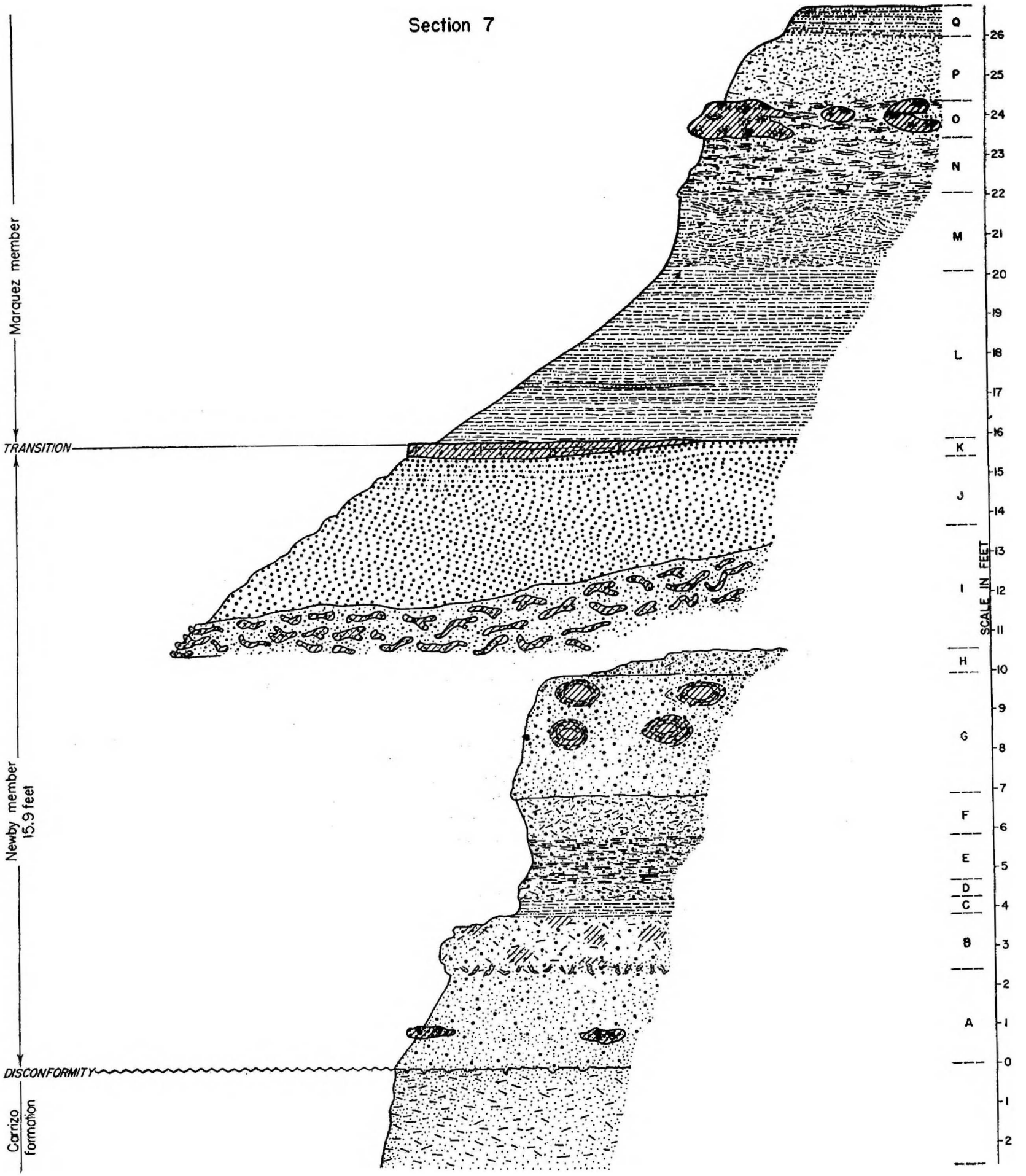


Fig. 27. Profile of section 7.

SECTION 9

Three bluffs on right bank of Hogpen Branch, 1,700 feet west-southwest of Oak Flat Cemetery, 900 feet north-northeast of State highway No. 204 (Cushing—Nacogdoches road), 2 miles airline distance east of Cushing, northwestern Nacogdoches County [Cushing quadrangle, U. S. Geol. Survey], figure 28.

The exposures on Hogpen Branch are next to locality 200-T-1 (Section 12), the freshest exposures of the Newby and upper Carrizo found in vicinity of the Henrys Chapel quadrangle. Although much of the glauconite is fresh, all fossils are already leached here. The exposures on Hogpen Branch have their downstream end where the branch enters the flood plain of Dill Creek. They extend upstream for about 600 feet airline distance to a waterfall at the upstream end of a high bluff. Upstream from the waterfall are many scattered, badly weathered, small exposures of the upper Carrizo in the stream channel; these are, however, of no particular interest. The waterfall is caused by the induration of the upper part of the cross-bedded sand bed of the Carrizo, bed (a) of the section. Above the waterfall the sand is indurated by secondary limonite infiltrations and forms many irregular narrow ribs across the channel. The Section 9-A, given below, was measured at the uppermost and highest of the three bluffs, located a little downstream from the waterfall at a place where a north-south property-line fence crosses the branch.

SECTION 9-A

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, 17.3 feet thick:	
(k) Upper beds, not detailed.	
(j) Clay-ironstone ledge	1.2
(i) Coherent and tough, olive-brown-gray on outside, chocolate-brown on fresh breaks, indistinctly bedded, argillaceous, glauconitic, fine-grained sand containing chocolate-brown clay matrix in cloud-like distribution	5.6
(h) Coherent and tough, olive-green-gray on outside, chocolate-brown on fresh breaks, poorly and thinly bedded, muscovitic, glauconitic, very fine-grained sandy, carbonaceous shale	1.5
(g) Loose, grayish olive-brown on outside, grayish-green where fresh, porous, slightly muscovitic, glauconitic, fine-grained sand	0.8
(f) Hard, bench-forming, maroon-red on outside, dull brownish-gray on cross-breaks, continuous, somewhat wavy, glauconitic, locally fossiliferous clay-ironstone, full of fine-grained sand; fossil shell imprints in basal 1 inch	0.8
(e and d) Soft, olive-brown and green on weathered surface, thinly and indistinctly bedded, very argillaceous, glauconitic, fine-grained sand; the argillaceous cement is a chocolate-brown, carbonaceous clay; there are nests of much less argillaceous sand, which are probably sand-filled burrows	1.4
(c) Slightly coherent, deeply weathered to a dirty rust-brown, grayish-green where fresh, massive, porous, slightly argillaceous, glauconitic, coarse-grained sand enclosing well-preserved cavities and imprints of large thick single valves of *Venericardia planicosta* Lamarck (6.5 cm long) and other pelecypods, some containing boring sponge holes and attached single corals, found in groups at the base of the bed; the bed grades upward into fine-grained and rests on an irregular surface; clay pebbles (2 by 3 inches to 1½ by 2 inches in size) are present in basal part	2.1
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 6.3 feet only:	
(b) Soft, dark gray spotted with light yellow limonite on outside, dark green and brown where fresh, thinly and poorly bedded, glauconitic, muscovitic, lignitic shale full of very fine-grained sand; imprints of various thin-shelled mollusks, pteropods included, are present; about 0.6 foot below top is a layer rich in flat, rounded pebbles of lignite and isolated hard, flat concretions, 1 by 4 inches, composed of dark gray-brown very fine-grained siderite	2.5
(a) Coherent, dirty rust-brown weathering, medium gray where fresh, gently inclined cross-bedded, porous, muscovitic, slightly glauconitic, very fine-grained, clean sand containing a few very thin (⅛ inch), irregular, discontinuous, slanting partings of grayish chocolate-brown clay; exposed down to water level where several potholes are eroded into it	3.8

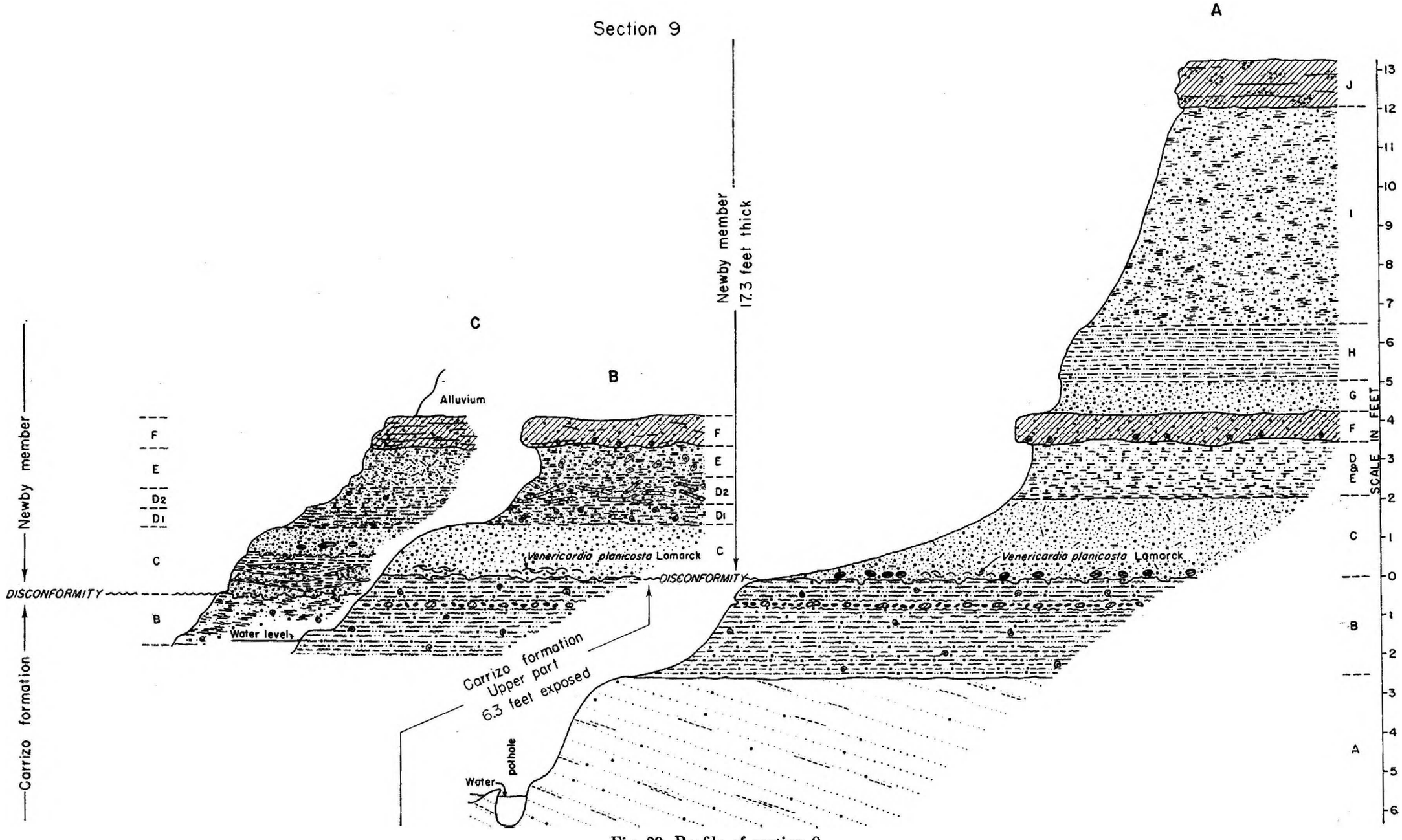


Fig. 28. Profile of section 9.

SECTION 9-B

The Section 9-B was measured on the second bluff on the right bank of Hogpen Branch about 100 feet west of the north-south property-line fence and 250 feet downstream from the highest of the bluffs. Compare figure 28 on page 53.

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, basal 4.1 feet:	
(f) Same as (f) Section 9-A	0.8
(e) Coherent, olive-brown and green on weathered surface, thinly but indistinctly bedded, very argillaceous, glauconitic, fine-grained sand; the argillaceous cement is chocolate-brown clay	0.8
(d_2) Coherent and tough, grayish olive-brown on surface, dark gray-brown where fresh, indistinctly bedded, glauconitic, argillaceous, fine-grained sand, full of half-inch-thick pipes of more sandy material	0.7
(d_1) Coherent and tough, grayish dark brown on surface, dark brown and green where fresh, crinkly bedded, argillaceous, glauconitic, fine-grained sand; the argillaceous cement is chocolate-brown shale; imprints of small fossils are present	0.5
(c) Coherent, dark rusty brown on weathered surface, dark green where fresh, irregularly interbedded, porous, glauconitic, medium to coarse-grained sand containing a few imprints of large fossils (*Venericardia planicosta* Lamarck) and brown, argillaceous, glauconitic, fine-grained sand	1.3
Marine transgressive disconformity	
Upper part of Carrizo formation:	
(b) Same as (b) of Section 9-A; 1.7 feet to water level.	

SECTION 9-C

The Section 9-C was measured in the channel of Hogpen Branch at a sharp left turn of the branch, on the left bank about 100 feet upstream from the place at which the branch enters the flood plain of Dill Creek. Compare figure 28 on page 53.

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, basal 3.7 feet:	
(f) Same as (f) of Section 9-A.	
(e) Very soft, gray-green, massive, very argillaceous, glauconitic sand	1.0
(d_2) Friable, dark brown, indistinctly bedded, glauconitic, very argillaceous, fossiliferous sand; imprints of fossils are common; some of the quartz sand grains are of medium size but most are fine	0.5
(d_1) Coherent, dark chocolate-brown, crinkly bedded, glauconitic, lignitic, very fine-sandy shale containing flat pebbles of lignite, 4 by 25 mm in size, and some large glauconite grains (3 mm)	0.5
(c) Coherent, rusty yellow-brown, dark gray-green where fresh, massive to poorly lenticular, porous, glauconitic, fine to medium-grained sands in lenses, which have irregular burrows at their base; interbedded with soft, dark chocolate-brown, laminated, finely muscovitic, carbonaceous, slickensided shales. The uppermost sand lens is 0.6 foot thick; the sands contain also sandy pipe-like burrows, one of these is a *Halymenites*, half an inch thick	1.7
Marine transgressive disconformity	
Upper part of Carrizo formation:	
(b) Coherent, dark grayish-green and brown, massive, porous, glauconitic, argillaceous, fine-grained sand; the chocolate-brown, argillaceous cement has cloudy distribution leaving nests of loose, porous, green sand. The bed is rich in tiny shiny crystals of marcasite; a few thin-shelled mollusk imprints are present	1.3

SECTION 10

Deep cut on State highway No. 204 (Cushing—Nacogdoches road), 0.15 mile west of channel of Jones Creek, 3.72 miles southeast of crossroads, in Cushing or 3.23 miles northwest of crossroads in Trawick, northwestern Nacogdoches County [Cushing quadrangle, U. S. Geol. Survey], figure 29.

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, 15.0 feet thick:	
(q) Hard, red-maroon to olive and rusty brown, nodular to layered, clay-ironstony glauconite arenite, contains very little sand	2.0
(p) Slightly indurated, dirty orange-red with gray-green streaks, poorly bedded, slightly muscovitic, glauconitic, argillaceous sand enclosing irregular pipes, about 2 inches in diameter, of hard, red-maroon to rusty brown, earthy clay-ironstone, containing clouds of glauconite and sand	1.1
(o) Same as bed (m), soft and gummy	4.5
(n) Hard, red-maroon in its harder places, rusty brown in many places, nodular to thinly layered, earthy clay-ironstone having cloudy distribution of sand and glauconite grains, enclosing some thin (¼ inch), smooth pipes; forms a conspicuous continuous ledge throughout exposure	1.2
(m) Soft, light gray-green, massive, sandy, highly argillaceous, glauconite arenite having thin (¼ inch) burrows filled with dark green, more richly glauconitic material	0.9
(l) Soft, gummy, light greenish-gray, poorly bedded, muscovitic, sandy, glauconitic clay, the glauconite distributed in irregular clouds	1.0
(k) Soft, tough, brownish-gray, thinly and indistinctly bedded, muscovitic, sandy, glauconitic, carbonaceous clay	1.0
(j) Similar to (h) but lower 0.5 foot is rich in burrows or nests of darker gray-green, richly glauconitic, argillaceous sand	0.8
(i) Hard, rusty yellow and brown, nodular, irregularly concentric, cavernous, pipe-like, sandy clay-ironstone, in part glauconitic	0.3
(h) Same as (f), but less weathered, hence light gray-green in color; clay pieces are distributed in curved, irregular swirls forming birds-eye structure patterns	1.2
(g) Hard, red-maroon in its harder parts, reddish rust-brown, poorly layered, in places earthy and pure, in others sandy and glauconitic, fossiliferous clay-ironstone, discontinuous	0.7
(f) Friable, light rusty yellow-brown with an olive tint, massive, argillaceous, slightly muscovitic, glauconitic sand	0.3 to 0.5
Marine transgressive disconformity	
Upper part of Carrizo formation; upper 12.4 feet exposed:	
(e) Soft, black-brown where fresh, chocolate-brown at east end of cut, thinly bedded, muscovitic, silty, carbonaceous shale with nests and lenses of brown, fine-grained sand, contains large grains if glauconite; some of the sand lenses are indurated with rust-brown limonite and show as irregular ledges	1.7
(d) Friable but tough, grayish chocolate-brown, weathering to spotted rusty yellow and brown, massive, fine-grained sandy, muscovitic, very slightly glauconitic, carbonaceous, argillaceous silt; some glauconite grains are 3 mm in size; the bedding appears to be destroyed by the numerous more sandy burrows; a small (1 inch) piece of lustrous black lignite or resin was found	3.5
(c) Hard and brittle, light rust-yellow, thinly bedded, limonitic sand filling a network of branching, flattened pipes of 1-inch diameter in a matrix of light gray-chocolate-brown, silty, muscovitic shale	0.2 to 0.3
(b) Friable, dirty orange-red, deeply oxidized, poorly to massively bedded, slightly glauconitic, muscovitic, porous, fine-grained sand with wavy, irregular layers of soft, faintly greenish-gray, leached, laminated, silty, muscovitic shale pieces pierced by sand-filled burrows of ⅛ to ½ inch diameter	3.8
(a) Soft, light chocolate-brown in fresher parts, faintly greenish-gray where leached, laminated, silty, muscovitic shale with thin (½ inch), friable, dirty orange to rusty brown, thinly bedded, muscovitic, fine-grained sand, cut by vertical cross joints; bottom not exposed	3.2+

The disconformity is shown by burrows, up to 2 inches in diameter, extending down into bed (e). Also lower surface of bed (f) is gently but clearly undulating in long waves, as can be seen by comparison with bed (n), which is straight.

Beds (o) to (q) were measured in this highway cut where a county road enters it from the south.

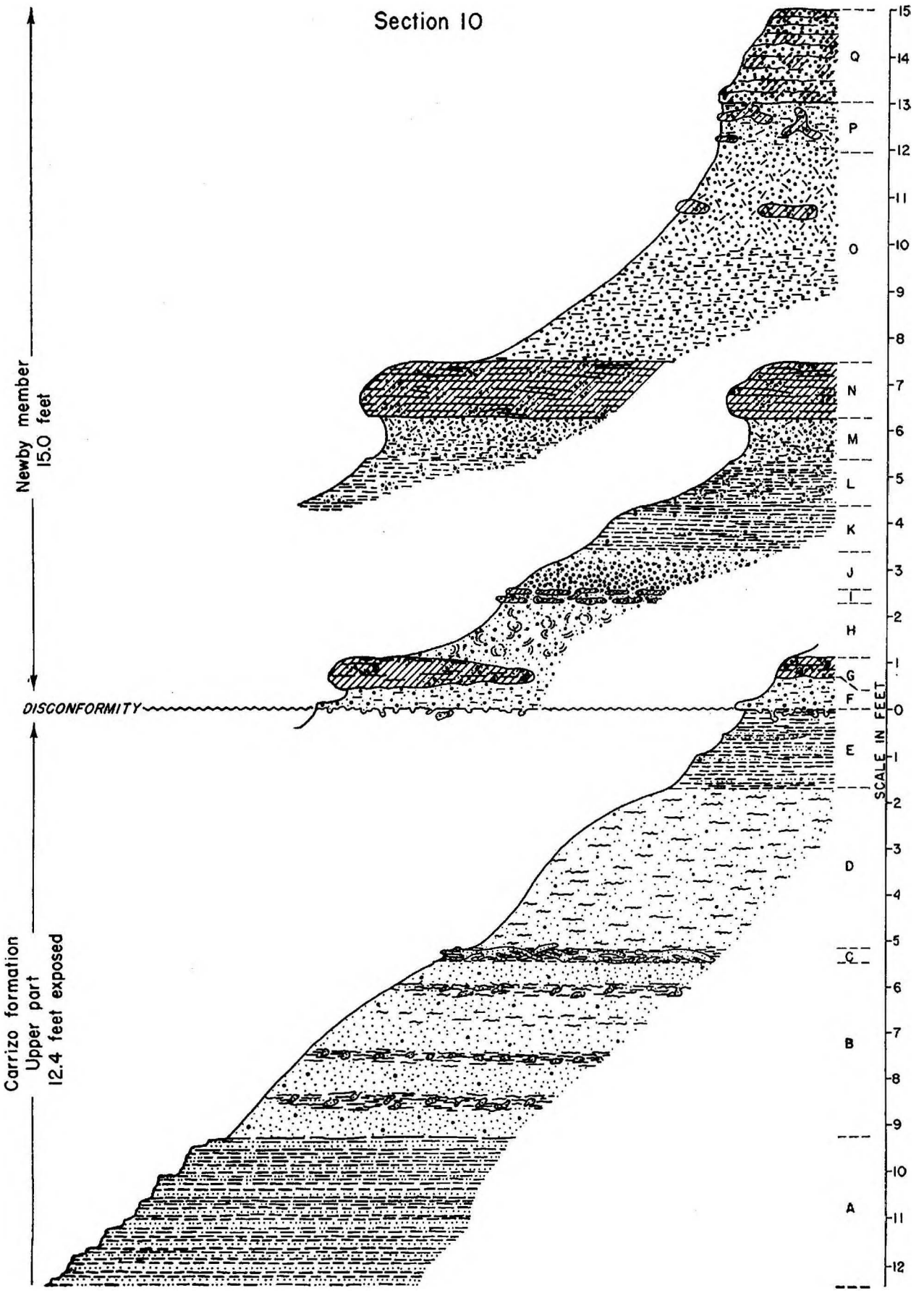


Fig. 29. Profile of section 10.

SECTION 11

Road cut on north side of State highway No. 204 (Cushing—Nacogdoches road) on the west slope of a hill leading down to the channel of Hogpen Branch, a right tributary of Dill Creek, 0.45 mile west-northwest of Oak Flat Church, where the old road joins the new highway at an acute angle at highway right-of-way concrete marker 455. 2.43 miles southeast of the crossroads in Cushing and 4.48 miles northwest of the crossroads in Trawick, northwestern Nacogdoches County, Texas [Cushing quadrangle, U. S. Geol. Survey], figure 30.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 4.6 feet only:	
(o) Soft and gummy, dark red-orange mottled on dirty light greenish-gray, deeply weathered, glauconitic, slightly silty clay with the glauconite remaining green in color; becomes more richly glauconitic and less argillaceous toward base; thickness exposed to top of cut	4.6
Newby glauconitic sand member of Reklaw formation, 16.9 feet thick:	
(n) Hard, red-maroon to olive and rusty red-brown, nodular, partly concentric, glauconitic, slightly sandy, earthy clay-ironstone; many ironstone knobs are hollow and filled with loose, greenish-gray, glauconitic sand	2.0
(m) Coherent, gray-green where fresh, weathering light rusty yellow, thinly and indistinctly bedded, argillaceous, glauconitic, fine sand; weathers to a streaked appearance and has birds-eye structure	2.1
(l) Hard and brittle, red-maroon, poorly layered, earthy clay-ironstone, containing nests of glauconite and sand grains and having a tendency to concentric structure with bright rusty yellow cores; forms a conspicuous and continuous ledge	1.0
(k) Much like bed (j) below but forms a concavity and is possibly less argillaceous	0.3
(j) Coherent, light gray-green, indistinctly bedded, sandy, glauconitic clay, upper part sandier; shows lenticular cross-bedding in west end of cut; weathers dirty rust-yellow or brown; has birds-eye structure	5.1
(i) Soft, gummy, brownish-gray, thinly bedded, sandy, glauconitic, carbonaceous shale having the sand and glauconite in horizontal clouds	1.7
(h) Coherent, olive-green where fresh, weathering to olive-brown, massive, sandy, argillaceous glauconite arenite having light greenish-gray, argillaceous swirls and rings (birds-eye structure) and a little clay-ironstone as interstitial cement and as local earthy clay-ironstone patches	0.6
(g) Hard and brittle, red-maroon, irregular to slightly layered, earthy clay-ironstone intermixed with olive rust-brown, massive glauconitic sand; discontinuous	0.5
(f) Same as (h)	1.2
(e) Clay-ironstone as (g); continuous	0.3
(d) Soft, light gray-green, weathering rusty yellow and brown, argillaceous, glauconitic sand; some glauconite grains are large	1.0
(c) Discontinuous clay-ironstone, as (g)	0.3
(b) Glauconitic sand, as (d), containing pieces of chocolate-brown clay	0.8
Marine transgressive disconformity	
Upper part of Carrizo formation, 5.6 feet exposed:	
(a) Coherent, light grayish chocolate-brown, massive to faintly bedded, carbonaceous, argillaceous, muscovitic, fine sand containing rare large glauconite grains and some smaller ones; weathers to dirty orange-red with dirty gray blotches and stringers, bottom of bed not exposed	5.6+

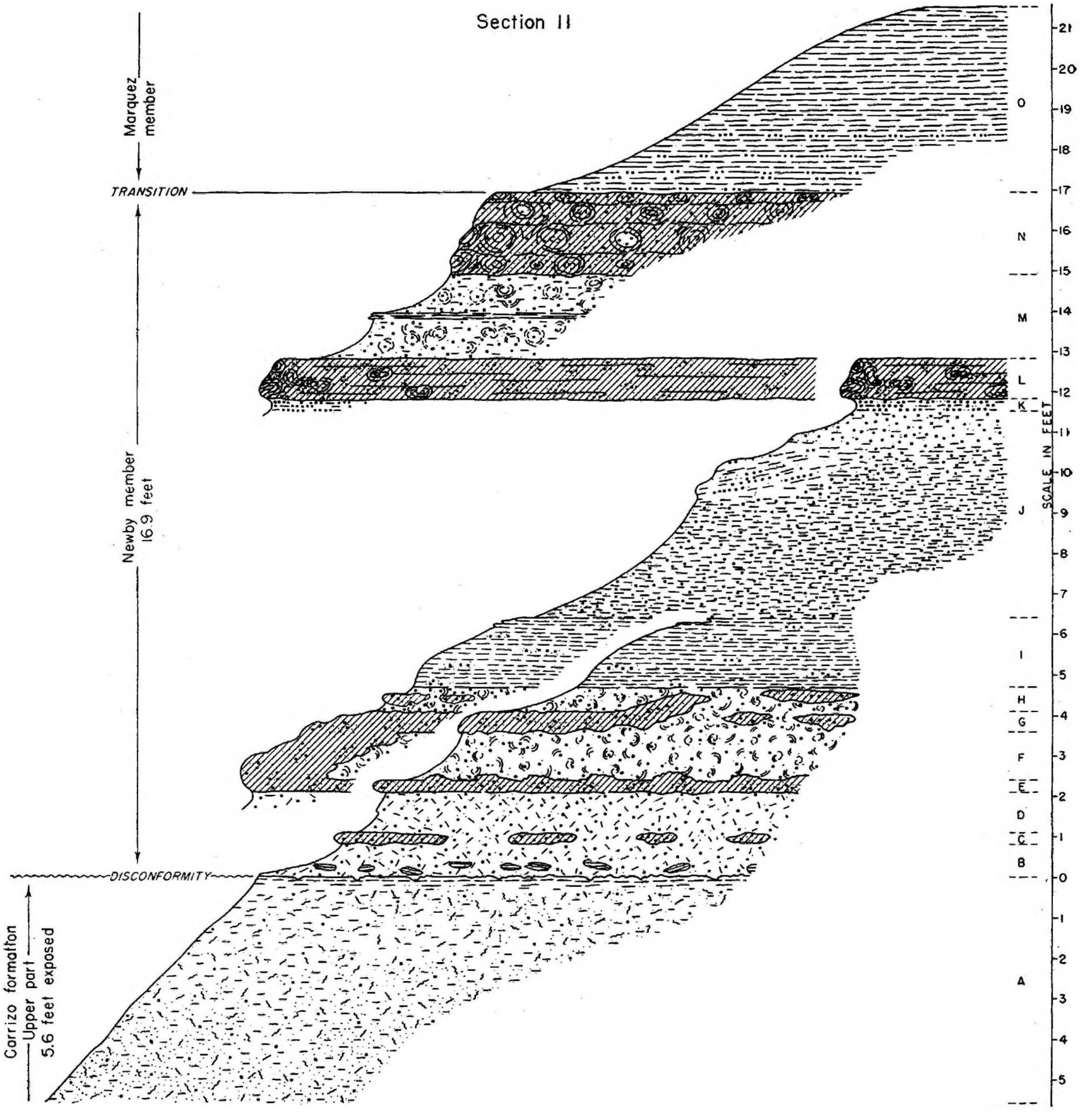


Fig. 30. Profile of section 11.

SECTION 12

Borrow pit on north side of U. S. highway No. 84 (Rusk—Mt. Enterprise road) on right side of the Angelina River, about 300 feet west of the stream, southwestern corner of Rusk County [Cushing quadrangle, U. S. Geol. Survey], Bureau of Economic Geology locality No. 200-T-1, figure 31.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 21.7 feet:	
(u) Hard, rusty olive-brown, indistinctly bedded, weathered, argillaceous glauconite arenite containing few and small fossil imprints and very litte sand; weathers by concentric exfoliation from jointed blocks	2.5
(t) Soft, gummy, light chocolate-brown, laminated, muscovitic, silty, carbonaceous shale; top 2.4 feet not well exposed, hence dubious; a 1-inch thick silt layer about 2.5 feet from top; top 8 feet have lignitized plant fragments on bedding planes; a bedding plane about 6 feet from base was full of imprints of thin-shelled coiled pteropods *(Limacina)*	16.0
(s) Soft, gummy, light greenish gray, laminated, glauconitic, silty shale enclosing pockets of small gypsum crystals	0.9
(r) Soft, gummy, rusty brown or yellow, glauconitic, silty shale	1.0
(q) Shale as (r) but contains layers of hard, splintery, rusty red-brown, irregularly nodular, dense clay-ironstone, each about 2 to 3 inches thick; some clay-ironstone forms numerous half-inch thick, branching pipes	1.3
Newby glauconitic sand member of Reklaw formation, 12.9 feet thick:	
(p) Hard, brittle, dark green on fresh break, light gray-green when dry, rusty red-brown on weathered surface, crudely bedded, richly glauconitic clay-ironstone	1.2
(o) Soft, tough, dark green and grayish-green and rusty olive-brown streaked, laminate-lenticular, glauconitic shale and brown, carbonaceous shale interbedded	2.0
(n) Tough, greenish-black, fairly coarse, massive, argillaceous glauconite arenite containing hard, rusty red pipes of clay-ironstone ½ to 1 inch thick	0.9
(m) Same as (o)	0.7
(l) Same as (n)	1.5
(k) Hard, brittle, red-maroon, knobby clay-ironstone having grayish rusty yellow and green-speckled, argillaceous, glauconitic sand in between the ironstone knobs; lower 0.7 foot is more continuous clay-ironstone and in spots full of small fossils (collection from this bed)	2.2
(j) Soft, gray-green, weathering to olive-green, indistinctly bedded, muscovitic, glauconitic, argillaceous sand containing fossil shells	1.9
(i) Hard, brittle, red-maroon, separate to confluent, ellipsoidal, silty, glauconitic clay-ironstone, contains some balls of chalky, light gray with green specks, massive, glauconitic, calcareous siderite up to 4 inches in diameter; toward the south, that is, about 25 feet from highway ditch, this bed is composed of many thin, branching clay-ironstone pipes lying loosely about	0.4
(h) Same as (j), contains oyster shells, shark teeth, and fish vertebrae; base of bed is a minor disconformity and has burrows	0.4
(g) Soft, dark brownish-black, glauconitic, argillaceous sand with some large glauconite(?) grains; matrix is in part brown carbonaceous shale	1.7
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 5.9 feet only:	
(f) Coherent, rusty orange-brown, massive to crinkly bedded, porous sand with dark brown, carbonaceous shale flitters; somewhat indurated layers 0.7 foot below top of bed	2.3
(e) Soft, gummy, white, leached shale	0.2
(d) Two thin (0.1 foot) indurated ledges of coarse, argillaceous sand separated by sand and leached shale similar to (f) and (e); bottom of lower hard sandy crust is full of imprints of *Lunulites, Corbula,* small gastropods, and other fossils	1.4
(c) Soft, rusty dirty orange and light greenish-gray mottled, indistinctly bedded, argillaceous sand	0.9
(b) Hard, rusty yellow-brown, continuous, earthy clay-ironstone heads, which include irregular nests of ferruginous sand; slightly glauconitic and fossiliferous	0.8
(a) Same as (c), visible only for	0.3

Oversized
page

SECTION 13

Deep cut on north side of U. S. highway No. 84 (Rusk—Mt. Enterprise road), on a westward slope, 0.65 mile east of underpass at Reklaw village, southwestern corner of Rusk County [Cushing quadrangle, U. S. Geol. Survey], figure 32.

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, 12.9 feet thick:	
(l) Hard, rusty yellow and red-brown, wavy and platy, concentrically weathering, glauconitic clay-ironstone; up to the soil	0.2
(k) Soft, rusty red-brown, weathered, glauconitic shale(?)	1.2
(j) Indurated, rusty red-brown, dark olive-green where fresh, indistinctly bedded, argillaceous glauconite arenite	1.3
(i) Soft, gummy, light greenish-gray, laminated, leached, glauconitic(?), sandy shale	0.7
(h) Soft, dirty rust-brown to olive-green, argillaceous, glauconitic sand	0.5
(g) Coherent to partly indurated, dirty rust-yellow or brown, slightly argillaceous, muscovitic, glauconitic sand; top 1.7 feet has many highly irregular, maroon, glauconitic clay-ironstone nodules; bottom 0.7 foot is indurated and has poorly developed thin bedding; base has some large grains of glauconite	2.8
(f) Glauconitic sand as (g) but soft	0.2
(e) Glauconitic sand similar to (g) but has indistinct, thin, wavy bedding and is more argillaceous and more glauconitic, contains a few fossil imprints; near base are coarse, soft, greenish grains of glauconite up to 3 mm in size	1.7
(d) Soft to coherent, dirty rust-brown to yellow, partly glauconitic, porous sand containing irregular lenses of gummy, light greenish-gray, laminated, leached shale; top 1.3 feet is very soft glauconitic sand; there are some large glauconite grains; bottom of bed is dark rusty brown and porous; the base is very irregular	4.3
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 11.1 feet only:	
(c) Coherent, dirty light greenish-gray and rusty, massive to indistinctly bedded or crinkly, muscovitic, faintly glauconitic, argillaceous, fine-grained sand; the more argillaceous and fresh portions distinctly carbonaceous; contains a few imprints of *Corbula*	4.8
(b) Soft, light chocolate-brown, wavily thin-bedded, muscovitic, carbonaceous, silty shale containing silt layers	3.7
(a) Partly indurated, rust-orange streaked with light greenish-gray, muscovitic, argillaceous sand containing leached streaks of carbonaceous shale; to bottom of exposure	2.6

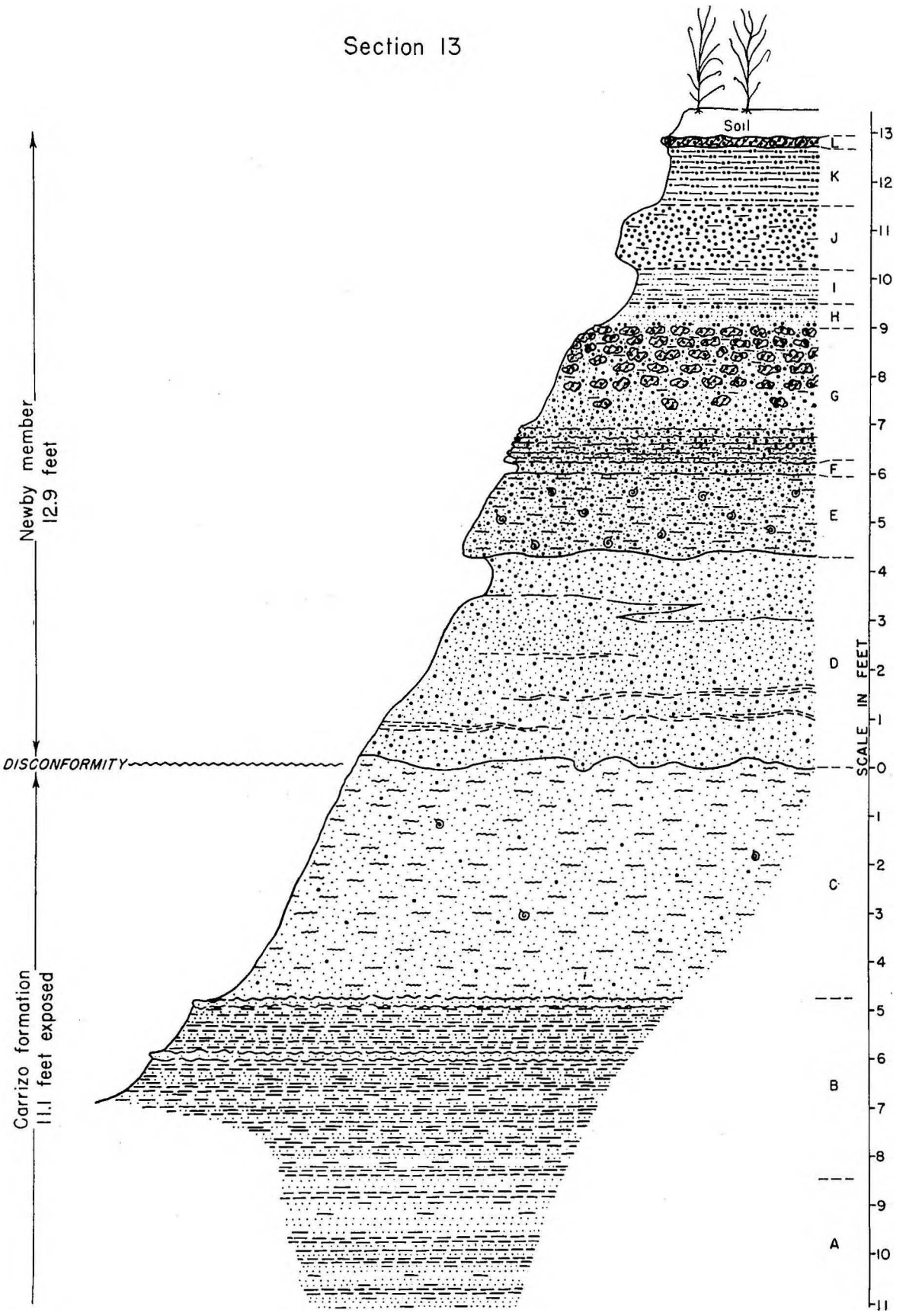


Fig. 32. Profile of section 13.

SECTION 14

Cut on Southern Pacific Railroad, 0.85 mile southeast of highway underpass at Reklaw village in southwestern corner of Rusk County [Cushing quadrangle, U. S. Geol. Survey], figure 33. This exposure is part of the type locality of the Reklaw formation.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 5.2 feet only:	
(m) Hard, rusty red-brown, nodular and slabby, sandy, glauconitic clay-ironstone in weathered, soft, glauconitic clay	3.4
(l) Soft, gummy, light greenish-gray, leached, laminated, glauconitic shale	1.8
Newby glauconitic sand member of Reklaw formation, 12.2 feet thick:	
(k) Indurated, olive-green, lenticular-bedded, sandy, argillaceous glauconite arenite	1.4
(j) Soft, light olive-green, massive, slightly argillaceous, glauconitic sand	0.3
(i) Soft, light grayish-green where fresh, argillaceous, glauconitic sand having some more shaly portions and fossil imprints; top 1.3 feet becomes in south end of cut a slightly indurated, bright red-maroon, glauconitic, earthy clay-ironstone	3.8
(h) Hard, rusty red-brown, crudely layered, richly glauconitic, sandy clay-ironstone with imprints of *Venericardia planicosta* Lamarck	0.8
(g) Soft, dark rusty brown to olive-brown, streaked, slightly argillaceous, glauconitic sand containing large grains of glauconite	0.3
(f) Firm, rusty red-brown, light gray-green where fresh, crudely bedded, slightly argillaceous, glauconitic sand containing few greenish-gray, glauconitic shale nests; bottom 0.1 foot is indurated	3.3
(e) Coherent, rusty red-brown and light greenish-gray blotched glauconitic sand and irregular, leached shale	1.2
(d) Glauconitic sand as (b)	0.3
(c) Soft, light chocolate-brown, laminated, muscovitic shale	0.5
(b) Coherent, rusty brown, massive, slightly muscovitic, porous, glauconitic sand	0.3
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 2.3 feet only:	
(a) Firm, faintly chocolate-brown, weathering to dirty rust-yellow, poorly bedded, argillaceous, carbonaceous, fine sand; to bottom of exposure	2.3

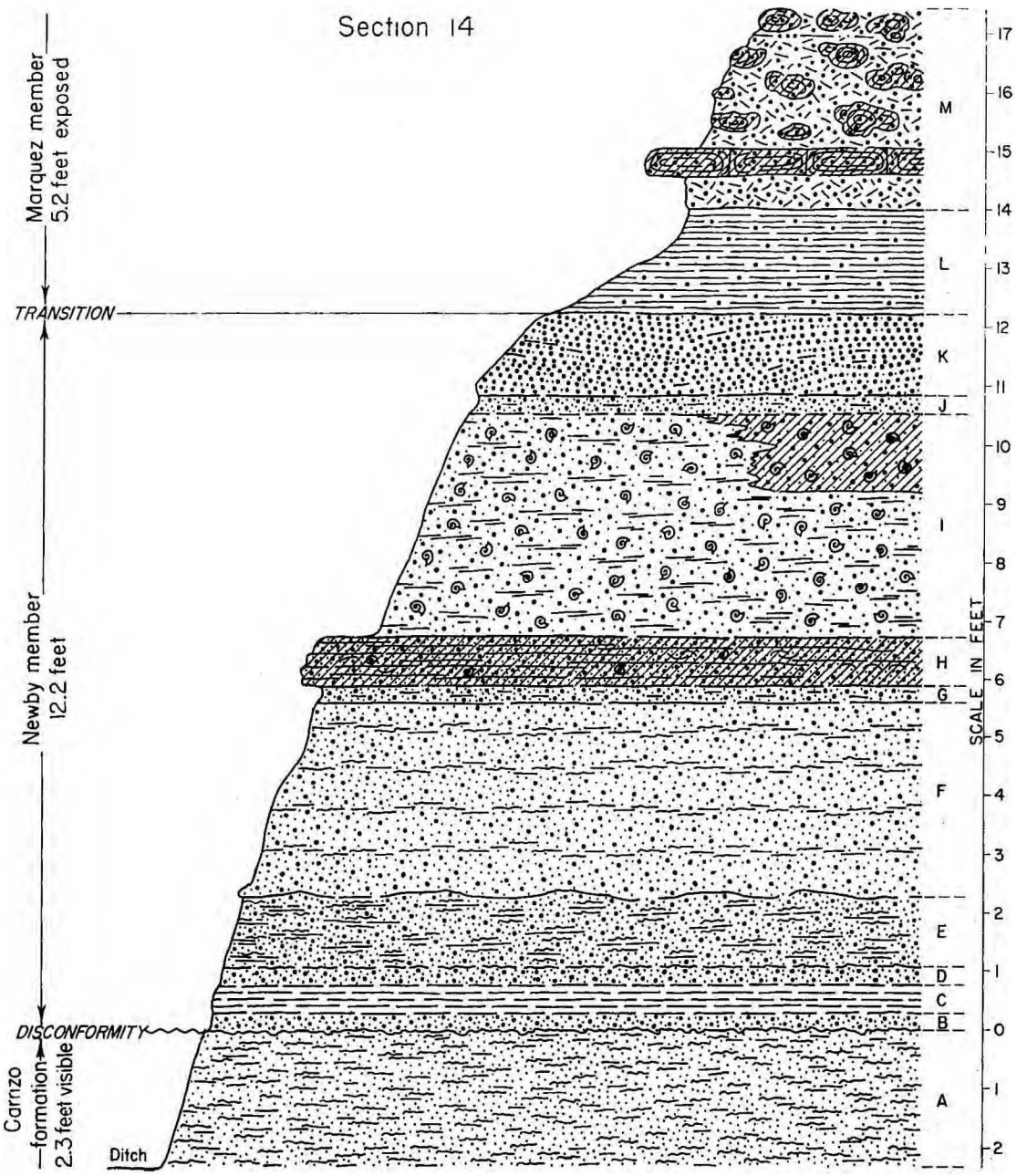


Fig. 33. Profile of section 14.

SECTION 15

Excavation in west-facing bluff, behind two 10,000-barrel oil storage tanks, overlooking flood plain of Striker Creek, at Gulf Pipe Line pump station, 0.25 mile east of west boundary of county and 0.75 mile north of U. S. highway No. 79 (New Summerfield—Henderson road), southwestern Rusk County [Henderson quadrangle, U. S. Geol. Survey], Bureau of Economic Geology locality No. 200-T-2, figure 34.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 5.0 feet only:	
(r) Soft, red-brown, weathered shale forming the slope at top of excavation	5.0
Newby glauconitic sand member of Reklaw formation, 12.7 feet thick:	
(q) Hard, rusty yellow-brown, nodularly bedded, sandy, glauconitic clay-ironstone; a soft layer in middle and 1.6 feet of cross-bedded, fossiliferous, sandy glauconite arenite at top; thickness variable, up to	4.5
(p) Soft, rusty olive-brown, massive, sandy glauconite arenite	1.3
(o) Soft, tough, chocolate-brown, laminated, muscovitic, carbonaceous shale containing burrows filled with glauconitic sand	1.6
(n) Indurated, rusty brown with an olive undertone, poorly bedded, sandy, argillaceous glauconite arenite containing irregular thin crusts, and clay-ironstone pipes	2.5
(m) Firm to indurated, dirty rust-orange, lenticular-bedded, muscovitic, glauconitic sand having thin, hard, irregular, ferruginous crusts	2.5
(l) Glauconitic sand similar to (k) but less shaly; in part a loose, brown or maroon-red, porous, glauconitic sand	0.8
(k) Coherent, rusty yellow-brown, poorly bedded, glauconitic sand enclosing light greenish-gray, sandy shale pieces of irregular shape; at one place cross-bedded	0.6
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 16.8 feet only:	
(j) Soft, tough, chocolate-brownish-gray, crinkly bedded, sandy, muscovitic shale, weathering by exfoliation, bottom half foot is similar to (h)	4.3
(i) Hard, maroon-red, irregular, slightly sandy, glauconitic, earthy clay-ironstone containing a few imprints of *Corbula;* up to	0.7
(h) Soft and tough, light bluish-green-gray, massive to crinkly bedded, glauconitic, very argillaceous sand	1.2
(g) Indurated, maroon, thin-bedded, sandy, glauconitic, shaly clay-ironstone	0.2
(f) Soft and tough, greenish-gray and brick-red mottled, indistinctly bedded, sandy, glauconitic shale	0.3
(e) Loose, light greenish-gray, massive, slightly argillaceous, muscovitic, glauconitic(?), fine-grained sand containing imprints of *Turritella;* has a ferruginous crust at top	0.5
(d) Indurated, rusty brown, crudely bedded, muscovitic, slightly glauconitic, fine-grained sandstone rich in imprints of *Venericardia planicosta* Lamarck and *Turritella,* grades locally into indurated, maroon, sandy, glauconitic, earthy clay-ironstone	1.2
(c) Fine sand like top part of bed (a)	0.8
(b) Indurated, rusty brown, irregularly bedded, muscovitic, slightly glauconitic, fossiliferous, fine-grained sandstone, contains imprints of *Venericardia planicosta* Lamarck and pebbles of chocolate-brown shale up to 0.5 by 1.5 inches in size	0.3
(a) Loose, grayish-white where fresh, light rusty yellow or brown on weathering, cross-bedded, non-argillaceous, non-glauconitic, muscovitic, porous fine-grained sand containing ⅛-inch thin, discontinuous, slightly wavy partings of gray to faintly chocolate-brown, muscovitic shale, of which some parts make flat shale pebbles; a 1-inch thick, hard, ferruginous layer is about 2.5 feet above the bottom; exposed down to the floor on which the oil tank rests	7.3

Section 15

Marquez member

TRANSITION

Newby member
12.7 feet

DISCONFORMITY

Carrizo formation
16.8 feet exposed

Turritella

Venericardia and Turritella

Venericardia

Floor

R
Q
P
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A

SCALE IN FEET

Fig. 34. Profile of section 15.

SECTION 16

Ditches of north-south county road between Alexander gin and Goldsberry School (Negro), about one-third mile north of schoolhouse and 2.5 miles airline distance east of Carlisle, west-central Rusk County [Henderson quadrangle, U. S. Geol. Survey], figure 35.

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 6.5 feet only:	
(l) Tough, light chocolate-brown, laminated, muscovitic, slightly silty, non-glauconitic, unctuous, carbonaceous shale containing few thin silt partings and some lenses or pipes of glauconitic fine-grained sand, exposed only for	5.6
(k) Hard, rusty yellow and brown, thinly and irregularly bedded, sandy, glauconitic clay-ironstone crust	0.1
(j) Soft, tough, weathered to dirty rust-orange, laminated, glauconitic, sandy shale	0.8
Newby glauconitic sand member of Reklaw formation, 9.7 feet thick:	
(i) Soft, light greenish-gray, poorly bedded, argillaceous, glauconitic, fine-grained sand similar to bed (e)	0.8
(h) Hard, rusty brown to olive-brown, concentrically weathering, discontinuous, muscovitic, sandy, glauconitic clay-ironstone containing imprints of fossils (*Turritella*, small gastropods)	0.5
(g) Soft, tough, dirty orange and greenish-gray mottled, poorly bedded, argillaceous, muscovitic, glauconitic sand enclosing shale pieces	1.0
(f) Indurated, light rusty yellow, irregular, sandy glauconite arenite containing fossil imprints	0.3
(e) Slightly coherent, very light greenish or brownish-gray, massive, nearly fresh, muscovitic, slightly argillaceous, glauconitic, fine-grained sand, weathers light rusty yellow; only 2.1 feet are visible but augured for a total of	5.7
(d) Covered by slope wash but augured as follows:	
(d_1) Olive-brown, weathered, sandy glauconite arenite similar to (e) but more glauconitic and olive-brown	1.0
(d_2) Same as (e)	0.3
(d_3) Hard, brittle, rusty brown, ferruginous sandstone	0.1
Marine transgressive disconformity	
Upper part of Carrizo formation, 13.8 feet thick:	
(d_4) Similar to (c)	9.8
(c) Soft, brownish-gray where fresh, laminated, muscovitic, silty, carbonaceous shale containing thin silt or sand partings, some of which are indurated by limonite	2.0
(b) Coherent, light brownish-gray, poorly bedded, muscovitic sand	2.0
Lower part of Carrizo formation, 43.0 feet thick:	
(a) Coherent, light chocolate-brownish-gray where fresh, weathering light rusty yellow, cross-bedded, muscovitic, fine-grained sands having thin, brownish, silty shale partings; visible are 12.0 feet, but plane-table profile of road indicates about	43.0

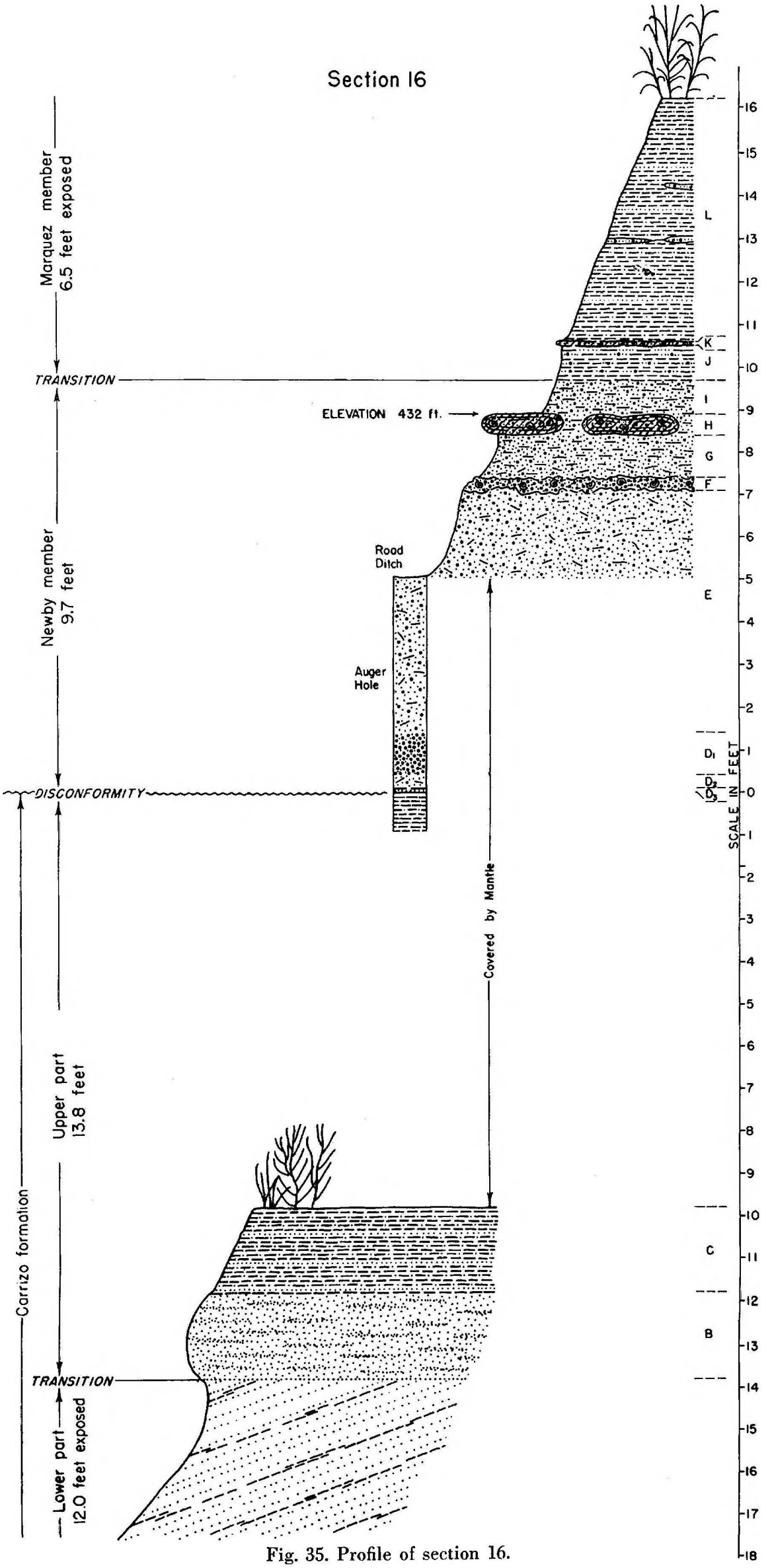


Fig. 35. Profile of section 16.

SECTION 17

Cut on east side of State highway No. 322 (Henderson—Longview road), 150 feet north of intersection with State highway No. 64 (Henderson—Tyler road), 100 feet east of International—Great Northern Railroad tracks and 150 feet north of highway-railroad crossing, in outskirts of Henderson, just north of city limits, central Rusk County, Texas [Henderson quadrangle, U. S. Geol. Survey], figure 36.

	Thickness *Feet*
Newby glauconitic sand member of Reklaw formation, 7.4 feet thick:	
(h) Gentle slope to top of hill, free of soil, material exposed as bed (g)	3.3
(g) Hard, dark red-brown, nodular or pipe-like, fossiliferous, glauconitic sandstone containing some clay-ironstone cement in a soft, whitish-gray, non-glauconitic, shaly silt matrix; there is less matrix than nodular sandstone; very many pipes or burrows at top of this bed	2.3
(f) Hard, rusty brown, continuous but irregular ledge of muscovitic, glauconitic sandstone in part containing a clay-ironstone matrix	0.3 to 0.5
(e) Similar to (d) but more indurated and poorly bedded	0.5
(d) Slightly indurated, mottled with dirty red-orange on a whitish-gray base, massive, slightly glauconitic, fine-grained sand	0.8
Marine transgressive disconformity	
Upper part of Carrizo formation, upper 6.3 feet only:	
(c) Soft to slightly indurated, rusty red-brown to light gray, thin-bedded to laminated, slightly muscovitic silts containing grayish-white, shaly silt layers. Top penetrated by burrows from bed (d)	2.8
(b) Similar to (a) but indurated to thin platy pieces and more dirty rust-yellow colors	0.9
(a) Soft to indurated, from light gray to light yellow to rusty brown to light dirty red, thin-bedded, slightly muscovitic silts having thin shale partings; to road level	2.6

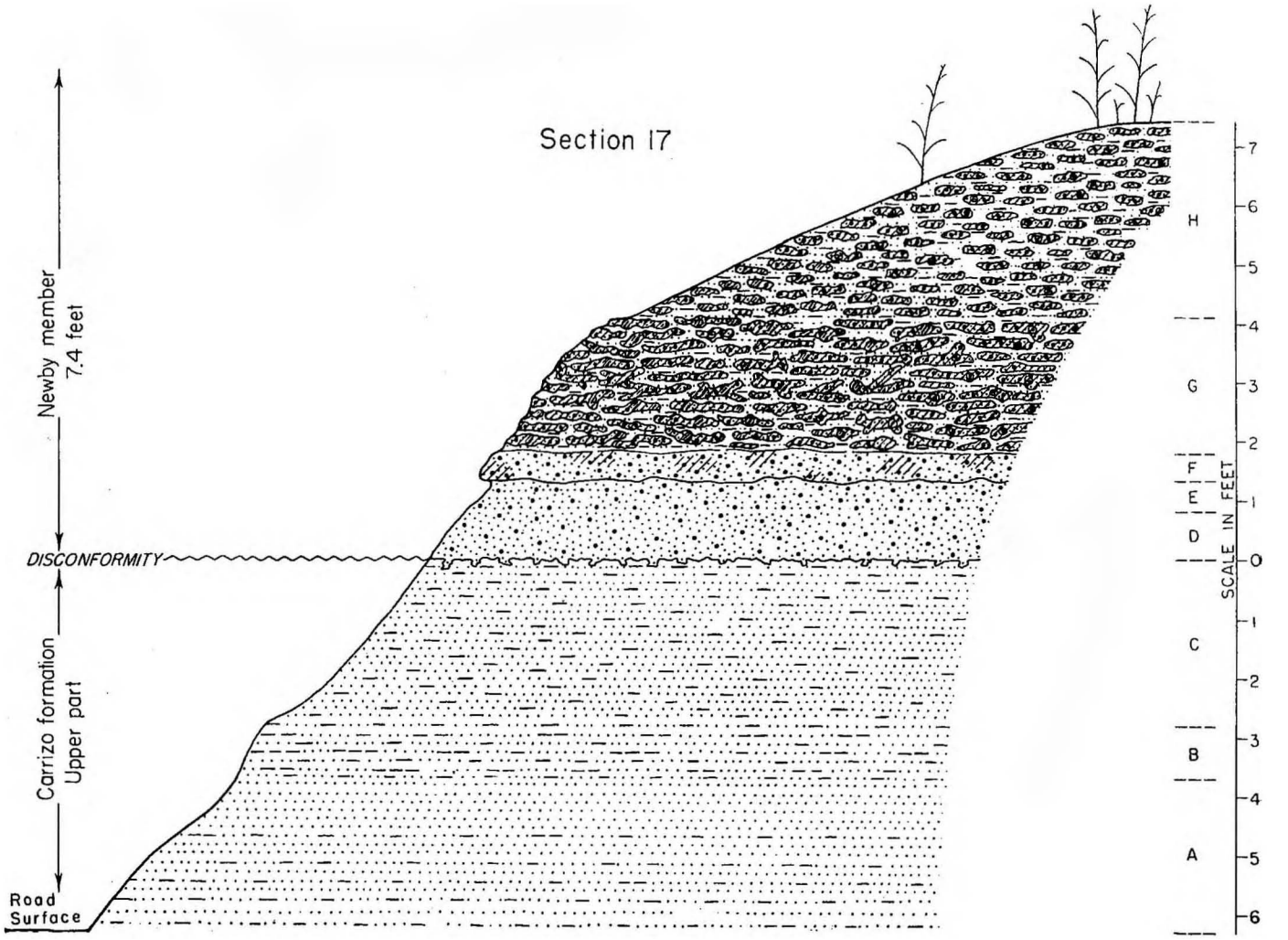


Fig. 36. Profile of section 17.

SECTION 18

Cut on north side of New Salem—Glenfawn county road, on ascent from and east of the flood plain of Buford Branch, 1.1 miles from crossroads in New Salem and 0.17 mile east of the Gulf Refining Company pipe-line crossing of the county road, southwestern Rusk County [*Cushing quadrangle, U. S. Geol. Survey*], *figure 37.*

	Thickness *Feet*
Marquez shale member of Reklaw formation, basal 12.6 feet only:	
(y) Soft, gummy, greenish-gray blotched with dirty dark rust-red, thinly bedded, silty, muscovitic, leached shale; basal 0.3 foot is rich in sand and glauconite grains	2.5
(x) Hard, red-maroon and rusty brown or yellow, concentric, nodular, earthy clay-ironstone enclosing clouds of sand and glauconite grains	0.3
(w) Soft, grayish-green blotched with dirty dark rust-red, poorly and thinly bedded, muscovitic, glauconitic, very argillaceous, fine-grained sand	0.9
(v) Hard, red-maroon and rusty olive-brown, nodular, sandy, glauconitic, earthy clay-ironstone	0.3
(u) Similar to (w) but is sandier and has an earthy clay-ironstone matrix in many small places	1.4
(t) Similar to (s) but is hard, reddish olive-brown, and thinly bedded to somewhat nodular	1.9
(s) Coherent, light green-gray spotted with dirty orange-brown, thinly and indistinctly bedded, muscovitic, argillaceous, richly glauconitic, very fine-grained sand	0.8
(r) Hard, red-maroon and rusty brown, concentric, silty, glauconitic, muscovitic clay-ironstone containing imprints of fossils *(Corbula)*	0.7
(q) Soft, light greenish-gray striped dark rusty brownish-red, thinly bedded, muscovitic, glauconitic, fine-grained sands interbedded with muscovitic, glauconitic, silty shale	3.8
Newby glauconitic sand member of Reklaw formation, 16.9 feet thick:	
(p) Hard to coherent, rusty olive-brown, massive, argillaceous, sandy, medium-grained glauconite arenite containing many horizontal, wavy, brittle crusts of dark brown, sandy ironstone; at top are indurated, bright yellow, concentric, earthy clay-ironstone nodules	1.5
(o) Coherent, gray-green spotted with rusty orange-brown, massive, argillaceous, glauconitic medium-grained sand	0.3 to 0.6
(n) Like (m) but clearly cross-bedded	2.1
(m) Friable, rusty olive-brown, indistinctly bedded, argillaceous, sandy, medium-grained glauconite arenite	1.6
(l) Similar to (j)	1.2
(k) Indurated, rusty olive-brown, poorly bedded, muscovitic, very glauconitic, argillaceous, fine-grained sand containing many small, rusty yellow-brown, earthy clay-ironstone nodules, half an inch or less in size	1.9
(j) Coherent, light gray-green, weathering to dirty rust-yellow, poorly bedded, muscovitic, glauconitic, argillaceous, very fine-grained sand	2.2
(i) Hard, brittle, red-maroon, irregularly layered, glauconitic, sandy, earthy clay-ironstone containing imprints of fossils	up to 0.5
(h) Coherent in lower, friable in upper part, rusty yellow-brown with a few light greenish-gray pockets or burrows, indistinctly bedded, partly cross-bedded in upper harder part, porous, slightly argillaceous, glauconitic, fine-grained sand having a discontinuous layer of hard, knobby, slightly sandy and glauconitic, earthy clay-ironstone, up to 0.4 foot thick	3.0
(g) Coherent to friable, weathering tc rusty yellow-brown, light greenish-gray where fresh, well-bedded, muscovitic, glauconitic, argillaceous, fine-grained sand similar to (e), interbedded with soft, leached to light greenish-gray, light chocolate-brown where fresh, laminated, finely and abundantly muscovitic, silty shale; much of the sand occupies compacted burrows, oval in cross section (½ by 1½ inches)	0.8
(f) Hard, brittle, maroon-red, irregularly thinly layered, earthy clay-ironstone having a few clouds of sand and glauconite grains and many thin, branching burrows of 2 mm diameter, filled with brown sand; the largest clay-ironstone is 3.0 feet long	0.4
(e) Coherent, weathering to dirty rusty orange-red, light greenish-gray where fresh, indistinctly bedded, slightly muscovitic, glauconitic, argillaceous, fine-grained sand	1.4
Marine transgressive disconformity	

	Thickness *Feet*
Upper part of Carrizo formation, upper 2.8 feet only:	
(d) Soft, dirty rusty orange-brown weathering, grayish chocolate-brown where fresh, crinkly bedded, slightly glauconitic, muscovitic, fine-grained sandy carbonaceous clay	0.2
(c) Soft, weathering dirty rusty yellow-brown, light brownish-gray where fresh, thinly layered, muscovitic, slightly argillaceous, porous, fine-grained sand interbedded with soft, gummy, light grayish-brown, laminated, silty, muscovitic shale layers, about half an inch thick, and hard, brittle, rusty dark brown, thinly layered, dense, earthy clay-ironstone crusts, more prominent at top	0.9
(b) Friable, dirty rusty yellow-brown, indistinctly cross-bedded, porous, fine-grained sand	1.4
(a) Coherent, rusty yellow-brown, massive, porous, muscovitic, medium-grained sand, in bottom of road ditch	0.3

Paleontology.—In the area of the quadrangle, fossils are common in the Newby member but are found only as imprints because of the thorough weathering of all exposures, except in the inlier of the Newby member in the channel of Bridge Creek in the southwestern part of the quadrangle. A handful of loose, fairly well-preserved shells of *Venericardia* was found at that place.

Although the Newby member carries elsewhere a rich and varied fauna, in the area of the quadrangle only two species are present, but these two are locally abundant. The two species are the ribbed pelecypod *Venericardia planicosta* Lamarck, which is up to 6 cm in size, and *Turritella turneri* Plummer (Stenzel and Turner, 1943, card no. 106), which is up to 4 cm long. The *Venericardia* is the as yet undescribed subspecies of *V. planicosta* Lamarck mentioned by Julia Gardner and Edgar Bowles from the Newby member of Magnolia Crossing on the Trinity River in southern Anderson County, Texas (Gardner and Bowles, 1939, p. 173). The *Turritella* was found to be particularly abundant in blocks of a layer in the Newby outcropping on the slope leading down to the flood plain of Grissom Creek, 950 feet west of the county road crossing over the creek and 200 feet north of this county road, 0.5 mile north-northeast of the church at Henrys Chapel. Elsewhere the *Turritella* is present but not that abundant. The *Venericardia* is quite abundant in many places.

Both fossils are easily detected by reason of their size. Hardly a layer of the Newby member is entirely free of them in the area of the quadrangle. However, the fossils are very rare in the upper cross-bedded or massive glauconitic lenses of the member in the extreme south part of the quadrangle.

Finding the fossil imprints, particularly those of *Venericardia*, is the best method of recognizing the Newby member in the field and of distinguishing the ferruginous sandstone of the Newby member in its weathered outcrops from the superficially very similar ferruginous sandstones in the upper Carrizo formation. As the Newby member is the key bed of the whole area the fossils by which the member is recognized are the real guides to the unravelling of field geology in the area.

On account of the use of the *Venericardia* imprints in recognizing the Newby member and their widespread occurrence in the member in east Texas, the Newby member has been called the "*Venericardia*-rock" by some east Texas geologists. Abundant *Venericardia* imprints have been seen by the writer in the Newby member from the rim of the Butler salt dome in southeastern Freestone County to Marshall in Harrison County.

Carrizo-Newby contact.—The nature of this contact was investigated for the first time during field work in Leon County, and a disconformity at the base of the Newby member was discovered at that time (Stenzel, 1939, pp. 67–70, and map, Pl. I). The disconformity was substantiated at that time by observations in Leon and Gonzales counties. Since then numerous exposures have been seen in Texas at which the base of the member is well exposed and disconformably on the Carrizo formation. Many exposures of the contact have been found in Cherokee, Nacogdoches, and Rusk counties, and in every instance a disconformity separates the Newby member from the Carrizo formation below. Most of the places listed under "Thickness" are good examples of such exposures. This marine transgressive disconformity is one of the reasons for revising the Reklaw section (see p. 34), and its

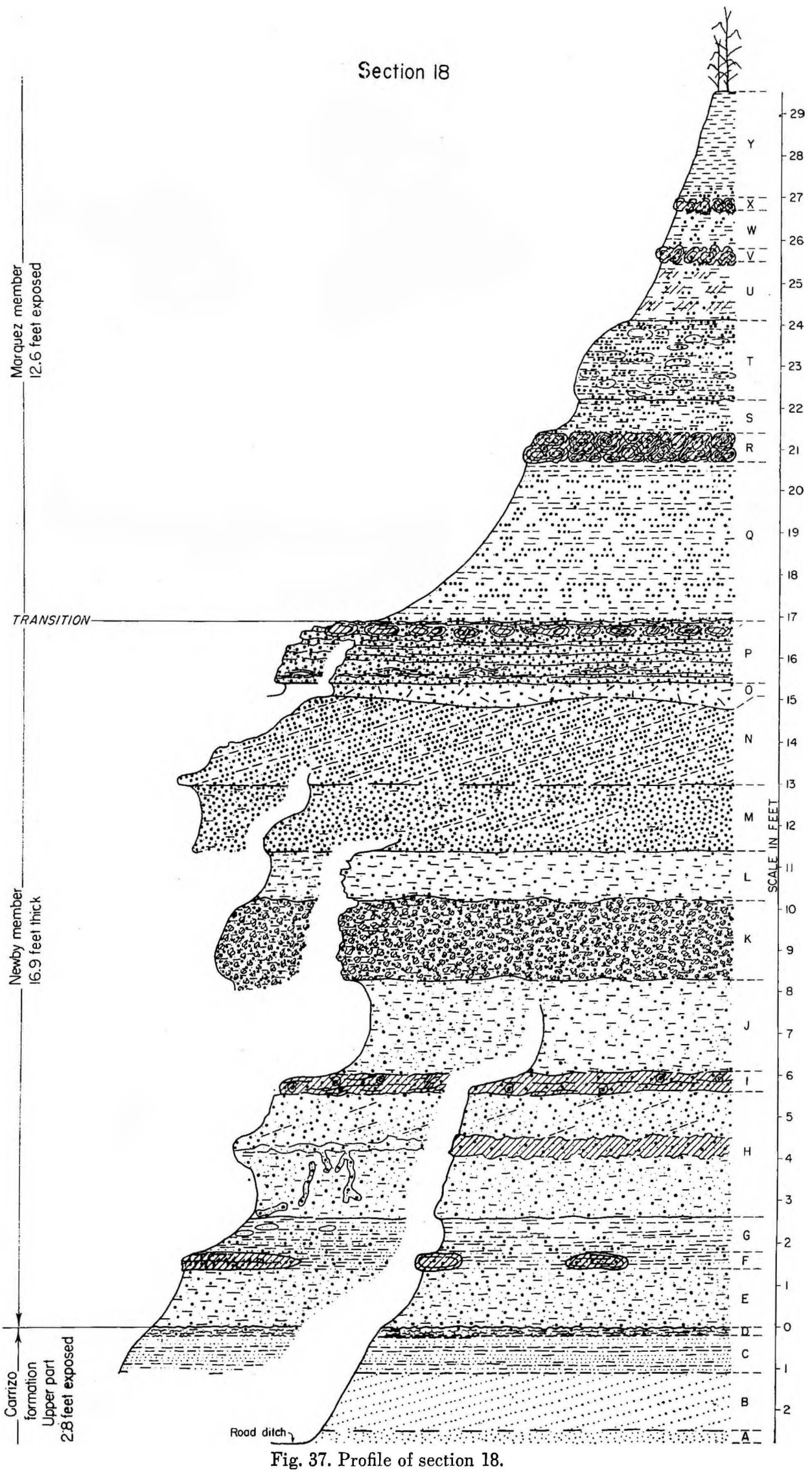


Fig. 37. Profile of section 18.

importance has been reemphasized by Stenzel (1952a, b) and Stephenson (1953).

At all places except one, the underlying Carrizo formation and the Newby member are parallel as regards their bedding. The only exception to this condition was found at locality 1 listed under "Thickness"; at that place the topmost Carrizo beds differ in attitude from the overlying Newby beds and are beveled by them so that an angular unconformity is made; over a distance of 20 to 25 feet a 1.5-foot thick bed of the Carrizo is beveled out completely, and the Newby member comes to rest on the next lower bed of the Carrizo. The apparent angle of the unconformity is therefore 1.5 feet per 25 feet or 316.8 feet per mile or 3° 24′. There seems to have been a slight tectonic movement here that inclined the upper Carrizo after its deposition and before it was beveled by the transgressing Newby sea, unless the Carrizo bedding is an unrecognizable kind of cross-bedding (see fig. 38).

Animal burrows filled with Newby sediment and extending down from the base of the Newby into the Carrizo formation below are common in this region and have been found in all the exposures listed under "Thickness." At locality 6 listed under "Thickness" the burrows were particularly abundant, and the uppermost bed of the Carrizo formation, which here consists of coherent, grayish chocolate-brown, massive to poorly bedded, silty, richly muscovitic, carbonaceous shale with nests of sand, is riddled for 1.7 feet with many burrows filled with Newby glauconitic sand. These burrows are three-eighths of an inch thick in the lower part but become up to 2 inches wide in the upper part of the 1.7 feet they penetrate. In this upper part the burrows intersect, branch, and twist so much that the Carrizo shale is dissected into many small highly irregu-

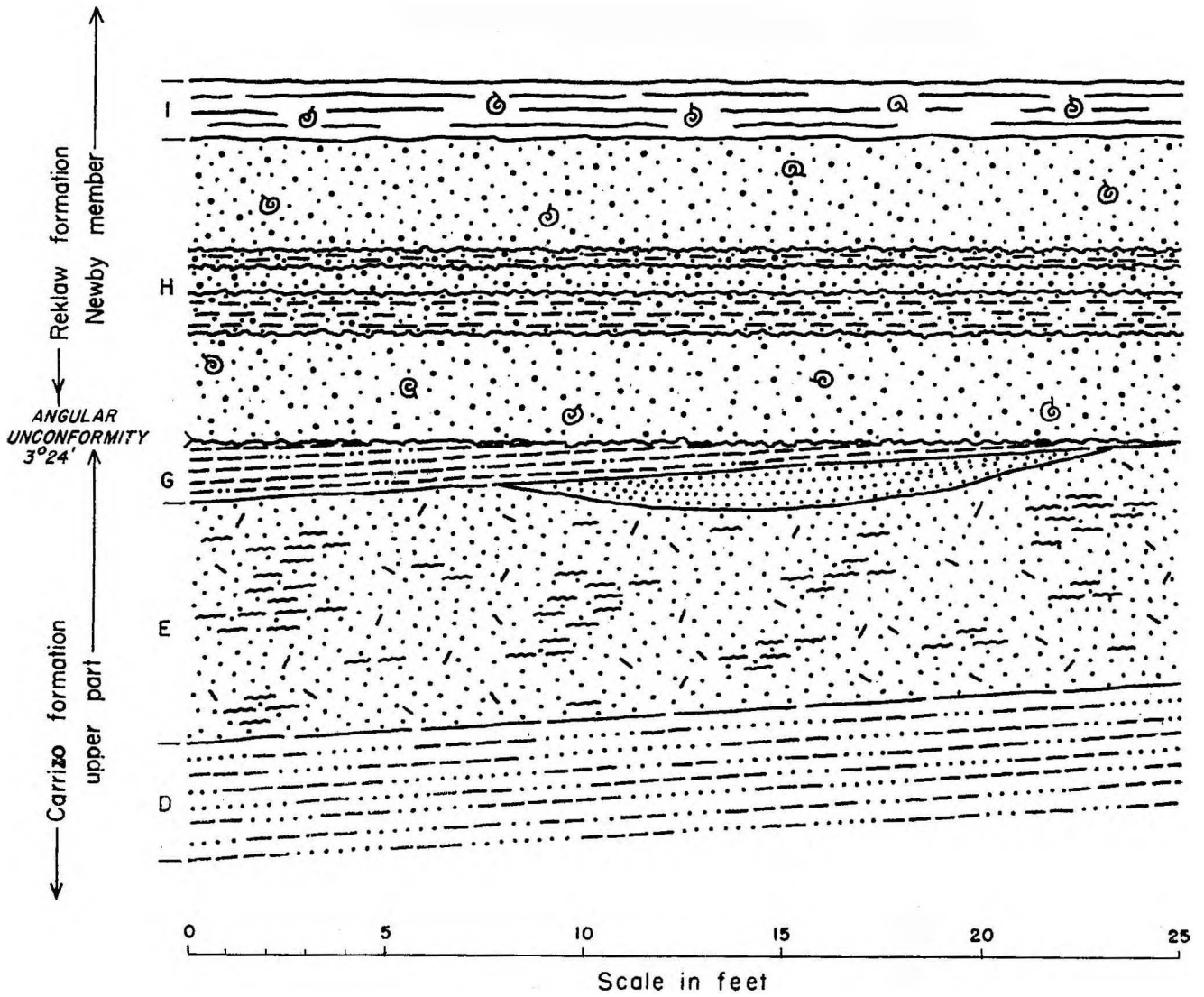


Fig. 38. Angular unconformity between the Carrizo formation and the Newby member of the Reklaw formation at roadside cut and ditch on north side of U. S. highway No. 84 (Reklaw-Rusk road) on descent to flood plain of Mud Creek, on the west side of the valley, 1.7 miles southwest of underpass at Reklaw village, east-central Cherokee County (Rusk quadrangle, U. S. Geol. Survey). Compare fig. 22 and section 1 of the detailed sections measured.

lar pieces. There are also flat pebbles composed of the Carrizo shale embedded in the base of the Newby glauconitic sand at this place. Such burrows are indication but not necessarily proof of a disconformity. (Compare Section 6 and fig. 26 on pp. 48–49.)

In some places these burrows at the basal disconformity of the Newby member are so abundant that the thorough riddling of the uppermost Carrizo beds by them simulates a gradual transition from the pure Carrizo bed below to Carrizo mixed with what appear to be glauconitic sand nests to the pure glauconitic sand of the overlying Newby member.

Stephenson (1953, p. 38 and pl. 3) indicated that possibly a ferruginous conglomerate seen by him near Reklaw village, Cherokee County, is the base of the Newby. The exposure is very well known to the writer. The conglomerate is the base of a terrace deposit of Mud Creek and rests here on Carrizo sand. No such conglomerates as Stephenson has described occur at the base of the Newby in the area shown on figure 39.

The numerous exposures of the basal disconformity prove conclusively that the disconformity is widespread and continuous. It is particularly important that the disconformity is present in the type area of the Reklaw formation around Reklaw village, where it was seen in all clear exposures of the base of the Newby member (localities 1, 10, and 11 listed in the preceding list of thicknesses of the Newby member). This disconformity is one of the reasons for revising the Reklaw section as outlined on page 34.

Facies.—In the area of the geologic map two facies of the Newby member are present; a third facies is developed south of the geologic map (Pl. I).

The southern facies is known to the writer from the vicinity of Reklaw village, which is in Cherokee County near the southwestern corner of Rusk County, to the region a few miles east of Cushing in northern Nacogdoches County, a distance of about 14 miles. It is the facies that is represented at the type locality of the Reklaw formation, which is "a cut on the T. and N. O. Railway right-of-way 2 miles southeast of Reklaw in northwestern Nacogdoches County" (Wendlandt and Knebel, 1929, p. 1352).[4] The best exposure of this facies, that is, the least weathered exposure, is the borrow-pit on the north side of U. S. highway No. 84 (Rusk—Mt. Enterprise road) on the right bank of the Angelina River, about 300 feet west of the river channel, southwestern corner of Rusk County, Texas (Bureau of Economic Geology locality no. 200-T-1); the section exposed on this place is detailed on page 60 (Section 12 and fig. 31).

The southern facies is characterized by (1) a uniform thickness, which varies from 12.2 to 17.3 feet in a distance of 14 miles and averages 14.3 feet; (2) an abundance of glauconite, which is partly of very coarse grain size (diameter 3 mm) in some of the lower beds and especially abundant and medium sized in the upper part of the Newby member, making these upper beds dark greenish-black in over-all color (compare detailed description of section at locality 200-T-1 on page 60); (3) an abundance of hard, deep red to red-maroon, sandy and glauconitic clay-ironstone knobs, lenses, concretions, and beds up to 2 feet thick; (4) prevailingly level bedding to some extent modified by pipe-like structures or fossil burrows; (5) an abundance of species of invertebrate and vertebrate fossils; and (6) the great number of individual fossils contained in the beds.

The last two points merit some explanation. In nearly all sections exposed the fossils are leached out, but their imprints can be found. The best locality is 200-T-1, where fairly well-preserved fossils are to be had; this is the only known locality in east Texas where fossils rather than their imprints may be collected from the Newby member. The locality has yielded the following fossils:

Vertebrae of teleost fishes
Swordfish rostrum, *Glyptorhynchus* (family Xiphiidae)
Shark teeth, two to three species of *Odontaspis (Synodontaspis)*
Ray teeth, *Myliobatis*
Cephalopod, a species of *Belosepia*
Gastropods, among them *Cypraea, Volutospina, Architectonica, Cyclichnina, Natica, Sinum, Ectinochilus, Turritella*
Pelecypods, among them *Barbatia*, an oyster, *Nemocardium, Venericardia planicosta* Lamarck, a venerid, *Corbula, Chama, Plicatula, Periploma*, and a boring pelecypod
Shipworm, *Teredo*, in lignite
Boring annelid, *Polydora*
Bryozoa
Compound hexacoral, 1 species

[4] Although the northwest corner of Nacogdoches County is quite near to the type locality, the latter is in Cherokee and Rusk counties.

Hexacorals, 2 species
Boring sponge

The faunule is clearly marine. This is proved by its richness in species and the presence of corals, *Belosepia,* and *Cypraea.* The oyster species present is not one of the usual shallow-water or brackish-water oysters but is of the group related to *Pycnodonte,* which is known to occur today only in deeper marine waters.

The central facies is found at the exposures in the channel of Bridge Creek, west-southwest of Griffin, and south of Boggy Branch; both localities are at the south margin of the Henrys Chapel quadrangle. It is also represented to the east of the south margin of the quadrangle at Bureau of Economic Geology locality no. 200-T-2, the location of which is given under item (15) in the preceding paragraph on "Thickness." Hence the belt occupied by this facies is narrow but at least 6.5 miles long in an east-southeast direction from the locality in the channel of Bridge Creek. Because of its position at the southern threshold to the Tyler basin

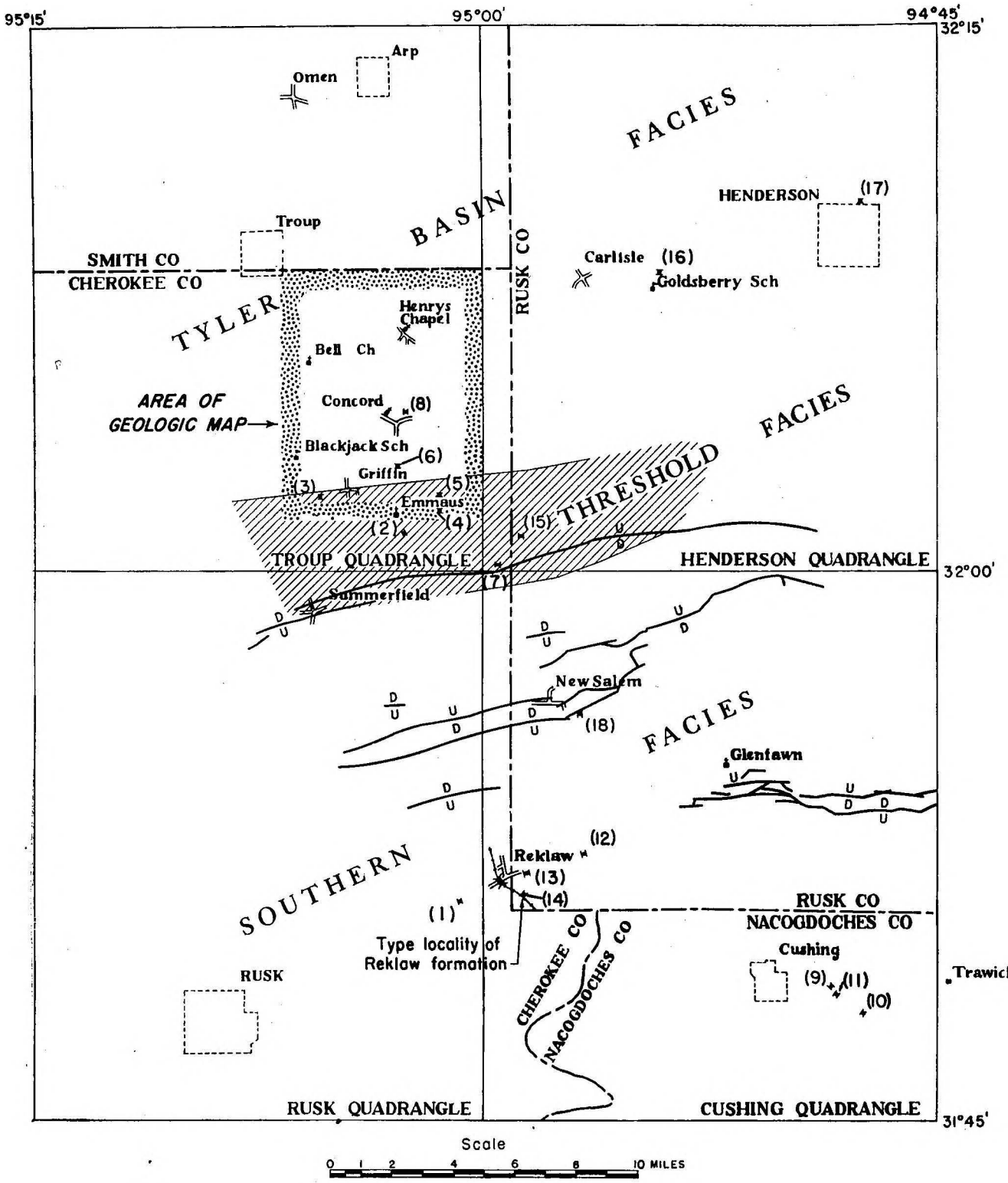


Fig. 39. Map showing the distribution of the three facies of the Newby member of the Reklaw formation in Cherokee, Nacogdoches, and Rusk counties, eastern Texas.

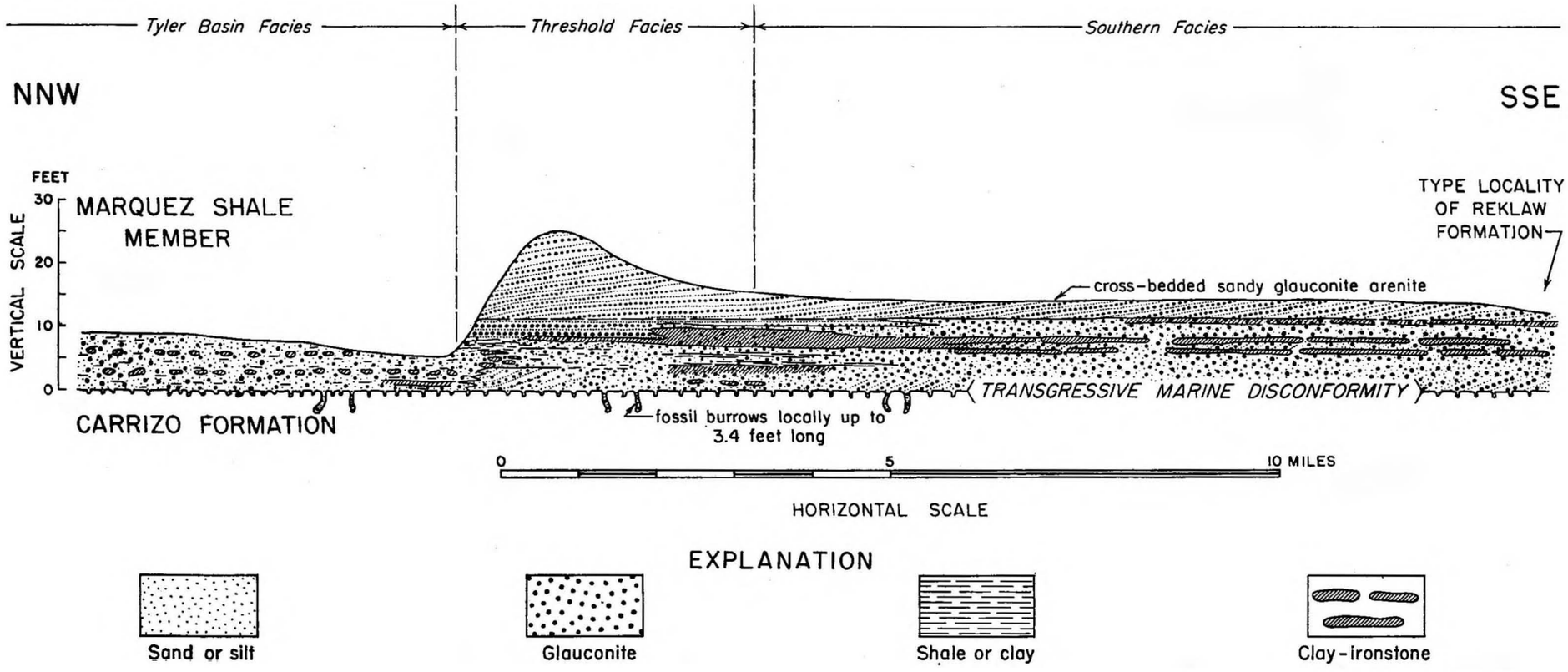


Fig. 40. Cross section of the three facies of the Newby member of the Reklaw formation in Cherokee, Nacogdoches, and Rusk counties, eastern Texas.

the facies might well be called the threshold facies (figs. 39 and 40).

The threshold facies is characterized by (1) a variable thickness ranging from 12.7 to 23.7 feet: (2) an abundance of glauconite in glauconitic sands and sandy glauconite beds, particularly in the upper part of the Newby section; (3) a scarcity of clay-ironstone beds or larger concretions, although some interstitial cement of that composition is present in the glauconitic sands; (4) well-developed cross-bedding or massive bedding, particularly in the medium-grained, sandy glauconite beds at the top of the section; and (5) a scarcity of fossils, which are almost entirely absent in the cross-bedded or massive lenses of glauconitic sands at the top of the section. The irregularity in thickness is clearly caused by the rapid thickening of local cross-bedded or massive glauconite lenses that occupy the top of the Newby member of the threshold facies.

The northern facies is north of the narrow belt occupied by the threshold facies, and the change from one to the other takes place rather abruptly in a distance of less than a mile. The northern facies is extensively distributed on the east flank of the Tyler basin; it occupies most of the area of the Henrys Chapel quadrangle and reaches at least to Henderson in Rusk County. It might well be called the Tyler basin facies.

The Tyler basin facies is characterized by (1) a greatly reduced thickness of little variation ranging from 5.1 to 9.7 feet, averaging 7.4 feet; (2) a great reduction in the amount of glauconite present, which is fine grained and contributes to sedimentary rocks that are in the main only slightly glauconitic fine-grained quartz sands; (3) a scarcity of clay-ironstone, which is only up to half a foot thick and usually concretionary rather than a continuous bed; (4) massive or even bedding, with the former predominating; and (5) an abundance of fossils limited to two species of mollusks, *Venericardia planicosta* Lamarck and *Turritella turneri* Plummer.

The distribution of fossils, with an abundant and varied fauna in the southern facies and a depauperate fauna in the Tyler basin facies, definitely proves a normal marine environment in the south and strongly suggests a brackish one in the north. This distribution is also in accordance with the regional pattern of the Gulf Coastal Plain. The greatly increased and variable thickness in the intervening threshold facies suggests a barrier between the open sea and the brackish environment. The predominance of cross-bedding in the threshold facies tends to confirm this suggestion as does the absence of clay-ironstones.

The Newby sea, it is believed, at first transgressed rapidly over the soft Carrizo sediments and must have had very little difficulty in reducing the top of the Carrizo formation to a nearly even surface, establishing a transgressive disconformity at the base of the sediments deposited by the sea. Near the end of deposition of Newby sediments a barrier was built up out of cross-bedded and highly lenticular sandy glauconite beds. This barrier is preserved in the threshold facies and originally separated the sea into a brackish portion, that is, a lagoon, and an open sea portion. The lagoon occupied essentially what is now the Tyler basin.

The barrier is located within and immediately north of the belt of faults which goes through Summerfield, 12 miles south of Troup, and parallel to the faults. This position is presumably not an accident, because several other Eocene formations change facies rapidly at the threshold to the Tyler basin. The barrier that existed in Middle Eocene Newby time is therefore regarded as one of the early Middle Eocene forerunners of the earth movements, the cumulative sum of which resulted in the formation of the threshold to the Tyler basin as it appears today. This threshold is now underlined, as it were, by a belt of post-Eocene faults.

MARQUEZ SHALE MEMBER

The Marquez member was named in 1939 from the town of Marquez (pronounced Markay) in Leon County (Stenzel, 1939, pp. 65, 71–78) where the member forms extensive outcrops. The member corresponds to the brown clay with streaks of sand and greensand and clay-ironstone concretions, up to 100 feet thick, described by Wendlandt and Knebel (1929, pp. 1352–1355) as composing the upper part of the Reklaw formation. The member is traceable from Louisiana through east Texas to central Texas. A section of the Marquez member well exposed in Bastrop County has recently been described (Lyth, 1949).

Distribution.—Outcrops of this member are extensive and occupy all the western half of the quadrangle, except where outliers of the Queen City formation interrupt. There also are two outliers of the Newby member that are capped by the Marquez member.

Topography.—The Marquez member is composed largely of very soft shales that have little resistance to erosion. Their weakness is apparently caused to some extent by widely and finely distributed marcasite or pyrite. These iron-sulfide minerals weather readily, producing sulfuric acid, which in turn helps to decompose the shale matrix. Because of the low resistance to erosion and the softness of the shales the Marquez member forms an exceedingly flat surface. This flat surface is characteristic of the Marquez and is in many places the best guide to its mapping; such flat areas are well developed from Louisiana to central Texas. In southern Bastrop County the outcrop of the Marquez is rather narrow, and the resultant narrow and well-defined belt of flat country had attracted the attention of the early settlers who aptly called it String Prairie.

In the Henrys Chapel quadrangle the flat surface of the Marquez begins at the brow of the cuesta formed by the Newby member and extends to the base of the rounded hills formed by the Queen City outliers. The width of this flat surface is variable; the average is 1¼ miles. The average slope of the surface is 70 feet per mile.

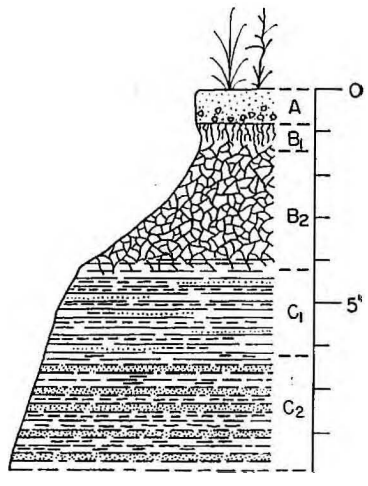


Fig. 41. Soil profile of Marquez member of Reklaw formation in north ditch of Farm Road 13 at the entrance to Henrys Chapel and graveyard.

Some of the thicker and more persistent clay-ironstone beds of the Marquez member erode into low, rounded hill knobs covered with red-brown clay soil containing many fragments of the clay-ironstone that look like broken red earthy pottery. Such hills are present on the Marquez flats to both sides of Grissom Creek headwaters north of Henrys Chapel in the northeastern part of the quadrangle. In the southwestern corner of the quadrangle the John Smith Cemetery is on top of such a clay-ironstone hill.

Soils and vegetation.—Soils of the Marquez member are of the podsol type. The brownish-gray leached sandy top soil, soil zone A, is well developed in this area and surprisingly continuous and deep. Thicknesses of 1 to 3 feet have been seen. The subsoil consists of a velvety red-brown joint clay cut into small angular blocks by numerous desiccation cracks. The weathered parent rock beneath is usually soft, unctuous, and dirty dark red-brown or dirty orange-red with greenish-gray blotches.

The following soil profile is regarded as typical of the Marquez soil. It is taken in the north ditch of Farm Road 13 at the entrance to Henrys Chapel and graveyard (fig. 41).

Soil profile of Marquez shale member.

	Thickness *Feet*
(A) Loose, light gray-brown, unstratified, very fine-grained sand full of small subangular fragments (⅛ to ¼ inch) of hard, black to black-maroon, ferruginous siltstone. pH = 5.0	0.8
(B_1) Soft, plastic, brick-red, jointed, unstratified clay containing subangular fragments of hard, dark brick-red, earthy clay-ironstone up to 1 inch in size. pH = 5.0	0.6
(B_2) Soft, plastic, mottled dirty brick-red and greenish-gray, unstratified joint clay; its color changes downward to predominating greenish-gray, but brick-red predominates at the top. pH = 4.5	2.8
(C_1) Soft, plastic, light greenish-gray with small dirty orange-red blotches, thinly bedded, muscovitic, silty, leached, carbonaceous shale. pH = 4.5	2.0
(C_2) Soft, slightly plastic, light chocolate-brown, thinly bedded, abundantly and finely muscovitic, silty, carbonaceous shale with broken lignitized leaf imprints and plant fragments; contains some coherent, brownish-gray, long-lenticular, muscovitic, porous silt beds. pH = 4.5. To bottom of ditch	2.7

Not so readily seen on the ground but easily noted on aerial photographs is the pimple-mound structure of the soil produced on the Marquez flats. On the photographs the mounds show as light-colored, round spots of about 50 feet diameter separated by narrow darker bands. The mounds rise only one-half to 1 foot above the general level of the surface and have a soil of lighter color, because the humus and clay content of the soil is less on the mounds than on the surrounding bands, which for that reason photograph darker. In those places where the surface is flat the mounds are scattered without any particular arrangement; but where slopes are slightly steeper and rainwash down the slope toward the nearest drainage is more active, the mounds merge into rows and between the mound rows are darker and narrower streaks that lead to the nearest drainage. On some flat surfaces the mounds have grown larger than 50 feet in diameter by the confluence of several mounds and may then be 200 feet or more in diameter.

The flat surface of the Marquez is so inviting to agriculture that much of it has been cleared, but large areas have now reverted to pasture. Presumably all the Marquez surfaces or nearly all were wooded originally with the oak trees in a loose park-like grouping in most places.

Composition.—The bulk of the Marquez shale member is composed of soft, black-brown to chocolate-brown, laminated, highly muscovitic, silty, carbonaceous shale.

The Marquez shale exposures slough off readily; hence they have usually well-rounded slopes. The slopes are covered with small (about 5 mm) and thin (less than 1 mm) pieces of gray chocolate-brown shale into which the Marquez has disintegrated. Desiccation cracks are usually abundant, also small-scale water rills made by rainwash.

In all road-side exposures the shale is already somewhat weathered as is shown by its acid reaction (pH = 4.0 to 4.5) and its chocolate-brown color, for the fresh material is very nearly black but is found only underground and in a few exceptionally fresh exposures, such as the bluffs on Bridge Creek.

The chocolate-brown shale of the road-side exposures is fairly firm. The shale has a tendency to break by conchoidal fracture into small blocks; it does not split readily along bedding planes except where silt layers facilitate the splitting. The small blocks have approximately a size of 2 by 5 by 5 cm.

The color is chocolate-brown when the shale is moist but becomes somewhat grayish chocolate-brown on drying. Along joints and parting planes thin, light rust-yellow films of either copiapite ($Fe_4(OH)_2(SO_4)_5 \cdot 18\ H_2O$), jarosite ($K\ Fe_3(OH)_6(SO_4)_2$), or natrojarosite ($NaFe_3(OH)_6(SO_4)_2$) are common but not abundant. On bedding planes are many slightly darker brown spots, which are lignitized plant fragments.

The shale is laminated. The laminations are emphasized by muscovite flakes and paper-thin silt partings. Tiny flakes of muscovite are abundant and lie flat on the bedding planes, making them glisten in the sunlight. Silt grains are present throughout the shale and are also concentrated in paper-thin partings. The silt partings are lighter grayish chocolate-brown than the shale and have more abundant muscovite. A few shale layers have many branching, silt-filled, 1 to 5 mm-thick tubes, which may be remains of silt-filled burrows or algal remains.

Lignitic matter is present in finely divided form and evidently produces the brown color of the shale. Tiny lignitized plant fragments, 1 mm or less in size, are common on some bedding planes. In a few layers fairly well-preserved leaves or leaf fragments are present.

Finely divided marcasite or pyrite is abundantly represented. Concretions of these iron sulfides are less common. Weathering of these sulfides is responsible for the acid reaction of the shales and produces the secondary minerals copiapite or jarosite and selenite ($CaSO_4 \cdot 2H_2O$). Clear selenite crystals of various shapes are locally found in the shale; many of the crystals have irregular inclusions of the shale or of mud derived from the shale.

In comparison with similar shales in the Queen City formation, the Marquez shale is more unctuous, more uniform in appearance, showing less interbedding with silts or sands, and more inclined to conchoidal fracture.

Common intercalations in these shales are friable to hard and brittle, variously rusty yellow or brown or red-brown to bright red-maroon and vermilion to olive rust-brown, concentric or uniform, glauconite-rich to nonglauconitic, sandy or silty to non-silty, earthy clay-ironstones, which may have various flat, irregularly layered, nodular, or ellipsoidal shapes and may have honeycombed or box-stone structures. They usually contain subangular sand or silt and round glauconite grains which are distributed in clouds, although the grains do not seem to touch each other. The glauconite grains are commonly weathered; they have shrunk away from the matrix and lie loose in their cavities, which retain the original shape of the grain. Muscovite flakes are usually present in the matrix but are small and comparatively rare. The clay-ironstones are derived through weathering from sideritic mudstones, and some concentric clay-ironstones have cores of unaltered mudstone, which are either earthy to chalky, massive, and gray to grayish-brown or hard, bluish-gray, and microcrystalline, depending on the proportion of clay to siderite in the individual sideritic mudstone. Usually several layers or horizons of concretions are found together in close vertical succession, but such grouped layers are separated by as much as 20 or more feet of shale free of clay-ironstone. The individual clay-ironstone layers are up to 2 feet thick; their average and common thickness is from 0.4 to 0.7 foot.

Under the microscope the clay-ironstones of the Marquez member show a very fine-grained matrix of clay stained orange-red with limonite, which makes up a large part of the rock. The detrital quartz sand grains are either scattered in streaks or tightly packed to form small rounded areas of fine-grained sandstone. These rounded areas may possibly be small pebbles derived from sandstone but are most likely the sand-filled cores of small narrow animal burrows seen in cross section. The detrital quartz grains average 0.1 mm (0.06 to 0.2 mm) in diameter, but there are extremely fine grains of less than 0.01 mm throughout the clay; the grains are angular in the main, but some of the largest grains are subrounded. Grains of muscovite, tourmaline(?), and zircon(?) are present; the latter two, however, are very scarce. A few grains of glauconite or alteration products of glauconite are present and about 0.2 mm in size. There are a number of round holes in the section which may have been caused by small fossils or glauconite grains that fell out during preparation of the slides. The average volume relations of the constituents are 92.4 percent (95 to 89.5 percent) for the matrix, 6.5 percent (9 to 4 percent) for the detrital quartz grains, 0.6 percent (1 percent to a trace) for the detrital muscovite flakes, and 0.5 percent (0.8 percent to a trace) for the grains of glauconite and alteration products of glauconite. (Microscopic description by Mrs. Kathryn O'Neill Dickson.)

Thin, loose, grayish-brown, lenticular, porous silt or more rarely very fine-grained subangular quartz sand layers are present but usually they compose only a small portion of the section exposed. Their usual shape is that of long slender lenses; however, short and thick, complicated, crumpled lenses produced by subaqueous sliding have been seen in the lower part of the Marquez member in bluffs on Bridge Creek in the southwest part of the mapped area (fig. 42).

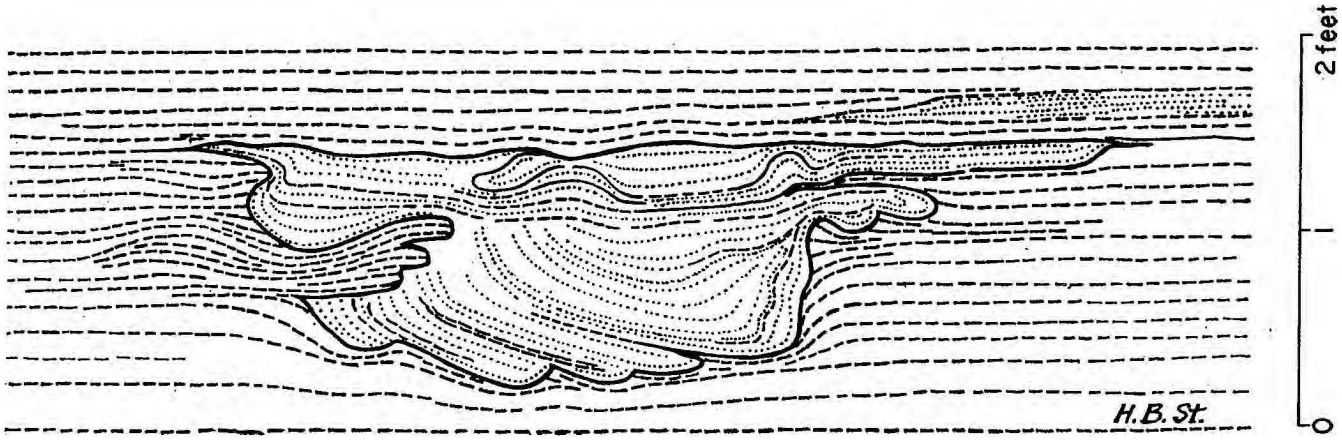


Fig. 42. Contorted silt bed in Marquez shale member, bed (n) of section 3 (p. 44). Bluff on left bank of Bridge Creek, second bluff 650 to 800 feet downstream from county road bridge, 3,300 feet southwest of the church at Griffin (compare fig. 12).

More rarely found than clay-ironstone or silt layers are various glauconitic beds. The following kinds have been seen: (a) coherent, dirty orange-red, thin-bedded, glauconitic, fossiliferous, very

fine-grained sand; (b) coherent, olive-green, cross-bedded, argillaceous glauconite arenite; and (c) friable, olive-brown, poorly bedded, argillaceous glauconite arenite grading laterally into glauconitic clay. Such layers are usually only 0.2 to 0.3 foot thick but may reach a thickness of 0.8 foot.

Thickness.—The thickness of the Marquez member is difficult to determine because of the width of the outcrop and the changing rate of dip in the area. A thickness of 85 feet is calculated in the southern and 105 feet in the northern part of the quadrangle.

Paleontology.—All exposures of the Marquez member are weathered and leached so that only imprints of fossils are found. Imprints of invertebrate marine fossils are common in the clay-ironstones, rare in the soft glauconitic beds, and lacking or almost lacking in the shales and silts. Most of this difference is due to the original relative abundance of the fossils before leaching, but the soft glauconitic beds may have had originally more fossils than they now show.

Invertebrate fossils are very rare in the brown shales, and most shales are for all practical purposes barren. A few layers have abundant imprints and clay fillings of the shell of the pteropod *Spiratella.* Much rarer are imprints of a small *Nuculana* having a smooth polished shell with concentric undulations at the umbo.

Among the fossils found in the clay-ironstones, most common and present in nearly all clay-ironstones are the imprints of *Spiratella* (*Limacina* Lamarck 1819 or *Spiratella* Blainville 1817). This very small pteropod mollusk (fig. 43) has a size of 1 or 2 mm, its shell is spirally coiled in such a fashion that the aperture lies to the left of the axis if the shell coil is held with the apex upward, that is, it is apparently sinistral (pseudosinistral hyperstrophic coiling; Pelseneer, 1906, p. 82), the spire is short making the whole shell nearly globular, each whorl is smooth and evenly convex, the shell wall is very thin, hyaline, and glossy, the aperture has a reflected margin making a collar around the aperture. Imprints of this shell are easily identified under the hand lens. The fossil is important because it serves to identify the ironstones as belonging to the Marquez member.

Other fossils found in the clay-ironstones are bryozoans, various small gastropods, and small thin-shelled pelecypods. An echinoid, 22 mm long, probably a new species of *Schizaster* (Accession no. 17749), was found by Mr. H. C. Fountain on the east slope of a clay-ironstone hill knob between Hampton and Grissom Creeks, 5,600 feet north and 1,800 feet west of the church at Henrys Chapel. The filling of the phragmocone of a *Belosepia,* a cephalopod, was found elsewhere.

The presence of echinoids and at least one cephalopod, the fairly large number of species of mollusks and bryozoans, and the association with glauconite indicate that the clay-ironstones were deposited in marine waters. However, the bulk of the Marquez member is composed of shales that have very few invertebrate fossils but are carbonaceous and carry lignitized plant fragments and a few fossil leaves. These shales may be marine in part but were presumably deposited in shallow brackish water. The Marquez member as a whole was probably deposited in shallow brackish waters that fluctuated a good many times into shallow marine. The common fossil of the clay-ironstone, the pteropod *Spiratella,* is a free floating, planctonic animal living in the open sea. If its shell was able to float in during Marquez time in such great numbers, it seems reasonble to assume that no effective barrier existed separating the area of deposition of the Marquez shale from the open sea.

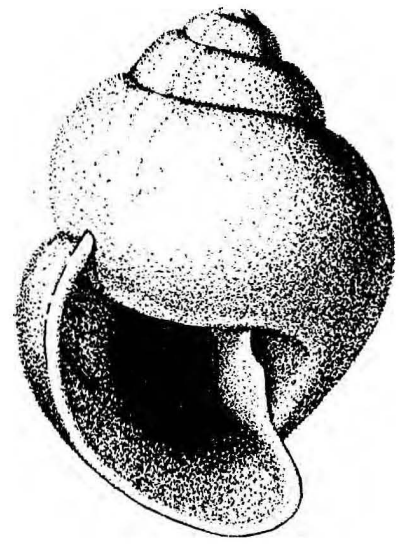


Fig. 43. The pteropod *Spiratella* from the Marquez shale member; magnified 24 times.

Newby-Marquez contact.—The Marquez shale rests conformably on the Newby member, and the transition between the two members takes place in a few inches.

The boundary is therefore generally distinct and is chosen at the place in the stratigraphic column at which soft brown shales lie on the harder glauconitic sandstones or glauconitic sandy clay-ironstones of the Newby member.

Generally this boundary is a well-defined one and easy to follow in the field, but in one small area difficulties were encountered. The area is along the westernmost exposures of the Newby member in the headwater branches of Campground Creek, from a place 3,950 feet west and 500 feet south of the church at Concord to a place 2,600 feet west and 6,250 feet south of that church. Here soft, somewhat mealy, dark olive-green, coarse to medium-grained glauconite arenite lies between Newby glauconitic sand, as normally developed, and brown shales of the Marquez. The soft glauconitic rock has been mapped as a part of the Newby member, making the Newby member unusually thick in this little area. However, it is suspected that the soft glauconite rock is rather a lentil in the base of the Marquez member, which elsewhere contains small, thin, local layers of this kind. It was not possible to decide whether or not the soft glauconite rock of this small area belongs to the Marquez, because exposures in this area are none too clear.

QUEEN CITY FORMATION

The Queen City formation was one of the first formations to be defined in east Texas. Kennedy (1892, pp. 50–52) named the Queen City beds from the town of Queen City in Cass County and recognized the approximate position of the beds in the stratigraphic sequence. However, no progress was made in mapping the formation throughout east Texas until Wendlandt and Knebel's paper appeared (Wendlandt and Knebel, 1929, p. 1349).

In the Henrys Chapel quadrangle the formation is the youngest of the Eocene formations present and is only incompletely preserved; its top parts are removed by erosion. In spite of the incompleteness of the Queen City section in the quadrangle, the formation is well represented and divisible over most of the area of the quadrangle into 3 distinct members, the Arp member at the base, the Omen glauconitic sandstone member in the middle, and the as yet unnamed upper sand member at the top.

ARP MEMBER

During geologic field work in Smith and Cherokee counties, C. L. Moody applied the name Arp to the sand below the Omen member. However, he did not publish the name, although the member is shown as a separate sand wedge in one of his sections (Moody, 1931, fig. 2 on p. 542). Nevertheless the Arp member is well known to geologists in east Texas under that name. In order to preserve this well-known name it is herewith published, and its type locality is defined as the vicinity of the Homer Lacey country store, which is located on the county road from Bell Church to Griffin (compare Pl. I), 1.89 miles by road southeast of Bell Church. There are excellent exposures in road cuts on the east side of the county road, from 0.07 to 0.17 mile northwest of the store, at the bend of the road; these exposures may serve as type exposures. Relationships to the overlying Omen member are quite clear at this place: The Omen member caps the hill at the west flank of which the type exposures are. The town of Arp is in southeastern Smith County, 6 miles north of the area mapped and the same distance north of the south boundary of Smith County.

Distribution.—The Arp member forms the lower slopes of the three larger Queen City outliers that are capped by the Omen member and 15 smaller outliers the tops of which are eroded down to below the level of the Omen member. All these outliers are in the west half of the Henrys Chapel quadrangle, extend from Griffin to the north boundary of Cherokee County, and form the divide between the drainage of Mud Creek in the west and Bowles Creek in the east.

Topography.—The Queen City outliers, the major portion of which is made up of the Arp member, are essentially a much dissected cuesta of the Coastal Plain type. The general trend of the outliers taken as a group is north-south, and because the beds dip at a gentle angle to the west, as a rule the steeper slopes of the various outliers, their infaces so-to-say, are on their east sides and the gentler slopes, their dip slopes, are on their west sides. The northern and central outliers of the Queen City

formation, that is, those lying north of an east-west line drawn approximately through Concord, are distinctly steeper and higher as a rule than those lying south of that line. There are also differences in soils and composition between these two sets of outliers. The infaces of the northern and central outliers slope at an average rate of 430 feet per mile to the east; their opposite slopes have an average rate of 360 feet per mile. Among the southern outliers the infaces slope at an average rate of 320 feet per mile and their opposite slopes have an average rate of 270 feet per mile.

Some of the medium-sized outliers are elongate. They may be 0.7 to 1.25 miles long and 0.25 to 0.3 mile wide. The three largest outliers may be regarded as groups of outliers not yet separated completely by the cutting of the creeks. Their grouping is such that a roughly parallel alignment is suggested, and some of the medium-sized elongate outliers follow this alignment, which trends in a N. 30° W.—S. 30° E. direction. The causes of this alignment are obscure. Possibly it is caused by the chief direction of drainage in this area being to the south-southeast to the Angelina River.

Aside from this alignment most of the medium-sized outliers have nearly circular peripheries. The lobes of the three largest outliers too are nearly circular as far as they go. The tendency of the outliers to assume approximately the outline of a circle or part of one is quite noticeable, and these circles seem to have about the same radius of about 600 to 900 feet length. From their base lines the sand hills rise in a gently convex curve. Where best developed such watchglass-shaped sand hills are about 60 to 70 feet high and have a diameter of 1,100 to 1,800 feet. Such hills are not greatly dissected by creek valleys, rather the valleys lie between them. Hence the shape of the hills is caused chiefly by rainwash or sheet-wash erosion. Originally these hills were fairly densely wooded, and forest litter covered the deep sand soil that blanketed their flanks. Much of the rainfall was temporarily retained by the forest and the forest litter or absorbed into the soil, but during prolonged rainy periods the soil was sufficiently saturated to allow run-off. During such times sheet-wash erosion was effective. Gullying developed only later on after the land was cleared.

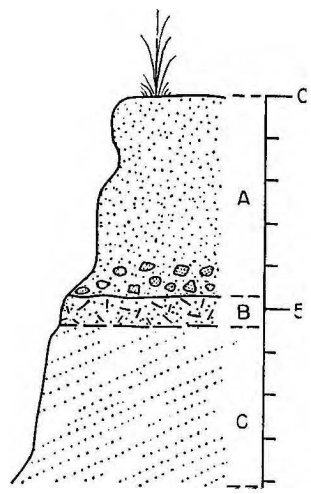


Fig. 44. Soil profile of the northern and central facies of the Arp sand member of the Queen City formation in unfinished silo trench at the site of old Knoxville, 350 feet southwest of Knoxville Spring and 500 feet north of the east-west county road 2,300 feet southeast of Knoxville Cemetery.

Soils and vegetation.—Deep podsol soils are developed on most of the Arp member. The A-zone of deep loose whitish-gray and only slightly humus-bearing sand soil is characteristic for the member in the northern and central outliers. Such soils originally had a fairly dense forest cover of oaks chiefly and some pines; pines are more abundant in the south part of the quadrangle. The following soil profile is typical of the northern and central development of the Arp member. It was measured in the unfinished silo trench at the site of old Knoxville, 350 feet southwest of Knoxville Spring and 500 feet north of the east-west county road, 2,300 feet southeast of Knoxville Cemetery (fig. 44).

Soil profile of northern and central facies of the Arp member of the Queen City formation.

	Thickness *Feet*
(A) Loose, brownish-gray, bleaching to ashy gray on exposure, unstratified, fine-grained sand soil; contains many subangular fragments of hard, dark rusty brown, ferruginous, medium-grained sandstone 0.2 to 0.7 foot above its base. pH = 7.0; pH = 6.5 near base	4.7
(B) Coherent, dirty flesh-colored, unstratified, ferruginous, clayey sand. pH = 4.5	0.7
(C) Friable, dirty rusty orange-brown, cross-bedded, very porous, medium-grained sand; base not exposed. pH = 5.0	3.7

In most of the southern outliers, except for those at the east of the southern outliers, the A zone was very thin, perhaps a foot thick. Some of this A-zone material of loose sand has been lost and the reddish clayey sand subsoil (zone B) is bare over large areas. This part too was originally forested. The following soil profile is typical of the southwestern development of the Arp member. It was measured in a cut on the east side of State highway No. 110 (Troup—New Summerfield road) at the entrance of a private road leading up to a house situated on a small Omen sandstone outlier hill, 1.03 miles north of Black Jack brick schoolhouse (fig. 45).

Soil profile of southern facies of the Arp member of the Queen City formation.

	Thickness *Feet*
(A) Loose, light brownish-gray, unstratified, slightly clayey, fine-grained sand containing very small, subangular fragments of indurated, black or rusty brown, ferruginous, fine-grained sandstone. pH = 6.0	0.4
(B_1) Soft, brick-red, unstratified, silty clay cut by many desiccation cracks. pH = 5.5	0.2
(B_2) Soft, dirty brick-red, lighter in color than (B_1), silty, muscovitic clay grading imperceptibly into (C). pH = 4.5	2.2
(C) Soft, dirty orange-red, thinly bedded, abundantly and finely muscovitic, argillaceous silts and very silty shales. pH = 4.5. To bottom of ditch	2.3

The forest cover of the Arp member has been cleared for the most part and much of the land is under cultivation. Large areas of the cleared land have reverted to pasture. Bear grass is a characteristic plant of the abandoned fields where the sand soil is deep.

Composition.—The Arp member ranges from loose, light gray or slightly brownish, cross-bedded, porous, medium to fine-grained sands containing small whitish shale pebbles to loose, light grayish-brown, level-bedded, porous, very fine-grained sands and silts to soft, dark brown, thinly bedded, very silty, carbonaceous shales.

The shales and sands of the Arp member are lenticular and so irregularly distributed that sections of the member taken at different localities cannot be matched. In distinction from the underlying Marquez member of the Reklaw formation the Arp is much more sandy, and the sands are more toward the fine and medium sand size than toward the silt size as in the Marquez, muscovite is less common and clay-ironstone is practically absent; fossiliferous clay-ironstone containing *Spiratella* is absent. The shales of the Arp member are more sandy than those of the Marquez and generally do not have a tendency to conchoidal fracture.

Consistency of the sandy beds ranges from loose, porous, uncemented sands to hard, ferruginous sandstone. The sandstones are merely a minor portion of the

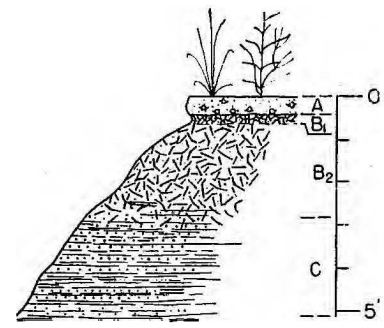


Fig. 45. Soil profile of the southern facies of the Arp member of the Queen City formation on east side of State highway No. 110 (Troup—New Summerfield road) at the entrance of a private road leading up to a house situated on a small Omen sandstone outlier hill, 1.03 miles north of Black Jack brick schoolhouse.

Arp section and occur almost exclusively at the top of the Arp member. On account of their economic importance they are treated below in a separate paragraph. Indurated siltstone was found only at one place. The shales are all soft.

The colors of the fresh rocks vary from light brownish-gray for the sandy and silty parts to dark chocolate-brown for the shaly parts. All these shades are produced by admixture of lignitic matter. However, most of the beds found in exposures are weathered to some extent; hence the oxidized ferruginous colors of weathering prevail.

Bedding varies from water-laid cross-bedding to level bedding to crumpled and disrupted bedding. The medium-grained sands are mostly cross-bedded, but some of the finer grained sands too are cross-

bedded. Level bedding is usually found associated with the shales and silts. Crumpled and disrupted beds of sand are found in those places where sands alternate with shales. Excellent exposures of crumpled and disrupted beds are in the road cuts north of the Homer Lacey store (fig. 46). Here a 6.2-foot thick bed of very fine-grained sand is intricately contorted in its upper 3 to 4 feet. The top of the bed is beveled in most places, and shale and silt lie with angular unconformity on the beveled crumpled bedding. Some of the heads in the crumpled bed seem to have pushed up into the overlying shale and silt; at one place the overlying shale is apparently sucked down into a crumpled part of the sand bed. A very fine-grained sand bed, about 1.5 feet above the crumpled bed, increases in thickness from 0 to 0.8 foot from north to south; its south end is abrupt as if the bed had been ruptured shortly after deposition. These crumplings and disruptions are penecontemporaneous with deposition and were caused by subaqueous sliding of the beds.

Muscovite is a common component of the shales and finer grained rocks of the Arp member. Lignitic matter finely divided is present in all beds, but the shales and finer grained rocks have more of it than the coarser sands. Lignitized plant fragments and leaf imprints are present in many beds, but lignite beds, even impure ones, are absent.

Nearly all the Arp member is free of glauconite. Glauconite, or possibly chamosite, is present only in the uppermost beds, which may more properly belong to the Omen member, and in the lower 20 feet of the Arp, which form the transition to the underlying Marquez member of the Reklaw formation. Glauconite was found in the lower 20 feet only in two places: (a) in the washed-out abandoned north-south road, 2,900 feet due west of the Homer Lacey store (compare Section 19 on p. 90 and fig 48) and (b) in the south ditch of the east-west county road, 2,000 feet east of the crossroads of 503 feet elevation and 2,800 feet south-southwest of Knoxville Cemetery. At the first place glauconite occurs in thinly bedded, richly muscovitic silt and one clay-ironstone concretion. At the second place the glauconite is found in a clayey siltstone.

Concretions of any sort are almost completely lacking. Only one concretion was found. This is a hard, red-maroon on cross break, olive-brown on outside, massive, silty, very glauconitic, earthy clay-ironstone having septarian shrinkage cracks and very few imprints of small pelecypods. The concretion is ellipsoidal, 0.7 foot thick, and 1.8 by 2.4 feet in size; it lies in coherent, deep rusty orange-red, thinly bedded, richly muscovitic, sparingly glauconitic silt of 1.7 feet thickness; it is 17.4 feet above the base of the Arp member (compare detailed description of Section 19 on p. 90 and fig. 48).

An unusual, fossiliferous, glauconitic siltstone is found approximately 24 feet above the base of the Arp member near the foot of the west slope of a hill along the east-west county road, about 2,000 feet east of the crossroads of 503 feet elevation and 2,800 feet south-southwest of Knoxville Cemetery. The siltstone and surrounding beds are involved in contorted bedding caused by penecontemporaneous subaqueous slumping. The rock is a friable, whitish-gray on fresh breaks, rusty orange on joints, contorted, richly muscovitic, slightly glauconitic, argillaceous siltstone.

Under the microscope the major portion of this siltstone is seen to consist of very fine grains consisting chiefly of quartz of a size of 0.06 to 0.14 mm, averaging about 0.1 mm. Present are biotite and muscovite flakes and the heavy minerals tourmaline, epidote, zircon, and magnetite. Glauconite or chamosite and an alteration product(?), a light tan waxy mineral with an index of n = 1.552+, are present in variously shaped grains about 0.1 to 0.5 mm in size. Clay pellets very similar to these are also found; some clay pellets have centers of the tan waxy mineral. The refractive index of the clay is about that of quartz, larger than that of montmorillonite, and smaller than that of kaolin. Clay also is found interstitial between sand grains. Whether it is an alteration product of volcanic ash is indeterminable. Certain heavy mineral grains such as magnetite and zircon have coatings of a green mineral very similar to the glauconite; the crystalline structure radiating from the grain forms a rounded grain which gives an interference-cross under polarized light. The clay does not react to any extent with benzidine, but the glauconite does. (Microscopic description by Mrs. Kathryn O'Neill Dickson.)

Oversized
page

Ferruginous sandstone. — Ferruginous sandstone beds are rare as a whole, but locally beds up to 3 and 5 feet thick have been found. In view of their importance as local building stone or road metal the ferruginous sandstones are shown by a special symbol on the map (Pl. I) and are discussed again under "Stone." These sandstones are best developed at location 7 given below, where a bed up to 5 feet thick is traceable for 2,350 feet at the north and east brows of the hill spur and was quarried in the past. The ferruginous sandstone-ledge exposures listed below under locations 1 to 7 are probably at the same stratigraphic level and may be the indurated portions of the same continuous sand bed. They are at the top of the Arp member, immediately below the Omen slabs. The sandstone ledge consists of hard, harsh, somewhat brittle, rust-brown to black-maroon, cross-bedded or thick-bedded, ferruginous, medium-grained sandstone. The ferruginous sandstone-ledge exposures were found in the following places, extending in a narrow band, 1,500 feet wide, for 2 miles in a northwest-southeast direction; they are listed below progressing from northwest to southeast.

(1) At the north tip of the Omen outlier, in the road ditches of the east-west county road, 0.5 mile airline distance south of Knoxville Cemetery.

(2) On the east slope of the same Omen outlier, 800 feet south of the east-west county road and 1,000 feet southeast of location 1.

(3) At the tip of a northwest prong of an Omen outlier, 700 feet east of location 2 across a small intervening valley, 1,000 feet west of the right-angle turn in the county road that runs southward from the road fork at elevation 510.

(4) In the road ditches of the county road, 1,100 feet east of location 3, at the right-angle turn of the county road that runs southward from the road fork at elevation 510.

(5) In at least three places on the south margin and on the tip of the southeast prong of the Omen outlier, the same Omen outlier on which locations 3 and 4 are, 2,250 to 3,400 feet south of the road fork of 510 elevation and 1.33 to 1.70 miles airline distance southeast of Bell Church.

(6) Top of small steep conical hill, 520 to 540 feet above sea level, one-third of a mile north of location 7, on the southeast side of Campground Creek, rising to 120 feet above the creek in a distance of 1,000 feet. Many small abandoned quarries are on top of the hill; the sandstone is 3 feet thick.

(7) At east end of eastward-projecting hill spur, 520 to 540 feet above sea level, overlooking the head of the valley of Campground Creek, 1.37 miles west-southwest of the church at Concord or 1.9 miles north-northeast of the crossroads in Griffin in airline distances. Countless small abandoned quarries are there; the sandstone is up to 5 feet thick.

Other, usually minor, outcrops of similar ferruginous sandstones are noted on the map.

Under the microscope a thin section made from a friable to hard, dark red-brown, ferruginous sandstone bed in the Queen City formation about 10 feet below the base of the Omen member from north of Farm Road 13 shows a rough orientation of the quartz grains with their longer axes approximately parallel. The detrital grains are well sorted, 0.3 to 0.4 mm in diameter, with only a few grains less than 0.2 mm; the grains are subangular to angular, but a few of them are well rounded. Most of the detrital grains are quartz, but a few are made up of quartzite consisting of an aggregate of small crystals showing mosaic or sutured structure with very rare crystals of microcline included in the quartzite. Detrital grains of chert are well rounded. The grains are coated with a 0.01 to 0.02-mm thick crust of dark red cement. The same material is present also in small grains of the size of the detrital quartz. The interstitial pore spaces are filled in some places with a light orange, double-refracting, banded material, probably limonite. Volume relations are: detrital quartz 55 percent, matrix and cement 37 percent, detrital chert 8 percent, and a trace of detrital feldspar grains, such as microcline and probably orthoclase, muscovite, tourmaline, questionable amphibole, and questionable zircon. (Microscopic description by Mrs. Kathryn O'Neill Dickson.)

The induration of these sandstones is caused by the infiltration of limonite into the pore spaces of the sands. This infiltration is of secondary origin and comparatively recent; it is related to the weathering processes that have attacked the Queen City outcrops. The limonite was probably derived from the weathering of glauconite grains in the overlying Omen member. At any rate the ferruginous sandstones of the Arp member are best developed and usually present only in the uppermost part of the member at a stratigraphic position immediately under or up to 10 feet below the level of the Omen member. However, the Omen member may no longer overlie the ferruginous sandstones of the Arp member, having been removed by erosion at that particular place.

Thickness.—Reliable thickness data are difficult to obtain because both the base and the top of the member are ill defined. Hence the thickness data given below are subject to correction if the top or bottom boundaries chosen are reinterpreted.

In the Henrys Chapel quadrangle the thickness of the Arp member ranges from 75.6 to 48.2 feet. The thickness is greatest in the northern and central part of the map and decreases toward the south and west.

The following is a tabulation of the thickness of the Arp member in the Henrys Chapel quadrangle, measured by hand level, listed going from north to south (fig. 47):

(1) Hill 560+ feet above sea level forming the southern end of the Queen City outlier at the north end of the quadrangle, located between the old and the new Troup—Henderson road (Farm Road 13), 3,350 feet south of the north boundary of Cherokee County ..... 61.0 feet

(2) Hill 540+ feet above sea level, culminating about 900 feet east of the north-south county road, 2,700 feet airline distance east-northeast of Knoxville Cemetery ..... 75.6 feet

(3) At Bell Church, measured along northwest-southeast running county road at the west side of the church ..... 66.8 feet

(4) Along east-west county road, on west slope of hill capped by the Omen member, 1,750 to 2,650 feet east of the crossroads of 503 feet elevation and 2,700 feet south-southwest of Knoxville Cemetery ..... 66.2 feet

(5) On county road connecting Bell Church with Griffin, at the ascent from a left tributary branch of Caney Creek to a hill 520+ feet above sea level, 1.2 to 1.3 miles south-southeast of Bell Church by road or 1.2 miles airline distance south-southwest of Knoxville Cemetery ..... 68.4 feet

(6) Along State highway No. 110 (Troup—New Summerfield road) and up a private road going east, 1.0 mile north of Black Jack brick schoolhouse ..... 48.6 feet

(7) South slope of hilltop, 520+ feet above sea level, on the straight north-south stretch of the county road connecting Bell Church with Griffin, 0.17 to 0.37 mile south of the road fork at elevation 501, about 2.1 miles by road north-northwest of Griffin ..... 52.7 feet

(8) Southeast slope of the Queen City outlier at Griffin, along county road zig-zagging southeastward from Griffin to Emmaus Church ..... 48.2 feet

Paleontology.—Poorly preserved and unidentifiable imprints of small thin-shelled pelecypods were found in three places: (a) the glauconitic clay-ironstone concretion described above, (b) the glauconitic siltstone described above, and (c) in a hard, rusty brown, thinly bedded, richly muscovitic, glauconitic, ferruginous, very fine-grained sandstone of the upper part of the Arp member. Place (c) is in the terraced field on the broad top of a hill, 500+ feet above sea level, 775 feet south of the county road that runs straight west from the road corner at elevation 500 and that connects State highway No. 110 (Troup—New Summerfield road) with the Bell Church—Griffin county road, 3,500 feet airline distance due east from the State highway or 5,450 feet airline distance northeast of the former Black Jack brick schoolhouse.

Elsewhere no remains of animals were found in the Arp member. Plant remains such as lignitized plant fragments are, however, fairly common on bedding planes of the more shaly parts of the member, and all beds of the member are more or less carbonaceous.

Reklaw-Arp contact.—The contact between the Marquez member of the Reklaw formation and the overlying Arp member of the Queen City formation is a gradual transition from the more shaly beds with fossiliferous clay-ironstone benches of the Marquez to the more sandy beds lacking clay-ironstone benches of the Arp member. The transition takes place within 6 to 20 feet, the average being 12 feet. Under such conditions the placing of the Reklaw—Queen City boundary becomes difficult and depends on the criteria one wishes to use. Some geologists prefer to place the boundary at the top of the highest fossiliferous clay-ironstone bench, thereby throwing the transition beds into the basal Queen City. Such a choice is very useful for structural mapping because exact elevations of the top of this clay-ironstone can be obtained and used for structure contours. The choice would be a good one were it not for the lack of persistence of the clay-ironstone bench. The bench is not a continuous layer but rather a series of long lenses at the same stratigraphic level or at least at nearly the same stratigraphic level. Probably one lens is replaced by another at a slightly different level. The other objection to this choice of a boundary is the fact that the shale immediately above the clay-ironstone is in some places identical to the shale immediately below; in other words, the boundary chosen does not separate two different bulk lithologies but is after all merely the top of a more or less fortuitously distributed singular

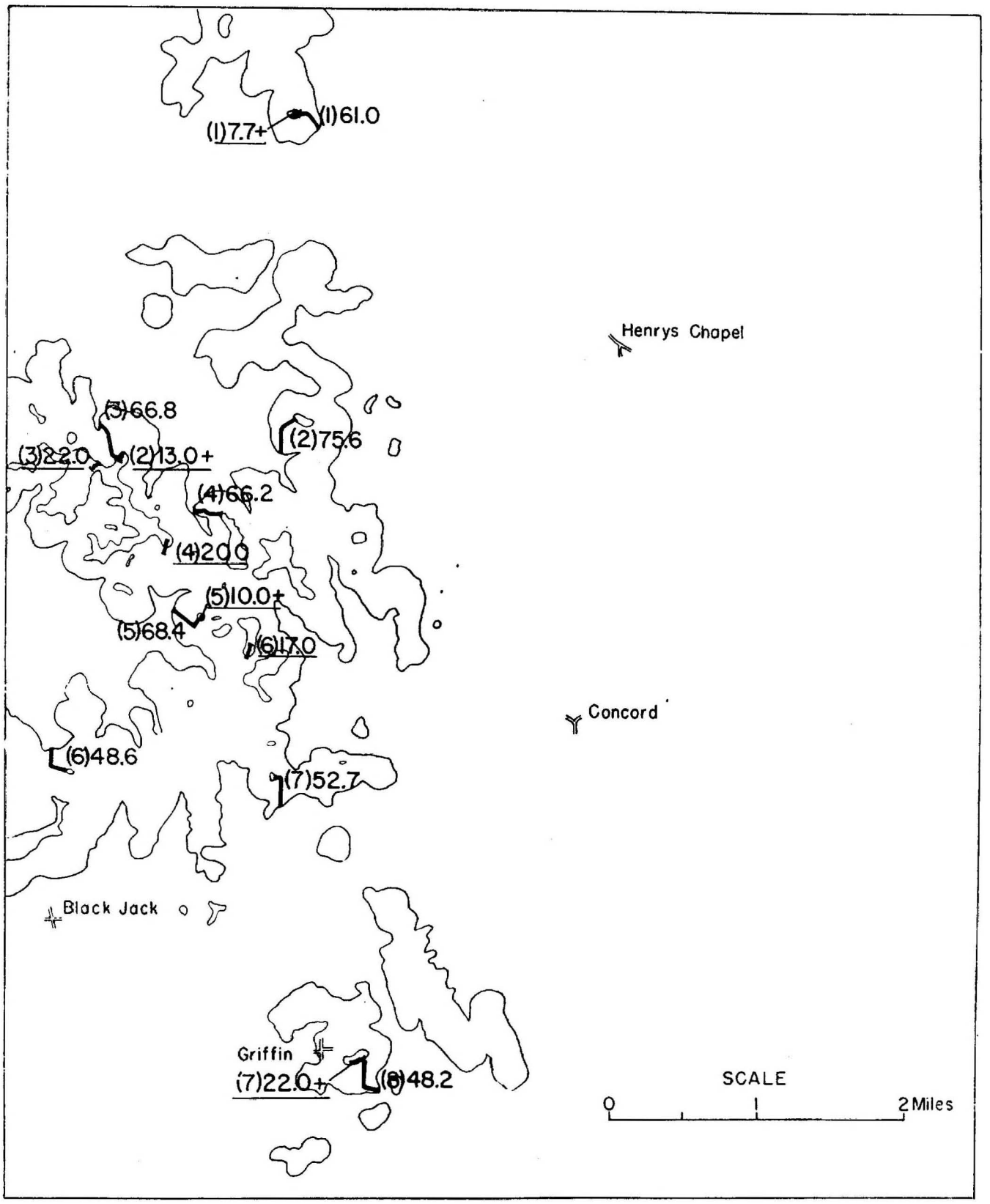


Fig. 47. Location of measured thicknesses of the Arp and Omen members of the Queen City formation in the Henrys Chapel quadrangle. Location numbers are given in parentheses and correspond to those given in the text on pp. 88 and 98; each heavy line indicates the position and direction in which the sections were measured. The thicknesses are given in feet. The data pertaining to the Omen member are underlined.

and lenticular lithology, that is, the top of a series of clay-ironstone lenses. For these reasons the boundary used in the present report is chosen where bulk lithology changes from predominating shales to predominating sands or silts. This is the same choice that was used in the mapping of Leon County (Stenzel, 1939, pp. 87–92). The difference between the two choices of the boundary is neither large nor significant.

The Marquez-Arp transition is particularly well exposed in the washed-out and abandoned north-south road, on the north slope of a hill, 480+ feet above sea level, 2,900 feet west of the Homer Lacey store (fig. 48). Here the transition beds are 19.3 feet thick and contain some beds that carry glauconite, but the transition beds are predominatingly silty and fit the Arp bulk lithology better than they do that of the Marquez. Compare Section 19.

SECTION 19

Transition between the Reklaw and Queen City formation. Abandoned and washed out wagon road, on the north slope of a hill, 480+ feet above sea level, 0.55 mile due west of Homer Lacey country store (fig. 48).

	Thickness *Feet*
Arp member, basal 22.0 feet—	
(r) Chiefly brick-red clayey soils; to top of hill	19.7
(q) Silts with thin shale layers, up to 0.2 foot thick	2.3
Transition beds, 19.3 feet thick—	
(p) Coherent, deep rusty orange-red, thinly bedded, richly muscovitic, sparingly glauconitic silt with an ellipsoidal concretion (0.7 by 1.8 by 2.4 feet) of hard, red-maroon on cross break, olive-brown on outside, silty, very glauconitic, earthy, massive clay-ironstone having septarian shrinkage cracks and very few imprints of small pelecypods	1.7
(o) Similar to (n) but with the shales much predominating; the silts are only up to 0.3 foot thick	8.2
(n) Silts as (m), up to 0.7 foot thick, interbedded with shales similar to (l), up to 0.4 foot thick	5.1
(m) Friable, dirty rust-orange with whitish color on joints, thinly bedded, richly muscovitic silt	1.6
(l) Soft, plastic, chocolate-brown when fresh, whitish-gray weathering, laminated, finely muscovitic, silty shale; toward the south this bed develops into brown shale on top, a silt lens in the middle, and soft, dark olive-green thin-bedded, argillaceous, silty, medium-grained glauconite arenite, 0.4 foot thick, at base	0.2 to 0.7
(k) Same as (i)	1.3
(j) Friable, olive-brown, poorly bedded, argillaceous glauconite arenite thinning into glauconitic clay	0.2 to 0.3
(i) Coherent, light dirty orange with whitish-gray joints, thinly bedded, richly muscovitic silt and silty shale	0.7 to 1.4
Marquez shale member, 8.7 feet exposed—	
(h) Hard, brittle, light rusty yellow and brown, layered and concentric, earthy, silty, glauconitic clay-ironstone and boxstone	0.6
(g) Soft, light greenish-gray with few red-orange spots, laminated, silty, leached shale	0.3
(f) Hard, rusty yellow, brown, and in places vermilion, concentric clay-ironstone; the cores are earthy and have only a few thin branching pipes filled with glauconite and very fine sand; the envelopes are thin-crusty	0.5
(e) Coherent, olive-green, cross-bedded, argillaceous glauconite arenite	0.6
(d) Similar to (a); develops into a hard, olive-brown, glauconitic, silty, fossiliferous clay-ironstone, 0.4 by 6.0 feet in size; contains among other fossil imprints one of *Belosepia*	1.1
(c) Coherent, dirty orange-red, thinly bedded, glauconitic, fossiliferous, very fine sand	0.8
(b) Friable, olive-rust-brown, irregularly layered, glauconite-rich clay-ironstone; hard, brittle, rusty yellow, thinly honeycombed clay-ironstone; hard, dense, red-maroon and rusty brown, earthy, silty clay-ironstone with pteropod imprints; honeycombed clay-ironstone	0.7
(a) Coherent, banded gray and rusty red-orange on weathered surface, gray and chocolate-brown where fresh, thinly bedded with lenticular silt beds, muscovitic, porous silts and very silty shales; bottom not visible	3.9

Oversized
page

Facies.—Considerable facies changes occur in the Arp in the area mapped. The northern and central parts of the Arp outcrop consist almost entirely of loose, whitish-gray when fresh, cross-bedded, very porous, medium-grained sands. Westward and southward these sands grade into coherent, brownish, level-bedded, fine-grained and very fine-grained sands, and silts and silty carbonaceous shales become important. The transition from the northeastern facies to the southwestern is gradual and takes place over a distance of about 2 miles. In this distance three local facies may be distinguished. Their features are summarized below (figs. 49 and 50).

The three local facies of the Arp member

FACIES	SOUTHWESTERN	INTERMEDIATE	NORTHEASTERN
PREVAILING COMPOSITION	Coherent, chocolate-brown, abundantly muscovitic, argillaceous silts and sands	Coherent to loose, whitish-gray, muscovitic, fine-grained sands and interbedded chocolate-brown, abundantly muscovitic silty shales	Loose, whitish-gray, very porous, medium-grained sands
BEDDING	Thin and level	Medium thick and partly contorted	Cross-bedded
WEATHERING (B AND C ZONES OF SOIL PROFILE)	To dirty orange-red and brick-red		To friable, dirty, rusty orange-brown sandstones
SOIL (A ZONE OF SOIL PROFILE)	Thin (0.4 foot) gray sand soil (A zone) on brick-red silty clay subsoil (B zone)	Ashy gray sand soil about 1 foot thick	Ashy gray sand soil up 5 feet thick
TOPOGRAPHIC SLOPE	Very gentle slopes, 320 feet per mile	Intermediate	Fairly steep sand slopes, 430 feet per mile
THICKNESS	About 50 feet	Intermediate	About 75 feet
FOSSILS	Contains locally pelecypod imprints	Contains locally pelecypod imprints	No invertebrate fossils
DEPOSITIONAL ENVIRONMENT	Bottom-set beds; brackish and lagoonal	Fore-set beds; brackish and lagoonal	Top-set beds; fluviatile

Whether or not the boundary between the Marquez member and the Arp member as traced through the region stays at the same stratigraphic level is difficult to ascertain. In this connection it is immaterial at which particular position the boundary is chosen, and both choices discussed above are subject to the same considerations. As explained above the two members grade into each other through a transition of about 12 feet. It is quite possible that lowermost sand beds of the Arp member gradually become more shaly as they are traced across the quadrangle from the Smith—Cherokee County line toward the southwest toward Black Jack schoolhouse. If they do, they would gradually assume the composition of the transition beds and be indistinguishable from them. It is quite possible that the transition beds too change as they are traced southwestward across the quadrangle; possibly the transition beds gradually become more and more like the underlying Marquez shale, and possibly even fossiliferous clay-ironstones make their appearance in that stratigraphic level. In that way the Marquez-Arp boundary would gradually creep upward in stratigraphic position but the process would not be noticeable in any one particular exposure. Thereby the Marquez member would increase in thickness at the expense of the Arp member. To some extent this situation is indicated by the

data available, because the Arp sand does decrease in thickness appreciably to the south and southwest; but the Marquez member does not increase in thickness correspondingly as far as could be ascertained; on the contrary, it seems to thin southward. However, the southward thinning of the Marquez member may be

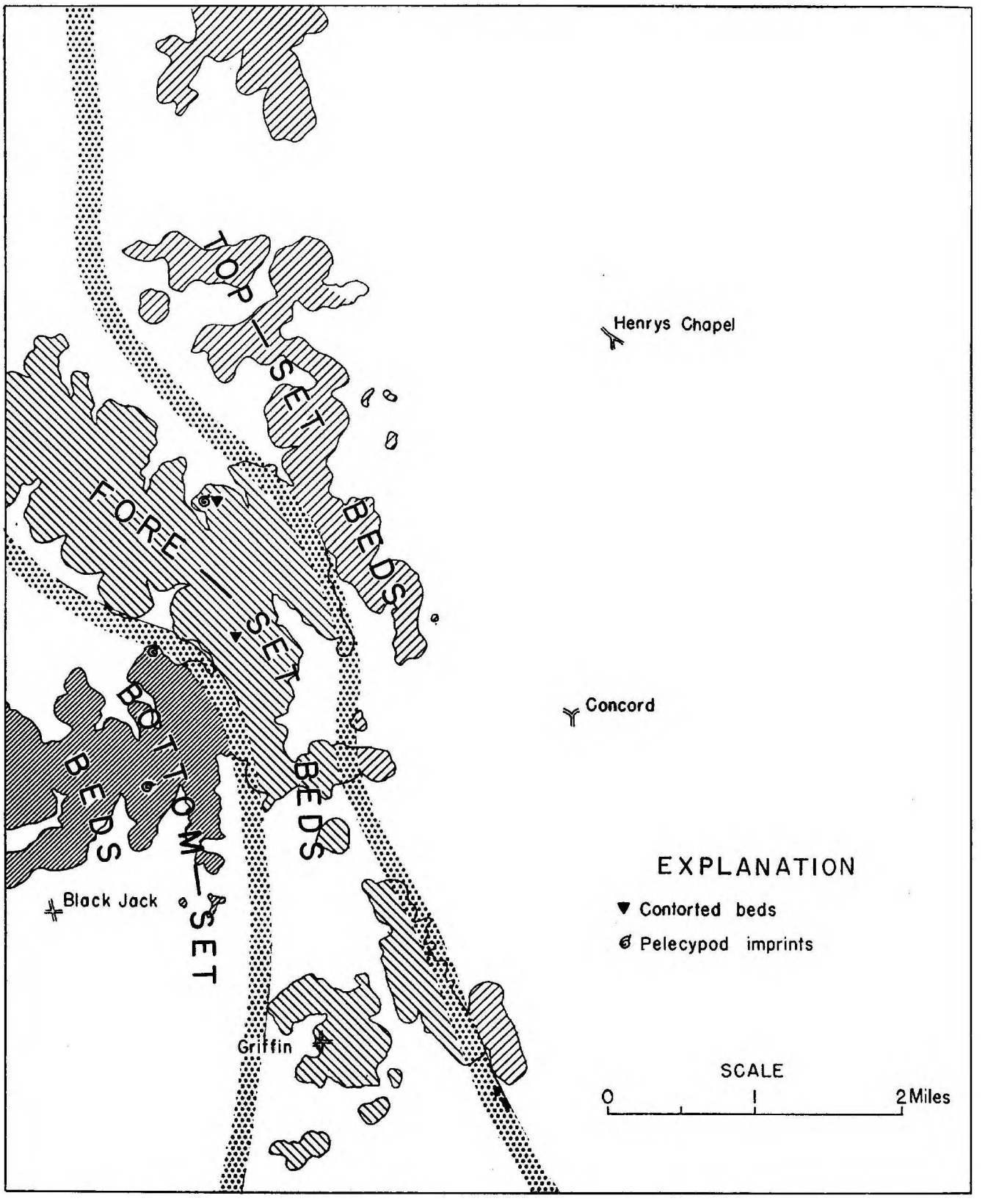


Fig. 49. Distribution of the three facies of the Arp member of the Queen City formation in the Henrys Chapel quadrangle.

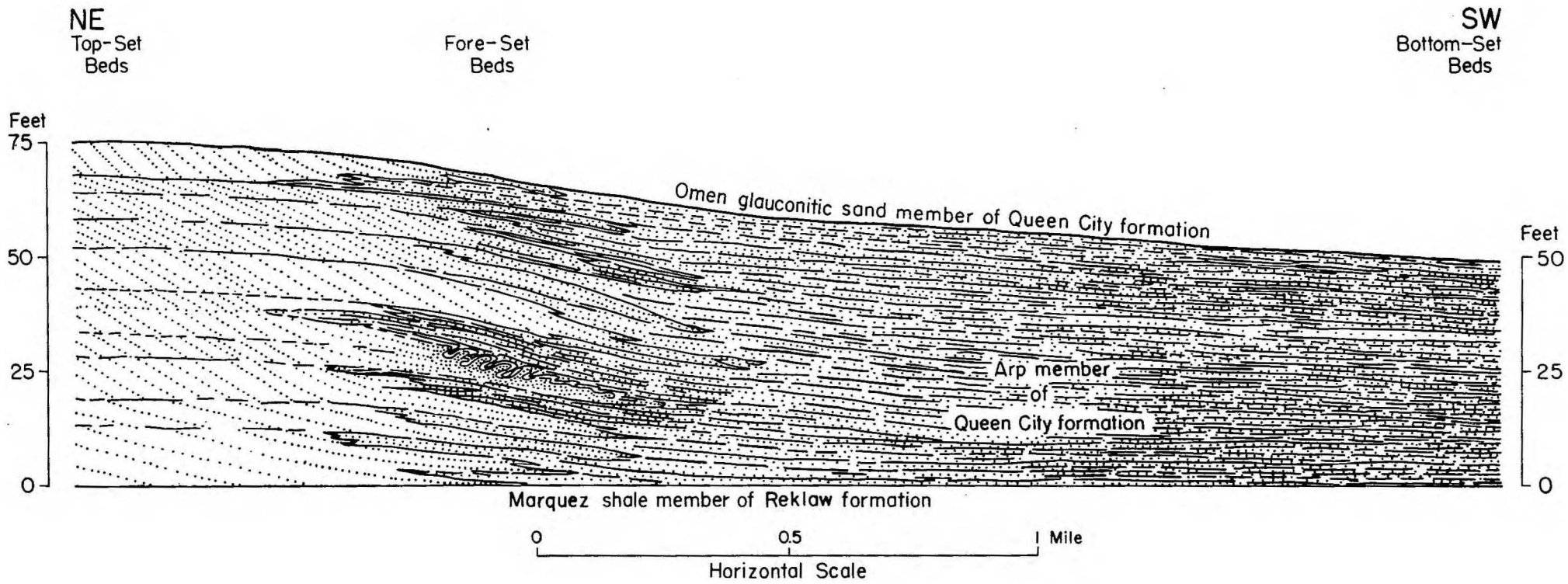


Fig. 50. Cross section of the three facies of the Arp member of the Queen City formation in the Henrys Chapel quadrangle.

caused by other changes within the Marquez member such as the gradual southward decrease in silt content of the shales, which is observable in the area. The writer considers it a distinct possibility that the Marquez-Arp boundary gradually creeps upward stratigraphically as the members are traced southwestward across the quadrangle.

On the other hand, it is possible that the Marquez-Arp boundary remains at approximately the same stratigraphic level throughout the area. In that case all thickness changes of the Arp member are confined to causes within the member itself. Possibly the Arp member thins toward the south and southwest because individual sand lentils within the member wedge out in that direction. To some extent this feature is indicated by the data available, for the Arp member does become thinner and more argillaceous in that direction.

Whatever interpretation be preferred it is an observable fact that the Arp member in being traced from the Smith—Cherokee County boundary toward the southwest becomes thinner as a whole, more shaly as a whole, and also changes from lacking molluskan fossils to slightly fossiliferous. The changes go hand in hand and indicate a lateral facies change from the thicker, sandier, nonfossiliferous, probably fluviatile facies of the north to the thinner, more shaly, fossiliferous, probably brackish lagoonal facies around Black Jack schoolhouse.

In order to complete the discussion of the facies changes in the Arp member and to present a different viewpoint, the conclusions of C. L. Moody (1931, pp. 538 and 542) are summarized here. According to Moody the Arp sand "is a well defined white massively bedded coarse-grained member underlying the Omen greensand described by Wendlandt and Knebel. This Arp sand is traceable southward into Cherokee County to the vicinity of Black Jack Church, where it is plainly seen to be a wedge in the Reklaw formation." (C. L. Moody, letter dated January 17, 1950.) As can be seen from this excerpt it is C. L. Moody's impression that toward the southwest the Arp sand wedges out completely and thereby lets the Omen member rest on shale, which on account of its lithology must be regarded as upper Reklaw. Hence in this southwestern area the Omen is merely the uppermost layer of the Reklaw formation. Therefore Moody regards the Omen, the Arp, and the under-

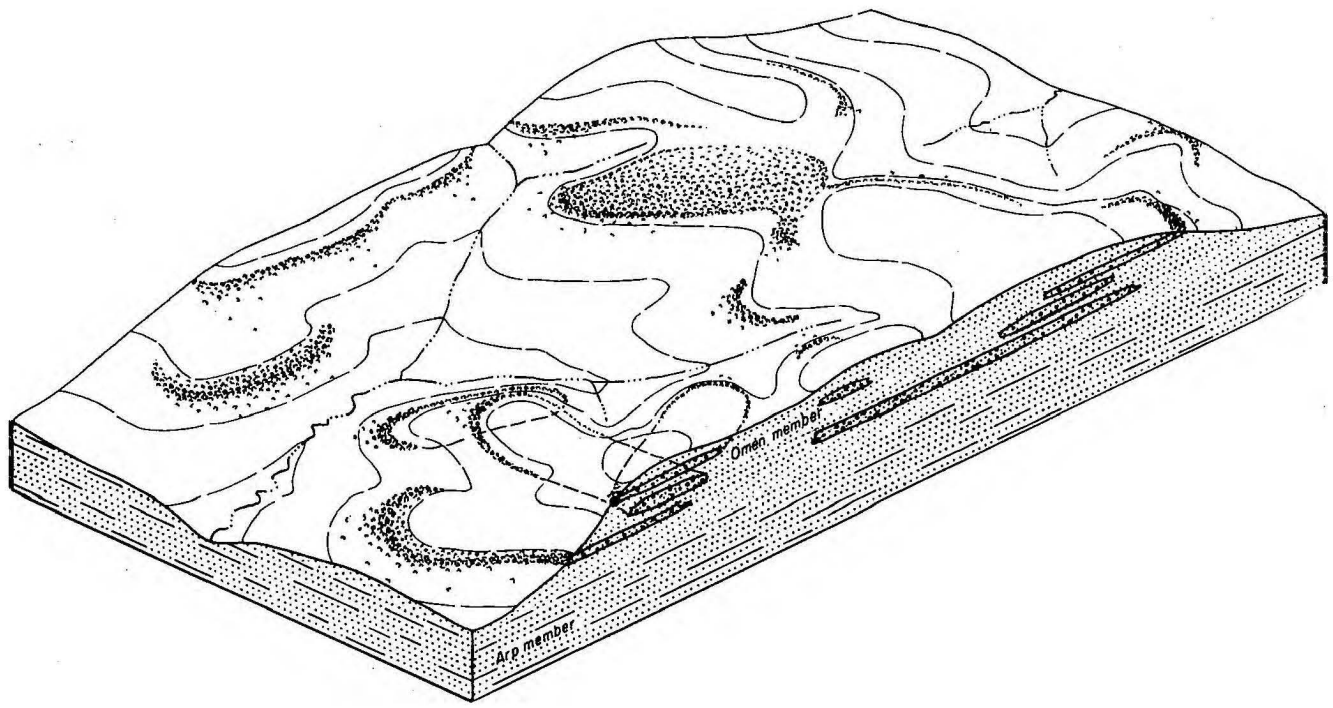


Fig. 51. Block diagram of a Queen City outlier capped with the Omen member showing the winding and twisting hill spurs characteristic of the larger Omen caps, caused by the lenticular indurated parts of the Omen member.

Rock-strewn slopes indicate the outcrop of individual indurated lenses of the Omen member.

lying Marquez and Newby members as parts of the Reklaw formation as redefined by him.

It can be seen that Moody's interpretation, aside from the redefinition of the stratigraphic size of the Reklaw formation, differs from the one given by the writer, at least in one essential point. According to Moody the Arp sand wedges out so completely to the southwest that only Marquez-type shales are left, whereas in the area mapped by the writer the Arp member can be separated from the underlying Marquez shale even where the Arp has become rather shaly. No time was available to pursue this problem beyond the area of the Henrys Chapel quadrangle to the southwest. The observations made by C. L. Moody may very well be corroborated in the region beyond the Henrys Chapel quadrangle.

OMEN GLAUCONITIC SANDSTONE MEMBER

Wendlandt and Knebel (1929, pp. 1355–1356) were the first to publish information on the Omen member, which apparently had not been recognized before the 1920's. According to these authors the member is 10 to 15 feet thick and lies stratigraphically 140 feet above the main glauconite of the Reklaw, that is, the Newby member, and between 240 to 280 feet below the top of the Weches formation. They reported the member as extending from Harrison through Gregg, northwestern Rusk, and eastern Smith counties, into Cherokee County. The member derives its name from the village of Omen in southeastern Smith County, about 5.4 miles north of the northwest corner of the Henrys Chapel quadrangle.

So far the Omen member has not been extended beyond the distribution given for it by the first describers, but somewhat similar strata in about the same stratigraphic position were described from Leon County from core holes of the Buffalo dome area (Stenzel, 1939, p. 87).

Distribution.—The Omen glauconitic sand member makes 29 outliers in the western half of the Henrys Chapel quadrangle. The largest of these is at Bell Church in the west-central part of the quadrangle. Most of the outliers are concentrated in the area between Bell Church and the Homer Lacey country store.

Topography.—The Omen glauconitic sand member contains indurated to hard ferruginous sandstone slabs; hence it is highly resistant to erosion and forms a protective cap on many of the Queen City outliers.

In outline these protective caps are simple elongate ovals if the Omen cap is small. But the larger caps, particularly the largest near Bell Church, are highly irregular because of the many hill spurs that extend outward in various directions. The hill spurs, capped by the Omen member, are winding and twist in some instances at nearly right angles; some spurs end abruptly with a nearly straight cross slope, as if cut off (fig. 51). These features are particularly noticeable because the lower slopes of these hills, composed of the Arp member, tend to simple rounded outlines. The cause of these features is the arrangement of the indurated portions of the Omen member, which is discussed below under "Facies."

Soils and vegetation.—The top part of the A zone, if it is present at all, is usually very thin, only 0.2 foot thick; its color ranges from the black-brown of humus-rich clayey sand to dark brown, that is, slightly lighter than chestnut-color, and tends in some places toward orange; it is a clayey sand. Under the top layer is rock rubble mixed with this dark brown clayey sand soil. Downward the rubble-bearing soil grades into dirty orange-brown clayey sand with rubble, which makes up the B zone of the soil profile. Most of the rubble pieces are 1 inch or smaller, but sizes up to several inches across are common; larger blocks are present but are few. The rubble is composed of ferruginous sandstone derived from the weathering of the Omen member.

The following soil profile is regarded as typical of the Omen member. It was measured in the road cut on the east side of the county road connecting Bell Church with the Homer Lacey store, on the descent from the southeast-pointing hill spur, 0.26 mile southeast of the crossroads with 503 feet elevation (fig. 52).

Soil profile of Omen member.

	Thickness *Feet*
(A) Loose, dirty brownish-gray, unstratified, porous, fine-grained sand soil full of subangular fragments of hard, ferruginous sandstone, most of which are smaller than 2 inches. pH = 6.5	1.1
(B) Coherent, dirty brick-red, unstratified, clayey, fine-grained sand. pH = 4.5	0.9
(C) Coherent, rusty red-brown to olive-brown, cross- and lenticular-bedded, medium-grained sand with many tiny white specks; partly indurated to hard ferrruginous slabs, 1 to 3 inches thick. pH = 4.5. To bottom of ditch	4.8

Originally the Omen member was wooded with oaks and pines, but most of it has been cleared for road-metal pits, for a few peach orchards, and for fields, now largely reverted to pasture.

Composition.—The fresh unweathered Omen member cannot be seen in any exposures in the quadrangle; all the Omen exposures and outcrops are oxidized, weathered, and thoroughly discolored. Fresh unweathered material probably cannot be had anywhere in the quadrangle, even by excavating, because the Omen member occupies everywhere a highly exposed position on hilltops. Fresh material may be seen in the road ditches on the east side of State highway No. 135 (Troup—Arp road) about 0.94 mile from the center of the town of Arp in southeastern Smith County, north of the Henrys Chapel quadrangle. The exposure consists of soft but coherent, dark olive-green, cross-bedded, mealy-appearing glauconite arenite.

The leading feature of the weathered Omen member in the quadrangle is its indurated portions. They compose the rubble in the soil cover. The rubble pieces are 1 inch in size or smaller, but sizes several inches large are common; large blocks or slabs up to 1.5 feet in size are present but very few. Larger blocks, up to 0.8 by 3.7 by 5.0 feet in size, were found, but these are usually conglomeratic, that

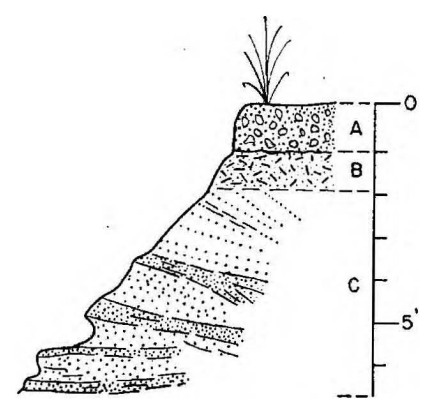


Fig. 52. Soil profile of Omen member in road cut on east side of county road connecting Bell Church with the Homer Lacey country store, on the descent from the southeast-pointing hill spur. 0.25 mile southeast of the crossroads at 503 feet elevation.

is, they are composed of tightly cemented rounded rubble pebbles in a matrix of ferruginous sandstone; they are probably caused by surface weathering, slight rolling around, and recementation; most probably they are comparatively recent and not Eocene conglomerates. The rubble consists of hard, harsh, brittle, generally rusty yellow-brown on the outside, rusty brown to rusty black-brown when freshly broken, ferruginous sandstone with poorly developed bedding. Some of this sandstone has many whitish to light rusty yellow specks of an earthy appearance and pin-head size. These specks are best compared to yellow corn meal and impart to the sandstone a mealy appearance, which was already noted by Wendlandt and Knebel (1929. pp. 1355–1356). This mealy appearance is rather characteristic of the Omen member and is not extensively developed in ferruginous sandstones of the remainder of the Queen City formation. The origin of the mealy specks is obscure; they are kaolinite grains discolored by limonite impregnations. Whether or not glauconite was present in this ferruginous sandstone

rubble of the Omen member can rarely be determined by inspection in the field, but most of these ferruginous sandstones probably were originally glauconitic to some extent. Thin sections show altered glauconite pellets.

Under the microscope bedding is not discernible. The detrital grains of quartz are from 0.1 by 0.1 mm to 0.6 to 0.4 mm in size and average 0.2 by 0.15 mm. Well rounded and angular ones are present. There are some detrital grains of chert and possibly of feldspar and a few grains of ferromagnesian minerals. The glauconite grains are pellets or fillings of foraminifera; they are altered to limonite to a large extent and show an orange-brown color, which is not removed by hydrochloric acid, but their index of refraction is substantially that of glauconite. Booklike crystals of kaolinite enclose a quartz grain or fill the chambers of replaced shells of foraminifera and replace the shell walls around the altered glauconite grains. These book-like crystals or fine mosaic-like masses have an index of refraction of n = 1.561 and are the whitish cornmeal-like specks of the rock. Muscovite is split along the cleavages and coated with limonitic clay. The volume relations of the rock are: detrital quartz grains 39 percent, limonitic clay matrix 42 percent, altered glauconite 16 percent, probable kaolinite 3 percent, and a trace of detrital chert grains. (Microscopic description by Mrs. Kathyrn O'Neill Dickson.)

In most places the rubble and rubble-filled soil are all that can be seen of the Omen member, but where road cuts or ditches afford a section of the Omen member it is seen to consist of a lenticular and cross-bedded series of hard, thin-slabby, chiefly 0.1-foot thick or less, but up to 0.3-foot thick, ferruginous sandstone layers separated by coherent, dirty rust-orange, cross-bedded, muscovite-free, mealy-appearing, slightly argillaceous sands that have many soft, plastic when wet, grayish-white on outside, light greenish-gray on cross breaks, thinly bedded, finely muscovitic, silt-free clay-shale pebbles or beds. The clay-shale pebbles are rounded to flat and strung into thin beds following the inclined cross-bedding of the enclosing sands. However, where the clay-shale pebbles are more crowded, they merge laterally into thin, cross- and lenticular-bedded shale layers, which may be up to 1 foot thick but contain sand partings. The freshest clay-shale seen was light brownish-gray and had some small, waxy, brown glauconite grains; the brownish color is presumably caused by slight amounts of carbonaceous matter; the grayish and greenish colors usually seen are caused by bleaching and leaching. The hard, thin-slabby, ferruginous sandstone layers furnish the rubble in the soil. The sandstone layers merge laterally into the coherent, dirty rust-orange, cross-bedded sands and thereby disappear. Such compound lenses are 2 feet thick and 48 feet long.

The best exposed section of the Omen member was found in the east ditch of the north-south stretch of the county road, at the road-metal pit that is on the east side of this county road, 0.85 mile south-southeast of Bell Church and 0.8 mile airline distance southwest of Knoxville Cemetery. The following section is exposed:

Section of Omen and upper Arp members, 0.8 mile southwest of Knoxville Cemetery, northeastern Cherokee County.

	Thickness *Feet*
(d) As (c) but containing hard, thin-slabby sandstone lenses	20.0
(c) Coherent, cross-bedded sands lacking hard sandstones but enclosing shale pebbles	3.0
(b) Coherent, dirty rust-yellow to yellow-orange, cross-bedded, muscovitic, porous, slightly argillaceous sand containing very few and very thin shale pebbles and stringers	8.6
(a) Soft, chocolate-brown, carbonaceous shale and sands alternating, not cross-bedded. Many of the sand layers terminate abruptly. Bottom not exposed	7.0

Presumably all cross-bedded sands, even if they do not possess indurated slabby portions, that is, (b) to (d) inclusive, should be united in the Omen member, and the level-bedded shale and sand sequence, that is (a) of the section given above, should be included with the Arp member. However, for reasons discussed below, the base of the Omen member is arbitrarily selected at the base of (d) of this section.

Thickness.—In most places the Omen member forms the top of the Queen City outliers and is obviously eroded to some extent. Such places cannot be used to give

a complete thickness of the Omen member, except where it is likely that very little of the top of the Omen member has been removed. Such thicknesses have been used but are noted as minimal. Wendlandt and Knebel (1929, p. 1355) indicated 10 to 15 feet as the thickness of the Omen. This figure appears too small in comparison with the data listed below, which show a thickness of slightly over 20 feet.

The following is a tabulation of the thickness of the Omen member in the Henrys Chapel quadrangle, measured by hand level, listed going from north to south (fig. 47).

(1) Hilltop, 560+ feet above sea level, forming the southern end of the Queen City outlier at the north end of the quadrangle, located between the old and the new Troup—Henderson road (Farm Road 13), 3,350 feet south of the north boundary of Cherokee County.....7.7+ feet

(2) Hilltop, 500+ feet above sea level, on which the abandoned Bell schoolhouse stands, 400 feet southeast of Bell Church.....13.0+ feet

(3) Hill slope, 1,200 feet southwest of Bell Church .....22.0 feet

(4) Hilltop, 520+ feet above sea level, on county road connecting Bell Church with Griffin, 0.85 mile south-southwest of Bell Church (compare section described above).....20.0 feet

(5) Hilltop, 520+ feet above sea level, northeast of county road connecting Bell Church with Griffin, at the ascent from a left tributary branch of Caney Creek, 1.3 miles south-southeast of Bell Church by road, or 1.2 miles airline distance south-southwest of Knoxville Cemetery..10.0+ feet

(6) Hilltop, 540+ feet above sea level, 0.1 mile south of the Homer Lacey country store on county road connecting Bell Church with Griffin 17.0 feet

(7) Hilltop, 520+ feet above sea level, 1,400 feet east of crossroads in Griffin.....22.0+ feet

Paleontology.—A few imprints of a coarse-grained kind of wood, up to 1.5 inches wide and 4 inches long, were found on the smaller one of the two Omen outliers north of Farm Road 13. No other larger fossils of any kind have been found in the Omen member, although the beds are somewhat glauconitic. Foraminifera are visible in thin sections.

Arp-Omen contact.—The section described above under "Composition" gives a fair idea of the contact between these two members of the Queen City formation. Judging from the kind of bedding developed and from the sporadic content of glauconite in the Omen member, the logical place to choose the boundary between the two members is the base of the cross-bedded, shale-pebble-bearing, glauconitic sands, that is, the base of (b) of that section. However, road cuts showing this boundary are rare, and on the hill slopes away from the roads the only boundary that can be seen and used for mapping is the one between rubble-filled soil above and sandy, nearly rubble-free soil below; this soil change coincides also with a break in topographic slope on the hill sides. Comparison of this mappable boundary with sections in road cuts shows that it falls at the base of the indurated, slabby, ferruginous sandstones, that is, at the base of (d) of the section given above. On that basis the Omen member has been mapped in the quadrangle and the thickness data have been given above. If one were to use the other boundary one would have to add from 6.0 to 11.6 feet, representing the cross-bedded, shale-pebble-bearing sands without ferruginous indurations; two such enlarged thicknesses of the Omen member would be 23 feet at location 6 and 31.6 feet at location 4 (for location descriptions, see under "Thickness"). The ferruginous sandstone ledges described as occurring at the top of the Arp member immediately below the Omen slabs then may have to be included with the Omen member.

Facies.—When one maps the base of the Omen member with the aid of the criteria discussed in the preceding paragraph one finds the Omen member built up of fairly distinct individual lenses that lie at slightly different stratigraphic levels. Standing on the base of the Omen member at one hill spur one can readily see that the base on the next hill is either higher or lower, and that impression can be verified with the use of a hand level. The Omen is not a continuously horizontal-bedded unit but rather a series of lenses, one lying above the other, and stretched out horizontally in about the same stratigraphic level. The base of this series of lenses goes up or down an interval of about 20 feet depending on the local pinching out of the individual lens that happens to form the base at any one particular place. Lenses are in some instances fairly distinct one from

the other and then can be separated in the field with a fair degree of success. Usually one such individual lens forms one small hill cap or one small hill spur. Larger hills or hill spurs are composed of compound stacks of lenses. Their size is, of course, variable; southwest of Bell Church the following approximate sizes of individual lenses were obtained: 560 by 400, 470 by 200, 450 by 250, 350 by 150, and 300 by 120 feet, horizontal dimensions. An interesting feature of these lenses is that their longer horizontal axes are hardly ever parallel to each other. A hill spur composed of several lenses lying at slightly different levels has the axes of these lenses pointing in different directions, in some cases even at right angles one to the other. The lenses are resistant to erosion and determine the course which rainwash erosion has to take on these hill spurs. The result of these conditions is that hill spurs erode to form winding and twisting ridges, and the winding and twisting are controlled by the particular positions in which the longer axes of the individual lenses are arranged (fig. 51). If one of these hill spurs ends with a lens that happens to lie at right angles to its neighbor lens, the hill spur ends abruptly with nearly straight cross slope as if cut across. Such hill spurs have roughly the outline of a "T." Where the Omen hill caps are very large, they are composed of so many lenses that their individual influences cancel out; hence in such very large Omen hills these peculiar shapes do not show up well. The hill spurs of the Omen outlier near Bell Church are good examples of the features described here.

Although the Omen is glauconitic it does not contain any larger fossils. One would expect to find some rolled mollusk shells in it because there are many clay-shale pebbles and cross-bedding in the beds below the Omen ferruginous sandstone slabs. But none have been found. The lack of rolled shells seems to preclude the possibility that the Omen member is a beach deposit, although its cross-bedding and lenticularity fit a beach sand. It seems unavoidable to conclude that the reason the Omen does not contain any shell fragments or rolled shells is that none were available for incorporation into the sediment at the time of its origin. This conclusion would exclude the Omen from having been deposited in truly marine waters and suggests that it was deposited in a brackish environment where no animals lived that grew thick enough shells to be rolled into pebbles. A brackish-water origin of the Omen member also fits better with the nature of the beds above and below it, which are transitional to the Omen and in the main nonmarine. The writer believes the Omen is the filling of anastomosing tidal channels in a deltaic or lagoonal mass of sediments. The water in the channels may have been sufficiently salty to allow accumulation of some glauconite or chamosite grains, and currents may have been strong enough to produce cross-bedding and clay-shale pebbles.

UNNAMED UPPER SAND MEMBER

The portion of the Queen City formation that lies stratigraphically above the Omen member has not yet received a name, because in the Henrys Chapel quadrangle only very small parts of this upper member are preserved. Therefore a name and type locality chosen from the quadrangle would not be representative. A good place outside of the quadrangle to name the member has not yet come to the writer's attention.

Distribution.—The upper member of the Queen City formation is preserved in the Henrys Chapel quadrangle in only two places. Both places are high hilltops on the large central outlier of the Queen City formation in the west-central part of the map. The larger of two places is located from 1,100 to 2,700 feet southwest of Bell Church; the smaller of the two is from 700 to 1,450 feet north of the Homer Lacey country store and about 1.6 miles airline distance southeast of Bell Church. The sizes of the two outcrops are about 1,800 by 1,000 feet and 800 by 300 feet.

Topography.—Both outcrop areas are hilltops sitting above the Omen member. The larger outcrop area is an evenly rounded fairly steep hilltop but less steep than the slopes below occupied by the Omen member. The smaller outcrop area

is a low rise above the steep slopes of the Omen member. No creek valleys reach up to these outcrops of the upper member, and only along a field road over the larger one are there gullies developed. The two places are between 520 and 540 feet in elevation; the larger area is probably a little higher than the smaller one.

Soils and vegetation.—The larger outcrop area has a loose, light gray, humus-poor sand soil, zone A, that contains countless slabs of hard, black-maroon, ferruginous sandstones. In some places, notably on the east side, the sand soil has washed down somewhat and is very deep. The area was originally wooded but the northern half is cleared and under cultivation; the southern half was cleared at one time but now has a second growth of timber. The smaller of the two outcrop areas is a fairly thin, loose, whitish-gray sand soil cover on the Omen member. It was cleared at one time but is now pasture and brush land and has a little second growth of timber.

Composition.—There are no exposures of the upper member of the Queen City formation. Hence composition can be surmised only from the soils developed on its outcrops and from exposures of the same member elsewhere. Presumably it consists of soft, brown, carbonaceous sandy shales and sands. Some of the latter are probably indurated to hard, black-maroon, ferruginous sandstones as is indicated by the fragments found abundantly in the soil of the larger outcrop area.

Thickness.—A complete thickness of the upper member cannot be given for the area of the quadrangle because only small parts of the member are preserved. The larger of the two outcrop areas has a vertical thickness of 34 feet, the smaller is represented merely by a thin sand soil layer, probably up to 5 feet thick.

Paleontology.—A definite statement concerning fossils cannot be made because of the lack of exposures, but the ferruginous sandstone slabs in the soil were found to contain no fossils.

Omen—upper member contact.—The contact is nowhere clearly exposed in the quadrangle, hence the nature of the contact remains unknown; it is presumed to be transitional and conformable. The boundary between the two was mapped on the basis of soils and the change in slope character. The slopes of the upper member are gentler and the soil is much sandier and freer of sandstone rubble than those of the Omen member.

Upland Gravels

Distribution.—Gravels are scattered on some small parts of the uplands underlain by the Carrizo formation at elevations around 420 feet. Such gravel patches are about 100 to 300 feet in diameter and have been found in the places listed below, listed in order from west to east. They are located over a distance of less than a mile, from 0.6 to 1.25 miles, southeast and east of Concord.

(1) On low hill in a field, about 300 feet south of the east-west county road that goes eastward and southeastward from Concord and 1,900 feet east of Farm Road 856, or 2,700 feet east-southeast of the church at Concord in airline distance. Elevation is around 410 feet; the scattered gravel consists of ironstone and quartz pebbles; the former are derived from the Newby member which forms a small outlier about 500 feet south-southeast of the gravel patch.

(2) On low hill in a field, about 800 feet northeast from the nearest point on the curving county road that runs eastward and southeastward from Concord and 2,300 feet south of the county road that runs eastward from Martins Chapel, or 3,300 feet southeast of Martins Chapel. Elevation is around 420 feet; the patch is about 100 by 175 feet in size and consists of conglomerate composed of ironstone and quartz pebbles.

(3) On broad hilltop in a field, about 900 feet northeast of location 2 and 3,250 feet east-southeast of Martins Chapel. Elevation is a little above 420 feet; the patch is 250 by 300 feet in size and consists of ferruginous conglomerate and sandstone containing a few small quartz pebbles.

Topography.—The gravel or conglomerate patches are usually on broad hilltops rising slightly above the general level of the surrounding upland, into which they merge with barely perceptible slope. Usually the gravel is scattered in the grayish-white sand soil of these hilltops.

Composition.—Most pebbles are composed of dark brown-black sandstones derived from the weathering of the indurated Carrizo sandstone or the Newby glauco-

nitic sandstones, which crop out near by in outliers and in the Newby cuesta to the west. The sandstone pebbles usually have a glistening metallic-looking dark surface skin and are lighter in color on the inside. Some of the larger blocks are hard, rusty red-brown, ferruginous conglomerates composed of mostly less than 5 mm, but up to 120 mm, large, poorly sorted, subangular ferruginous sandstones. The smaller components of the conglomerates are well rounded. These conglomerate blocks are remnants of a terrace conglomerate.

Thickness.—Most of the deposits are mere scatterings of gravel. The deposit at location 3 may be 1 or 2 feet thick but is not clearly enough exposed to permit accurate measurement.

Origin.—The gravels are remnants of terrace deposits that were at one time more extensive but have been largely removed or scattered by erosion. The material composing the gravels is chiefly local, derived from the Carrizo sandstone or the Newby member, but the rare quartz pebbles must have come from some distant area.

Age.—The age of these gravel remnants cannot be determined exactly in the area investigated beyond that they are post-Eocene. By inference from similar deposits elsewhere they are considered as early Pleistocene in age.

Lower Terrace Deposits

Distribution, topography, and composition.—Terrace deposits are very widely distributed along the creek valleys of the quadrangle but most of them are small and not distinctly set off from the soils and mantle that clothe the valley slopes. Hence only those terraces are considered here that stand out sufficiently either by forming an extensive flat surface or by having distinct gravel or conglomerate layers showing. All these terraces are confined to specific valleys of creeks or their branches, hence were made by local short creeks. Therein they differ from the upland gravels that are not confined to specific valleys and may have been deposited by a major stream formerly in existence here.

The larger areas of the lower terrace deposits that were mapped all have a characteristic position in that they form the narrow upland spur which sits in the acute angle formed by the valleys of two confluent creeks.

The largest of these terraces mapped is the long southeastward-pointing upland spur between Campground Creek and its large, nearly 3 miles-long, left tributary branch which drains from Concord and Martin Chapel toward the southeast. The spur is 1.7 miles long and only 0.35 mile wide at its widest place; its connection with the upland to the northwest is a narrow neck of flat upland only 0.14 mile wide and about half a mile long; the southeast end of the spur terminates bluntly and is about 1,000 feet wide. The top of the upland spur is a flat surface sloping from about 380 to 360 feet altitude in the neck portion of the spur; the remainder is nearly without slope and between 340 to 360 feet in elevation with the highest point at 362 feet in the center, that is, 42 feet above the creeks on either side. Exposures of the strata composing the terrace are few; a dry waterfall on a gully, 400 feet long, draining in the neck portion of the spur from the wagon road southward to the west end of a rounded meander scar cove, the bottom of which is swampy, exposes 8 feet of terrace deposits; where the Pure Oil—Liberty pipe-line descends the north slope of the spur into the swampy bottom of the left tributary to Campground Creek, ferruginous gravel has been dug up along the pipe; a dry waterfall in the right fork of the 1,800-foot long gully which drains southeastward across the end of the spur exposes a ferruginous conglomerate bench lying on terrace deposits. The top of the hill spur is covered by sand soil forming in some places a very well-preserved pimple-mound topography, which shows on the aerial photograph in those places only that have been plowed. However, the best developed pimple-mound topography was seen in the loosely wooded part where the neck portion widens into the main part of the hill spur. The pimple mounds are from 75 to 150 feet in diameter and up to 2 feet high.

At the confluence of Hampton and Grissom Creeks, southeast of Henrys Chapel, is an upland spur which begins at the foot of the prominent Newby cuesta and extends for 2,300 feet southeastward to wedge out in the form of a narrow curved hill of about 250 feet width at the confluence of the two creeks. Most of this upland spur has a gently southeastward-sloping flat surface covered with sand soil and sloping at a rate of 44 feet per mile from 378 feet to 363 feet elevation. At the south side of the upland spur is a meander-scar cove about 130 feet wide and 150 feet long, located 1,250 feet south of Farm Road 13 and 1,700 feet east of Farm Road 856. The floor of the cove is covered with flood-plain alluvium and material that was washed from the encircling bluff and is nearly on the same level as the flood plain of Hampton Creek near by, which is at 340.1 feet elevation; the encircling bluff of the cove shows 7 feet of cross-bedded Carrizo sand up to an elevation of 350.2 feet; above the Carrizo sand, gravels and a ferruginous conglomerate bench form the base of a terrace deposit of about 13 to 18 feet thickness (fig. 53). This terrace deposit composes most of the upland spur with the exception of the curving sand hill at its southeast end and occupies a triangular area 1,600 feet wide and 1,700 feet long. On the aerial photograph the soil pattern appears mottled showing lighter colored low pimple mounds of rounded outline separated by a network of darker soil; both soils are sandy and can be distinguished on the ground. The curving sand hill at the southeast end of the terrace, 250 feet wide, has a gently convex surface and deep loose grayish-white sand soil and is therefore regarded as composed of Carrizo sand under soil cover.

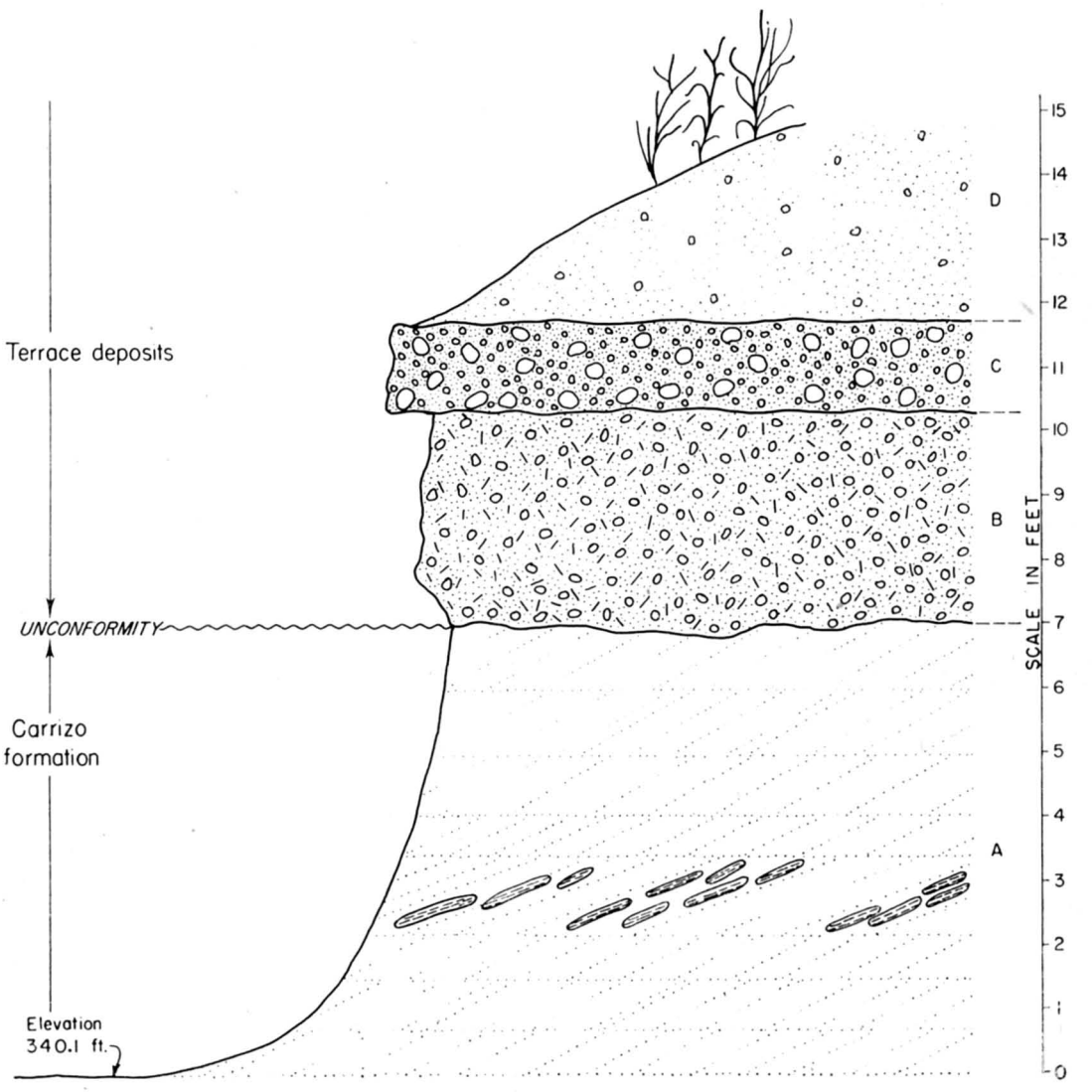


Fig. 53. Profile of exposure in the meander-scar cove, 1,250 feet south of Farm Road 13 and 1,700 feet east of Farm Road 856, on north margin of flood plain of Hampton Creek.

Section of terrace deposit on hill spur between Hampton and Grissom Creeks, in meander-scar cove, 1,250 feet south of Farm Road 13 and 1,700 feet east of Farm Road 856 (Henrys Chapel to Concord), northeastern Cherokee County, figure 53.

	Thickness *Feet*
(d) Slightly coherent, light brownish-gray, unstratified sand soil containing few pebbles, vertical distance to top of terrace flat	13.0
(c) Hard, black on outside, rusty black-brown on fresh break, crudely bedded, poorly sorted, ferruginous conglomerate composed of subangular boulders up to 5 inches in size but chiefly ¼ inch in size, consisting of weathered ferruginous sandstone	1.4
(b) Friable, light dirty orange to brown, crudely bedded, clayey sand with gravel, up to 25 mm in size	3.3
Unconformity, elevation 350.2 feet	
(a) Carrizo sand: Coherent, flesh-colored to light rusty brown, cross-bedded, porous, well-sorted, medium-grained sand with shale pebbles up to 7 by 13 inches in cross section, bottom not exposed	7.0
Flood-plain level of Hampton Creek, elevation 340.1 feet	

Section of terrace deposit on hill spur between Hampton and Grissom Creeks, in abandoned road cut, 600 feet south of Farm Road 13 and 3,300 feet southeast of Henrys Chapel Church, northeastern Cherokee County, figure 54.

	Thickness *Feet*
(d) Slightly coherent, light gray, unstratified, slightly clayey, fine-grained sand soil	1.4
(c) Friable, dirty grayish-yellow, unstratified, clayey silt; basal 0.5 foot replete with nodules or pebbles of 6 mm size composed of hard, red-brown, pitted, ferruginous siltstones	2.7
(b) Similar to (a) but breaks into larger blocks and is more grayish; has prismatic cracks toward the top	3.8
(a) Soft and tough, grayish chocolate-brown with deep orange-red mottles, blocky, unstratified, silty clay (weathered upper Carrizo formation?)	2.6

A very small terrace remnant composed of hard, rusty brown, ferruginous conglomerate forms a triangular area, 90 by 150 feet in size, and is situated on the south side of Campground Creek 3,650 feet west of Farm Road 856 and 4,000 feet southwest of the church at Concord.

Another small terrace remnant composed of the same material forms a rounded conical hill, about 70 feet in diameter, on the north side of a right tributary of Mill Creek, 200 feet west of the north-south county road and 1.33 miles airline distance north-northwest of the church at Concord.

A very low terrace covered with sand soil and 1,000 by 1,700 feet in size is present on the north side of Mill Creek in the corner between the Pure Oil—Liberty and Gulf Refining Company pipe-lines near the center of the east margin of the map. Its altitude is between 320 and 340 feet, and it is about 10 to 20 feet above the level of the creek bottom.

Age.—The first four terrace remnants described above are all in about the same elevation (28 to 42 feet) above the bot-

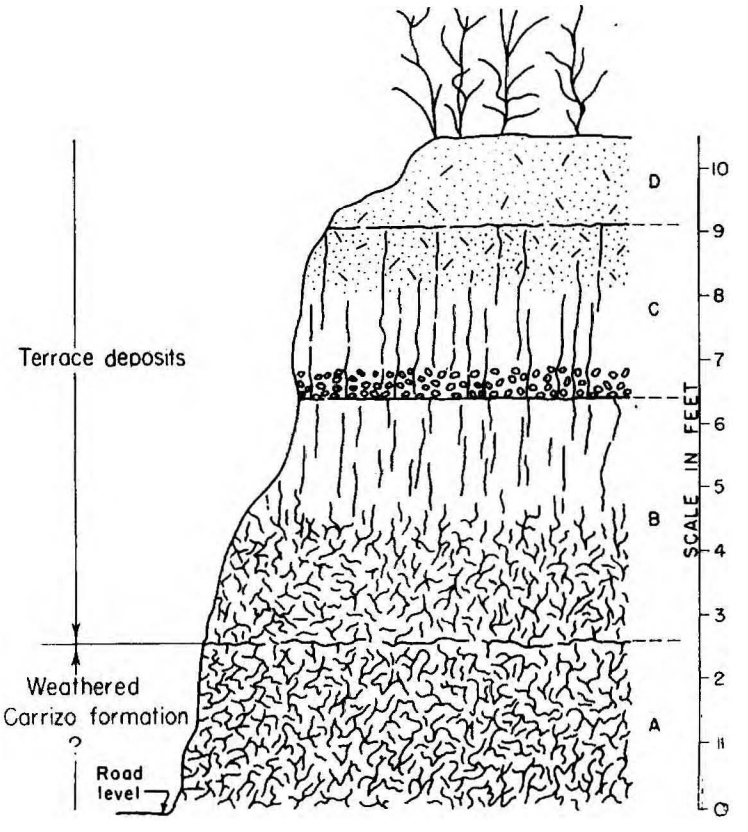


Fig. 54. Profile of terrace exposure in abandoned roadcut, on hill spur between Hampton and Grissom Creeks, 600 feet south of Farm Road 13 and 3,300 feet southeast of Henrys Chapel Church.

toms of the adjoining valleys. Hence they are probably remnants of the same nearly contemporaneous terrace system. The last-mentioned terrace is lower and probably younger. Their age cannot be determined in the area of the quadrangle except that they are younger than the upland gravels. Comparison with similar terraces found elsewhere indicates a Pleistocene age.

Alluvium

Distribution.—All creeks and their branches have a strip of alluvial deposits alongside their channels occupying a width commensurate with the size of the stream. Minor alluvial deposits along small creek branches have not been mapped, but all major deposits are shown on Plate I. Most of them were entered on the map by Mr. A. L. Lyth, Jr., through stereoscopic study of aerial photographs covering the area. The larger creeks have alluvial bottoms 0.1 to 0.2 mile wide. The largest alluvial bottoms are found at confluences of creeks and their branches, for instance, at the confluence of Hampton Creek with its right tributary at the clay pits near Henrys Chapel, at the confluence of Hampton and Grissom Creeks, and at the confluence of Campground Creek with its left tributary at the head of Willis Ditch.

The creeks and branches draining eastward from the cuesta formed by the Newby member of the Reklaw formation have better-developed alluvial bottoms than those in the western half of the quadrangle. The cause of this condition has been explained in the paragraph on "Topography" of the Newby member.

Topography.—The alluvial bottoms are composed of several elements, such as alluvial fans, natural levees, and swamp deposits, each of which has its own topographic expression.

Alluvial fans are very common as everywhere in the Texas Coastal Plain. Nearly all smaller streams entering the flood plains of large creeks develop alluvial fans of low gradient at their point of entry. Some of these alluvial fans have received recent additions and are growing fairly rapidly; such growing fans develop where plowing has furnished loose materials for removal by rainwash and are found at the end of small creek branches draining areas in that condition. Alluvial fans are so common that it seemed superfluous to map them separately; only a few particularly well-developed fans are shown, for instance, on the Bridge Creek flood plain west of Griffin. Large alluvial fans are developed at the east side of the Newby outcrop in the central part of the map where many creek branches originate and drain eastward from the Newby cuesta. Many large alluvial flats at the east foot of the cuesta are coalescent alluvial fans of fairly steep gradients. Some of the sand brought down by the creeks there and deposited on the alluvial fans is derived from the deep loose sand soil clothing the Arp outliers.

Narrow natural levees composed of sand are common on all meandering creeks even if their channels are deeply incised. Abandoned meanders and abandoned meandering channel parts are common.

Composition.—Most alluvial deposits in the bottoms of the creeks consist of gray to black, sandy clay or argillaceous sands. Gravels chiefly composed of ironstone or ferruginous sandstone fragments are less common. Their prevailing dark color is due to admixture of decaying vegetation and iron sulfide. Some of the finer grained clayey materials in particular are rich in iron sulfide and emit a characteristic odor. Sorting is usually very poor; so is bedding.

Some of the creek bottoms are exceedingly poorly drained and are swamps with interspersed small lakes. In such areas vegetal deposits, that is, peat, are forming. The course of Beaver Run in the quadrangle is one continuous swamp. Large parts of the bottoms of Mill Creek and Campground Creek and their tributaries are swamps, particularly the lower reaches.

GEOMORPHOLOGY

The presence of upland gravels at an approximate elevation of 420 feet above sea level indicates that the much higher hills composing the Queen City outliers, which reach elevations between 560 and 580 feet, were already in existence when the upland gravels were deposited by a stream. This means that the major divide which is composed of these Queen City outliers was already in existence, but it may have shifted slightly westward since that time because the heads of the present creeks draining from the divide to the east have steeper gradients and are more active than the heads of those draining to the west. Also at the time the upland gravels were deposited the Queen City outliers may have been larger, hence at least in part not yet so well separated into isolated groups.

The upland gravels lie at approximately the same elevation as the Newby cuesta but no gravel patches have been found on top of the Newby cuesta, although every foot of that cuesta has been mapped by walking. Hence it seems highly probable that the Newby cuesta was faintly higher than the land east of it on which the gravels were deposited.

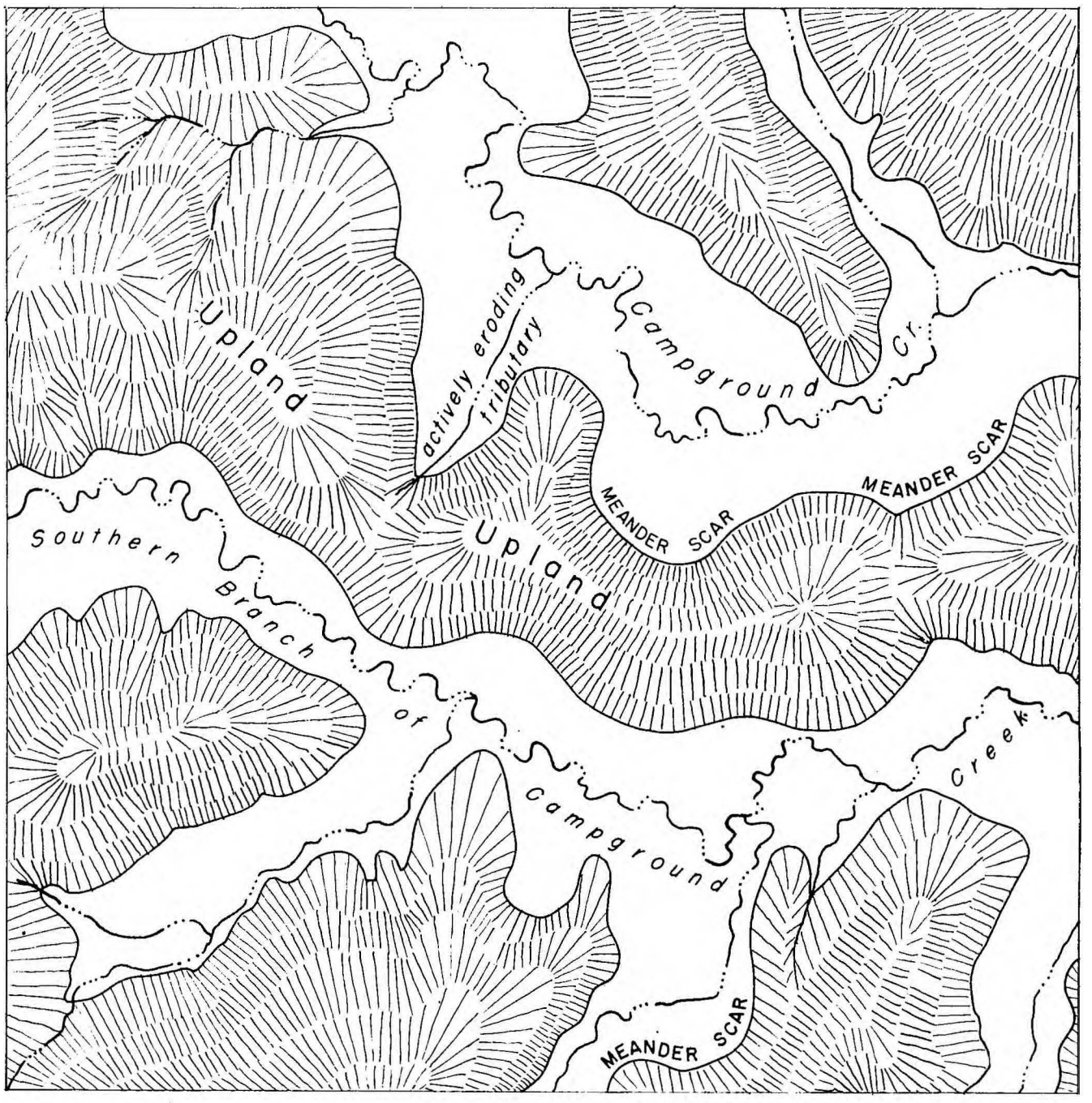
If the upland gravels were deposited by a stream, and the size and rounding of the rare quartz pebbles speak for that assumption, all the creek valleys of the eastern half must have been excavated since the time the gravels were laid down and by inference the western creek valleys too. As can be seen on the geologic map the eastern creek valleys and their headwaters branches originate for the most part at the Newby cuesta. Hence the features of that cuesta as they appear today were largely made by the erosion that also produced these creek branches. As these creek branches are quite young, that is, younger than the upland gravels, most of the features of the Newby cuesta are quite young also. In fact the Newby cuesta is a compound of young and old portions, of portions younger and portions older than the upland gravels. The old portions are those parts of the cuesta which have the upland in front of them and are very gently sloping and highly inconspicuous; the new portions are those parts which have creeks and their alluvial flats in front of them and are fairly steep and impressive.

The creeks draining east from the main divide of the quadrangle are young in geologic age but have nevertheless reached the stage of aggrading and have filled their valleys with alluvial flats extensive for the size of the streams. Shortly before the land was disturbed by agriculture and road building all the major creeks draining eastward had practically ceased to transport much sediment over their flood plains. So well were the slopes leading down to these creeks protected from rainwash erosion by dense vegetation, forest litter, and deep porous sandy podsol soils that very little material was washed down onto the flood plains or carried down by tributaries. Hence the surface of the flood plains of these creeks gradually accumulated decaying vegetation. Beavers had large colonies here and built many dams. Thereby drainage became more and more disarranged so that swamps interspersed with small lakes formed over these flood plains covering them from one side to the other, and peat deposits accumulated. In contrast with the eastern creeks the western creeks never became so stagnant as to become continuous swamps, and aggrading of their flood plains with overflow sediment rather than with vegetal debris continued until recent times.

Aggrading in the creek valley bottoms has produced some interesting local features, such as lakes and isolated hills. An example of both features is in the bottom of a right tributary to Campground Creek on the south side of the creek channel, 1.6 miles due south of Martin Chapel. The lake there is 850 feet long and 200 feet wide and is kept from draining by the natural levees of the creek. The isolated hill in the creek bottom, 250 by 430 feet in size, is 200 feet west of the southwest end of the lake. The hill was originally the north point of the upland spur to the south of it and has been isolated from the spur by the aggrading of the creek which deposited sediments on its valley floor until these sediments had risen high enough to fill in the low saddle between the hill and the upland spur.

A similar hill entirely surrounded by alluvial flats is in the valley of Grissom Creek 2,500 to 4,500 feet northeast of the church at Henrys Chapel at the abandoned Henrys Chapel schoolhouse. At the north this broad hill is separated from a southward-reaching upland spur by a narrow strip of alluvium, only 80 feet wide, that cross-connects the flood plains of two branches of Grissom Creek. The cross-connection is too narrow ever to have served as a streamway for either of the two branches and has been produced by aggrading of the flood plain of the eastern one of the two branches. Before the road was built there, floods on the eastern branch may have occasionally spilled westward through the cross-connection into the western branch, which flows at a lower level.

A similar cross-connection is at present in the making in the valley of Grissom Creek at a place exactly 1 mile a little east of due north from the church at Henrys Chapel. There a neck of upland, 50 feet wide, about 100 feet long, and only 5 feet high above the alluvial flat, is all that separates the flood plains of two major branches of Grissom Creek; the east side of the neck is being cut into by a meander of one of the branches; on the



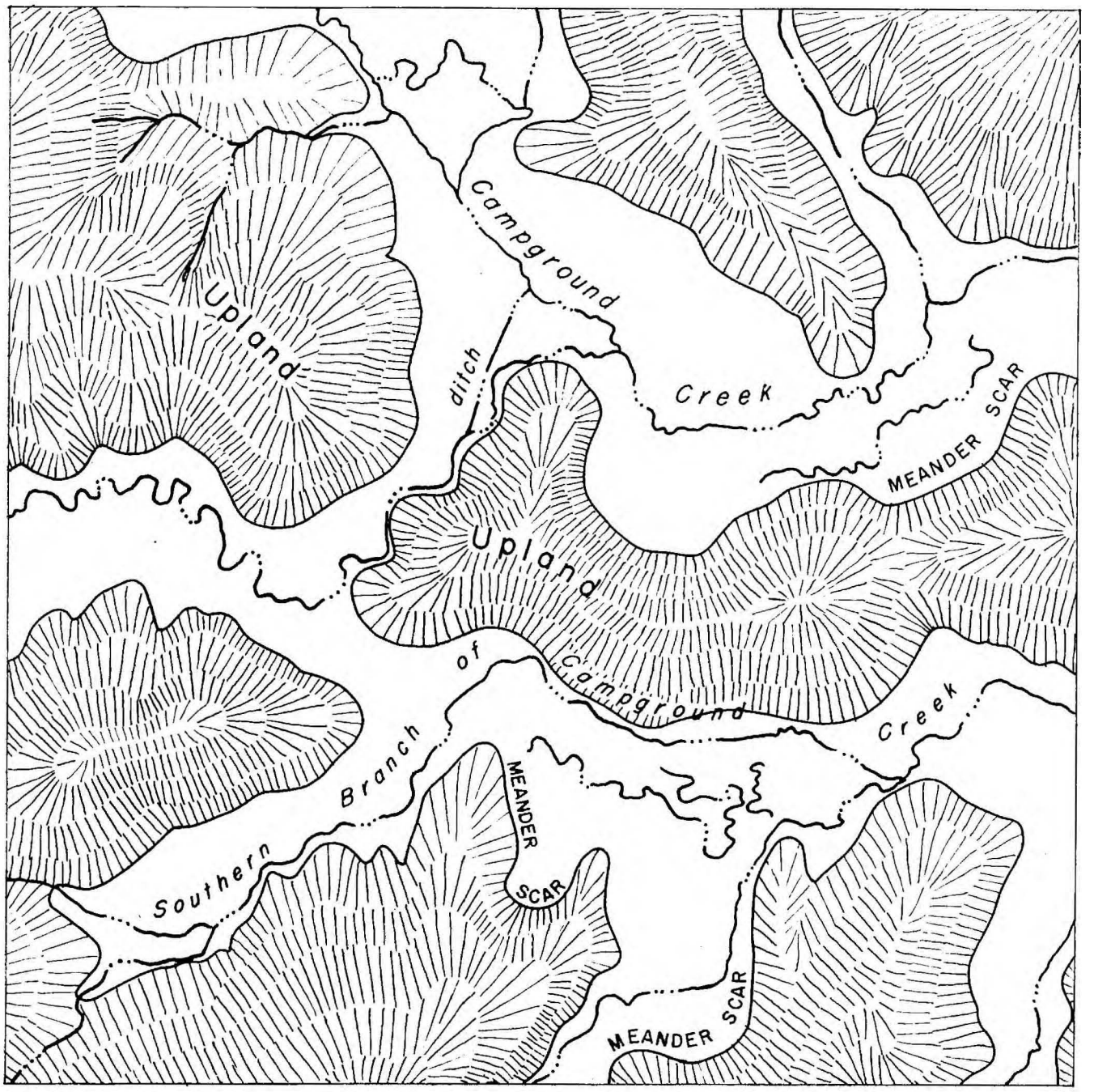
A

Fig. 55. Stream capture among the branches of Campground Creek. A, before capture. B, after capture.

southwest side of the neck is a small lake surrounded by swamp.

A low isolated upland hill surrounded by alluvium is located in the western headwaters branch of Grissom Creek about 0.4 mile south of the Cherokee—Smith County line. The upland hill is Carrizo, Newby, and Marquez, and at its northwestern tip is a remnant of terrace gravel and conglomerate. The alluvium on the west side of this hill is the old abandoned flood plain of this headwaters branch somewhat modified by small alluvial fans descending from the slopes at the west. The alluvium on the east side of this hill is the present flood plain of this headwaters branch and contains the present channel of the stream. The upland hill is the result of a shift in the position of the channel of this headwaters branch probably caused by local stream piracy.

An alluvial cross-connection of different origin is found 5,700 feet south of the crossroads in Concord and 1,400 feet west of Farm Road 856. Here two right tributary valleys to Campground Creek are connected by alluvium 300 feet wide; the cross-connection isolates a strip of upland stretching for 1.25 miles to the east and 0.43 mile wide at its widest place. The cross-connection is an abandoned creek valley. The head of the northern creek branch used to flow through this connection into the southern branch but was captured by headward erosion originating from Campground Creek, which flows at a lower level than its southern tributary. (See fig. 55, A and B.)



B

STRUCTURAL GEOLOGY

Regional Setting

The Gulf of Mexico basin, in which the Henrys Chapel quadrangle lies, is a very extensive structural and depositional province bordering the continent on the south, composed of ordinarily soft or only slightly indurated stratified rocks of Cretaceous and Cenozoic age that are only slightly disturbed from the original attitudes they achieved at the time they were deposited (fig. 56). The Coastal Plain is the surface of that portion of the Gulf of Mexico basin which is emerged from the sea. It has low topographic relief and slight elevation above sea level. Beneath the Coastal Plain the strata usually dip coastward and at a very low rate of dip, in most regions amounting to less than 1 degree. Hence the older of the strata composing the Gulf of Mexico basin, that is, the Cretaceous strata, ordinarily occupy the outer or inland fringe of the Coastal Plain and disappear coastward under the younger or Cenozoic strata. The various strata form long and narrow outcrop ribbons that are usually parallel to the coast line and in most places form topographic scarps or cuestas with a steeper slope inlandward and a gentler slope coastward.

Natural subdivisions of the emerged portion of the Gulf of Mexico basin are twofold. There are those that are approximately parallel and others that are approximately at right angles to the present coast line. Among the latter are the three embayments. The Rio Grande embayment in south Texas is separated by the San Marcos arch from the East Texas embayment, which occupies most of eastern Texas and includes the quadrangle. The Sabine uplift, which centers on the Sabine River at the Texas-Louisiana boundary, separates the East Texas embayment from the much larger Mississippi embayment, the axis of which lies approximately along the Mississippi River.

Among the boundaries of the subdivisions that are parallel to the present shore line, the one that is of significance here is the boundary between the outer, or inland, and the inner, or shoreward, part of the emerged portion of the Gulf of Mexico basin. Where this boundary crosses the East Texas embayment it is made apparent and even conspicuous by a belt of nearly parallel small faults of post-Eocene age extending from the vicinity of Mt. Enterprise in southeastern Rusk County in a nearly true western direction to the vicinity of Jacksonville in northern Cherokee County and then in a southwestern direction through Elkhart in southern Anderson County to the vicinity of Buffalo and Centerville in Leon County. The belt is made up of about nine major faults and many more minor ones; some of the faults enclose downdropped blocks or grabens; others are isolated faults. The fault belt separates the inland part or head of the East Texas embayment from the shoreward part. The head is called the Tyler basin from the town of Tyler in Smith County, which lies very nearly at the exact structural center of the basin. Hence the Tyler basin is bounded in the west and north by the inland or outer margin of the Gulf of Mexico basin, in the east by the west flank of the Sabine uplift, and in the south by the fault belt, which forms the threshold of the basin, so-to-say, and over this threshold the East Texas embayment extends into the Tyler basin.

The Tyler basin is a syncline that is open in the south, at its threshold, and the strata engaged in the basin-forming at the west, north, and east of the basin dip toward the center, which is occupied by the youngest Cenozoic rocks of the sequence of strata engaged in the basin-forming. The Henrys Chapel quadrangle is part of the basin but lies at its eastern margin not far north of the threshold fault belt. The nearest fault goes through the village of Summerfield, 11 miles south of Troup, and strikes approximately N. 74° E. Owing to the location of the quadrangle at the east margin of the basin, the strata of the quadrangle strike nearly north-south, to be exact, N. 12° W. to S. 12° E., and dip westward (S. 78° W.). Taken over a large distance and averaged, the rate of dip is only 5¼ feet per mile, that is, approximately 1 foot vertically per 1,000 feet horizontally; however, the attitude of the strata is not uniform but changes slightly from place to place so that the rate of dip given above is not directly applicable in many places.

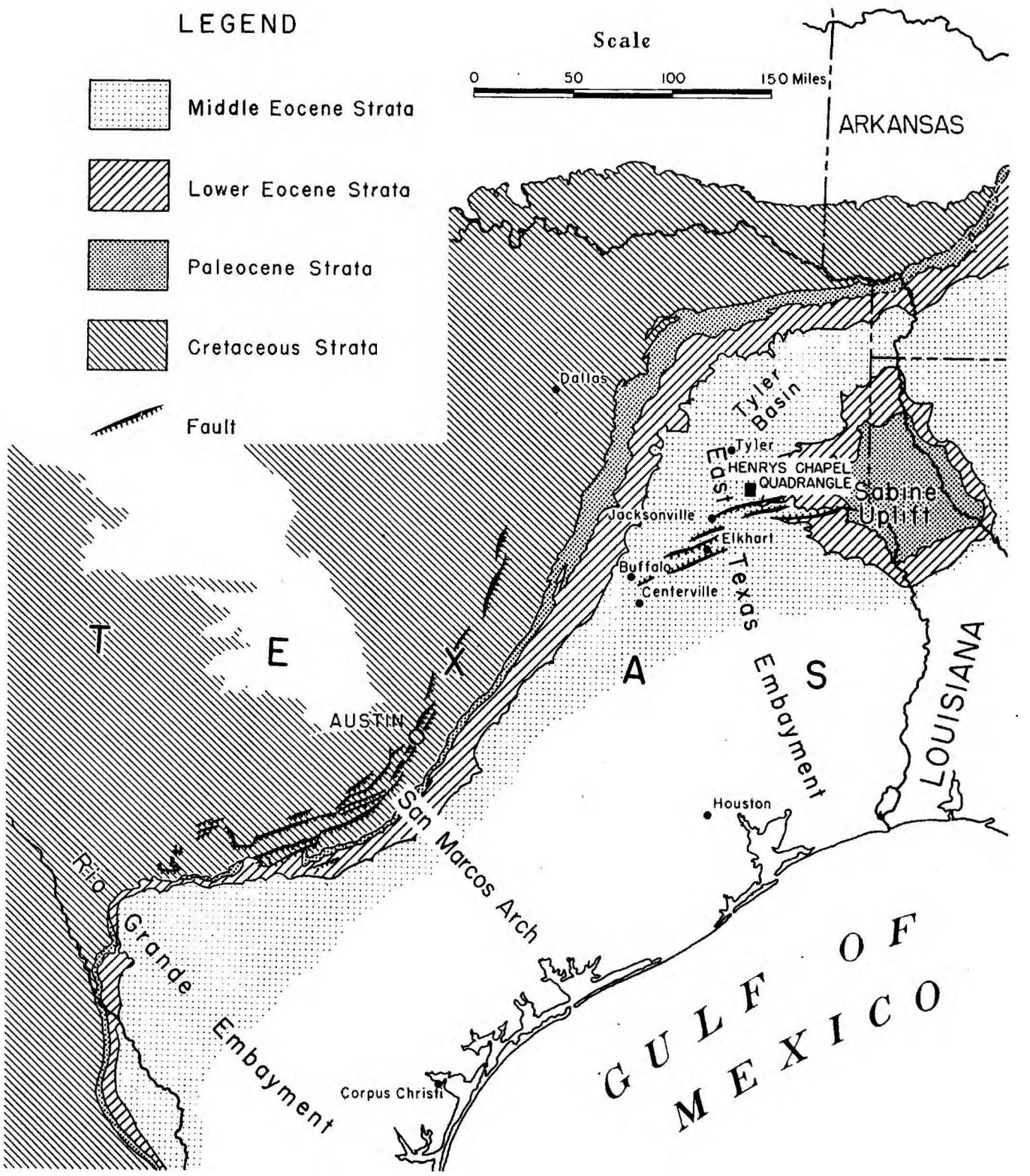


Fig. 56. Regional geological setting of the Tyler basin and Sabine uplift in the Gulf of Mexico basin. The Henrys Chapel quadrangle is indicated by the black quadrangle.

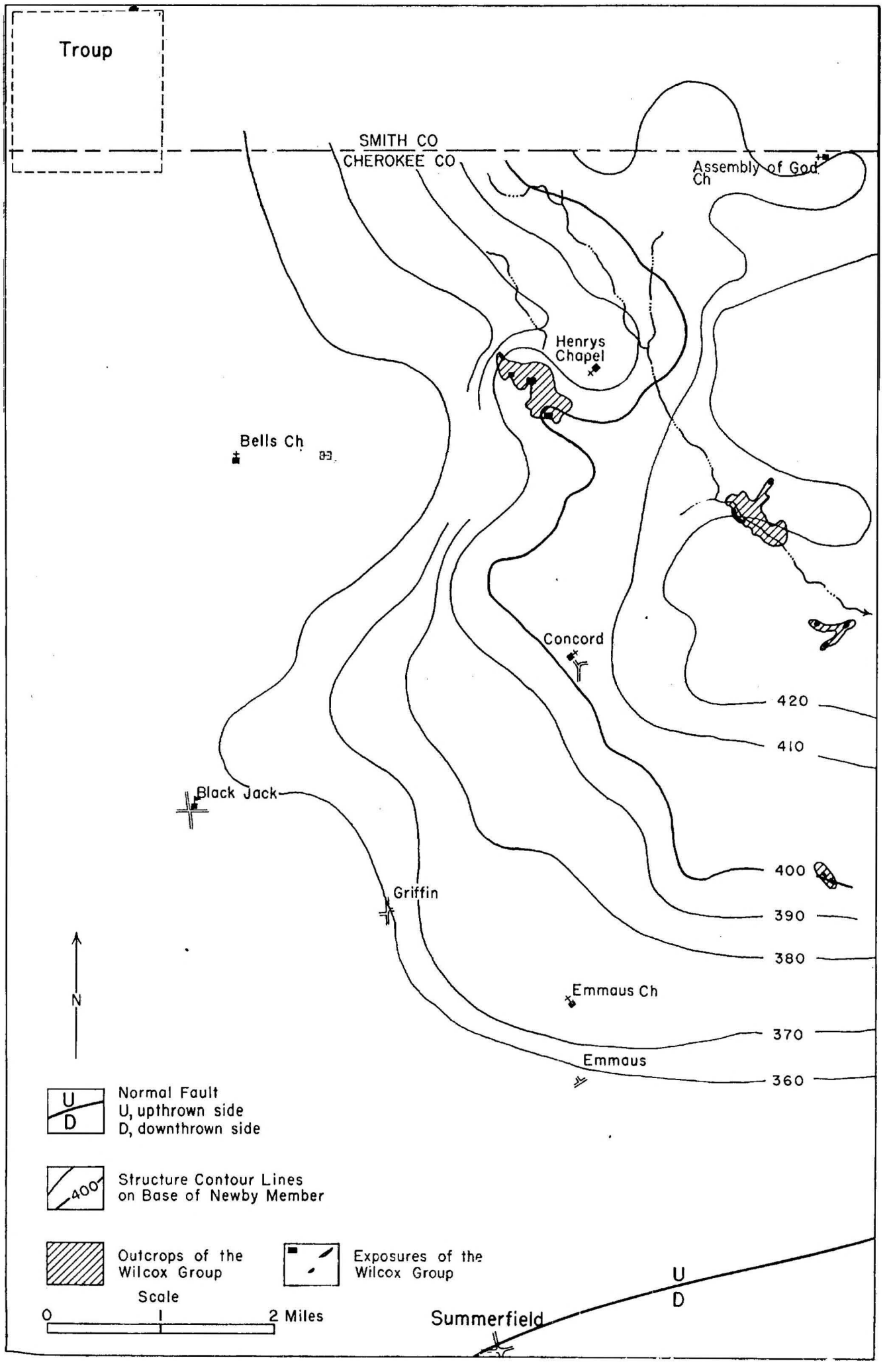


Fig. 57. Structure contour map of the vicinity of the Henrys Chapel quadrangle.

How many local deviations from the normal strike and dip there are in this quadrangle can be seen from the structure contour lines drawn on the base of the Newby member of the Reklaw formation, although the structure contour lines on this map are greatly simplified (fig. 57). One readily noticeable regional structural feature is the gradual change in strike and dip in the southern part of the quadrangle. As the threshold fault near Summerfield is approached, the strike turns from its normal north-south direction to a northwest-southeast direction and finally turns into a direction parallel to that fault, that is, nearly west-east, and the dip becomes southward. Simultaneously the rate of dip increases so that in the southern part the strata dip southward and toward the threshold fault at an increased rate.

Because of the general westward dip of the strata over much of the area and the southward dip in the southern part, the strata come to lie at greater and greater depth in these two directions, and the older strata, for instance, the upper beds of the Wilcox group and the Carrizo formation, crop out in the district only in the eastern portion and disappear rapidly under the surface of the ground in westward and southward direction.

A well-defined irregularity is shown by the structure contour lines in the vicinity of the clay pits southwest of Henrys Chapel. The area of the clay pits, indicated by hatchures on figure 57, is slightly anticlinal. This anticlinal attitude is probably caused by the settling of the strata over and around the buried Wilcox hill which has been demonstrated to exist there.

Another structural disturbance is indicated in the vicinity of Chinkapin Lake. A test well, the American Petroleum Company of Texas Childress No. 1, dry and abandoned, was drilled here in 1950.

Of major importance to the stratigraphic and structural history of the region is the threshold of the Tyler basin, which is made conspicuous and underlined, so-to-say, by the fault belt extending from Mt. Enterprise in the east to Centerville in the west. At this threshold many of the formations exposed in the Tyler basin undergo rapid changes in facies. The upper part of the Wilcox group is insufficiently exposed in the quadrangle to show any changes, but it does change from nonmarine to marine on the south flank of the Sabine uplift at the eastern continuation of the threshold (Murray and Thomas, 1945). The Carrizo formation begins to show brackish-water glauconitic fossiliferous beds at its top as one approaches the threshold from the north. The Newby formation has a probably brackish facies in the Tyler basin, a distinctly different facies at the threshold, and is fully marine south of the belt. The Marquez member is less silty and has more components of marine origin south of the threshold than north of it. Some changes are indicated in the Queen City formation, although these are not yet fully explored. The changes in the Eocene formations coincide partly exactly, partly roughly, with the fault belt. The cumulative sum of all these changes is in fact the threshold as it appears today, and the post-Eocene faulting is merely one of the later events that helped to shape the threshold.

The discussion of geologic resources given below concerns only those resources that are available at the surface or at shallow depth. The deeper lying resources, natural gas and petroleum, have been disregarded because the report as a whole treats only the surface strata of the area.

At the present time ball clay and road metal are of major importance and are exploited in the region.

Ball Clay

The ball-clay deposit has been described in detail in a separate report (Stenzel, 1950; Pence, 1950); hence only points of major interest are repeated here.

Under fire clay the industry understands a clay that can be used for the making of refractory firebrick, which is brick able to withstand high temperatures without spalling, melting, and slagging. Such clay is shaped and burned into various shapes, for instance, standard brick and sundry wedge, arch, skew, key, jamb, bung-arch, and neck shapes and saggers and muffles, and used by various industries, public utilities, and railway locomotives. Such clays must be free or nearly free of ingredients that might lower the melting point, for instance, compounds of iron, alkalis, and lime. Ball clay is a plastic sedimentary fire clay that burns white or nearly so.

In the Henrys Chapel quadrangle, ball clay is present in the vicinity of Henrys Chapel where it is exploited in three pits. The useful part of the clay is 10 to 20.1 feet thick and is the top part of the Wilcox group. The overburden is composed of soil, subsoil, mantle, and the Carrizo formation. The thickness of the overburden is variable according to the position of the clay pits, but about 30 feet is to be expected in most locations.

Description of Clay Pits

Thermo Fire Brick Company

The Thermo Fire Brick Company pit is located 430 feet south of the county road and southwest of Hampton Creek (Pl. I). The pit is 750 feet long and 150 feet wide. The lowest place in the main part of the pit has an elevation of 365.2 feet and is in the middle of the clay. The section exposed in the south wall of the pit consists of 12 feet of soil, subsoil, and Carrizo formation and 10 feet of ball clay. Because part of the pit has been inactive for some time the ball clay there has been exposed to the weather and is bleached to a grayish-white structureless mass of clay with many desiccation cracks and water rills. At the base of the Carrizo sand a great deal of water seeps out from the groundwater perched on the impervious ball clay. Even during October 1947, after a dry summer and fall, the lower part of the overburden was saturated with water and was seeping constantly.

Elevations of the top of the ball clay from west to east are: 375.6, 375.4, 375.1, 374.3 feet, all at the south side of the western part, and 375.2 feet at the south wall of the main part.

Overburden at the south wall of the pit consists of about 12 feet of soil, subsoil, and Carrizo shaly sand. Unfortunately dump heaps have been placed on top of this overburden along the south wall. About 150 feet from the east end of the pit the overburden consists of orange-red, stratified, rubbly gravel, sand, and clay, which is slope wash from the hill to the south. The material has cut out a small part of the top of the ball clay and cuts deeper to the east. The pit is operated intermittently.

General Refractories Company

The General Refractories Company pit is 700 feet north of the county road and southwest of Hampton Creek (Pl. I). The pit is 300 feet long and 390 feet wide (October 1947) in east-west direction. The lowest place in the pit is 345.3 feet above sea level and is in the northwest corner. The section exposed in the south wall where the overburden is thickest is composed of (January 11, 1948) 5 feet of soil, 7 feet of subsoil, 15 feet of Carrizo sand, and 10 feet of ball clay. The lower part of the Carrizo sand is moist at all times and seeps a small amount of ground water that is perched in the Carrizo sand above the impervious ball clay.

Elevations at the top of the ball clay are: 359.7 feet in northwest corner, 359.9 feet in southwest corner, 363.2 feet in

southeast corner, and 365.1 feet in northeast corner of pit.

Overburden is about 27 feet thick (January 11, 1948) and will increase gradually as the pit is extended southward into the hill spur. As in the Thermo Fire Brick Company pit, the overburden is loose enough to be removed by bulldozer or drag line. However, at the top of the south face a 2.1-foot thick, very hard and harsh, black-maroon to rusty dark brown, ferruginous sandstone ledge was uncovered in the upper Carrizo sand in October 1948. This ledge had to be blasted. The proportion of overburden to ball clay is roughly 3 to 1, that is, for every cubic yard of ball clay about 3 cubic yards of overburden are removed. The pit is well located on a comparatively low, long, northward-reaching hill spur. Dumps are placed to the north, east, and west of the pit and will not have to be moved again. The pit is worked continuously except during prolonged wet weather in the winter when clay is drawn from a stock pile on the hill spur between pit and county road.

The clay is trucked to Troup, a distance of about 6.5 miles, of which 0.9 mile is over improved county road, a dirt road, and the remainder over the asphalt road of Farm Road 13. The company operates a modern kiln and plant at the north side of Troup on a railroad spur connecting with the Missouri-Pacific system.

RELIANCE BRICK COMPANY

The pit operated by the Reliance Brick Company was opened in 1949. It is 700 to 1,000 feet west of the pit of the General Refractories Company. The pit is about 300 feet long in east-west direction and about 100 feet wide. It is the deepest of the three pits and utilizes the entire 20.1 feet of the Henrys Chapel ball clay and even 2 feet of the underlying very silty clay at the bottom of the pit. The overburden is as in the General Refractories Company pit.

The clay is trucked to Lindale, where the plant and kiln of the company are located; the distance is about 40 miles. The company uses the clay as 25 percent of the mix.

Placing Sand

Placing sand is used in packing the saggers and between the shapes in a kiln to keep the ware apart during the firing of refractories, whiteware, tile, and brick. Silica sand of high purity is required for placing sand used in the firing of whiteware and refractories.

So far none of the sands occurring in the Henrys Chapel quadrangle have been used as placing sands, but tests of a Carrizo sand sample indicate that it well qualifies. The sample was obtained from the Carrizo sand exposed under the terrace deposits in the deep cut of U. S. highway No. 84 (Rusk—Mt. Enterprise road) just east of the flood plain of Mud Creek, 0.3 mile west of the underpass in Reklaw village, northeastern Cherokee County. As the lower part of the Carrizo sand extends essentially unchanged northward from Reklaw village into the quadrangle it is possible to find similar sand there too.

Road Metal

The region of the Henrys Chapel quadrangle is devoid of stream gravels that can be used as road metal but is rich in other materials that can be used instead and are used extensively. Materials that can be used consist of natural mixtures of ironstones with soils in which they occur. The ironstones are either clay-ironstones derived from the weathering of sideritic layers or ferruginous sandstones derived from the weathering of glauconitic sands or nonglauconitic sands. Certain formations of favorable composition give rise to such rubble-filled soils which can be scooped up by drag line or other mechanical equipment. Formations or members of formations useful in this respect are:

(1) Omen member of the Queen City formation
(2) Ferruginous sandstones in the upper part of the Arp member of the Queen City formation
(3) Clay-ironstone beds of the Marquez member of the Reklaw formation
(4) Newby member of the Reklaw formation
(5) Ferruginous sandstones of the upper part of the Carrizo formation

In view of their importance as a local source of road metal, special attention has been given to their occurrence, and all have been mapped in detail except the ironstones of the Marquez member, which would have required much more time than was available. Special symbols are used on the map (Pl. I) to denote the occur-

rences of ferruginous sandstone rubble or blocks of the Arp, the Newby, and the Carrizo, and all abandoned or active road-metal pits have been accurately outlined.

A glance at the map suffices to show that several of the road-metal-producing members are widely distributed and are available in many places where they have not yet been touched. There are evidently enough road-metal deposits in the quadrangle available in many readily accessible locations to last for many years.

The Omen member is widely distributed in the western half of the quadrangle but is concentrated in the west-central part 0.65 mile airline distance southeast of Bell Church and to the east of that place. The parts of the Arp member that can be used are present in small areas only; the best area is the eastward-pointing hill spur and the isolated conical hill to the north of the hill spur, 1.4 miles airline distance west-southwest of the church at Concord. The clay-ironstones of the Marquez member are widely distributed in the western half of the quadrangle; they are more extensively used about 1.1 miles airline distance north of the crossroads in Griffin and on the hill spur 0.6 mile airline distance northeast of Concord. The Newby member can be used in many places along its outcrop, which goes roughly from north to south through the quadrangle and has many outliers to the east; it is better developed in the south, and the largest use is made of it at the hilltop south of Boggy Branch in the southeast part of the map. The ferruginous sandstones of the upper part of the Carrizo formation form local deposits scattered in the eastern half of the quadrangle; the largest deposit is in use and is the road-metal pit 450 to 700 feet north of Farm Road 13, near the east margin of the map.

Each of the members that furnish road metal has its own features and characteristics, and the road metal they furnish differs in character according to the member from which it is derived, but the character of the road metal derived from one member stays remarkably uniform over the area investigated. The geologic map should be helpful in recognizing the character of deposits in advance of exploitation and can be used to find places where road-metal pits can be opened.

Sand

Immense deposits of loose, grayish-white, humus-poor sand soils occur in the quadrangle. They can be used as common sand for many purposes. Formations producing such soils are the lower part of the Carrizo and the sandy portions of the Arp member. Other formations may locally produce such sand soil of sufficient depth.

Loose to friable, reddish, clayey sand soils are common and can be used for purposes where some coherence of the sand is essential, for instance, as fill for embankments and small dams. Such soils are common in the Arp member of the southwestern and west-central parts of the quadrangle and on the upper part of the Carrizo member in the eastern half of the quadrangle. Elsewhere the Marquez can furnish such sand soils.

Stone

Stone sufficiently hard and coherent to serve as crushed stone or rough trimmed building stone is rare in the quadrangle. Some of the larger blocks of ferruginous sandstone derived from the weathering of the Newby member have been used for this purpose but are comparatively weak. The best material is the ferruginous sandstone ledges, up to 5 feet thick, that are found locally near the top of the Arp member. The ledges are composed of hard, harsh, somewhat brittle, rust-brown, to black-maroon, thick-bedded ferruginous sandstone. Deposits of this rock have been found in at least seven places in a strip 1,500 feet wide but 2 miles long in a northwest-southeast direction located in the triangle formed by Bell Church, Concord, and Griffin. Exact locations of deposits located are given on page 87.

Lignite

The lignites so far found in the area have no commercial value because they are either too thin, too impure, or of too small horizontal extent. Whether better lignite deposits occur underground is not known, because no accurately sampled core holes have been drilled. The lignite from locality 11, described on page 18 (fig. 7), may have special value on account of its fossil resin content.

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INDEX

aerial photographs: 7, 79, 102, 104
age, terrace remnants: 103
A. J. Wait survey: 12
Alexander Gin: 40, 68
alignment of outliers: 84
alluvial fans: 104
alluvium: 104
altitudes: 7
American Petroleum Company of Texas Childress No. 1 well: 111
amphibole: 87
Anderson, T. M.: 5
Anderson County: 72, 108
Angelina River: 7, 8, 38, 40, 60, 75, 84
angular unconformity: 74
annelid, boring: 76
Architectonica: 75
Arp: 83, 96
  member: 83–95
    ferruginous sandstones in: 113
    —Marquez boundary: 91, 94
    —Omen contact: 98
    sand in: 114
    section of: 97
A zone, soil, Arp member: 84, 95
  Omen member: 95

ball clay: 15, 17, 18, 30, 31, 112
  Henrys Chapel: 14
Barbatia: 75
barrier: 78
Bastrop County: 34, 79
bear grass: 85
Beaver Run: 20, 104
bedding: 97
  Arp member: 85, 86
  contorted: 23, 24
  ripple-mark: 23
Bell Church: 8, 83, 87, 88, 95, 97, 98, 99, 114
Belosepia: 75, 82, 90
bench marks: 7
benzidine: 86
biotite: 25
birds-eye structure: 38
Black Jack Church: 94
  schoolhouse: 38, 85, 88, 91
Boggy Branch: 19, 35, 38, 40, 46, 76
bogs: 13
boring annelid: 76
boring sponge: 76
borrow pit: 60
boulders: 31
Bowles Creek: 8, 83
Bowles, Edgar: 72
box-stone: 81
Bridge Creek: 8, 19, 20, 26, 27, 28, 29, 30, 35, 36, 37, 38, 44, 76, 80, 81, 104
bryozoans: 82
Buffalo: 108
  dome: 95
Buford Branch: 40, 71
buried hill: 32
  cross section through: 33
burrows: 23, 25, 38, 55, 56, 74, 75, 81
Butler salt dome: 72
B zone, Omen soil: 95

Callianassa: 38
Campground Creek: 8, 12, 19, 25, 35, 40, 48, 50, 83, 87, 101, 103, 104
  stream capture on: 106, 107
Carlisle: 28, 68
Carrizo formation: 19–34, 100
  contorted layer in, thickness and stratigraphic position of: 24
  ferruginous sandstones: 113
  —Newby contact: 72–75
Cass County: 83
Centerville: 108, 111
cephalopod: 75, 82
Chama: 75
chamosite: 27, 86
Cherokee County, thickness data: 39–40
chert: 87
Childress No. 1 well, American Petroleum Company of Texas: 111
Chinkapin Lake: 13, 28, 111
Claiborne group: 19–100
clay-ironstones: 78, 79, 81, 82, 88, 90
  concretions: 27, 34, 75, 86
  layers: 37
  Marquez member: 113
    microscopic description of: 81
clay pebbles: 25
clay pellets: 86
clay pits, description of: 112–113
clay-shale pebbles: 99
claystone, microscopic description of: 25
columnar section: 10
Concord: 8, 12, 19, 25, 35, 48, 50, 87, 100, 101, 103, 114
concretions: 27, 52, 80, 81
  clay-ironstone: 34, 75, 86
conglomerate, ferruginous: 75
contact, Arp-Omen: 98
  Carrizo-Newby: 72–75
  Newby-Marquez: 82–83
  Omen—upper member: 100
  Reklaw-Arp: 88, 90
  Wilcox-Carrizo: 30–32
contorted bedding: 23, 24, 81, 86
contorted layer of Carrizo formation, thickness and stratigraphic position of: 24
copiapite: 80
Corbula: 28, 29, 45, 60, 62, 71, 75
core holes: 95
corn meal-like specks, Omen member: 96
cross-bedded glauconitic lenses: 72
  sands: 32
cross-bedding: 21, 78, 85
cross section, facies of Arp member: 93
  through buried hill: 33
crumpled beds: 86
cuesta: 35, 36
Cushing: 40, 52, 56, 58, 75
Cyclichnina: 75
Cypraea: 75

Daniel Parker survey: 12
Darton, N. H.: 8
detailed sections: 40–72
Deussen, Alexander: 7, 34
Dickson, Mrs. Kathryn O'Neill: 5, 19, 25, 27, 81, 86, 87, 97
Dikes survey: 12, 27
Dill Creek: 40, 52, 55, 58
dip slope: 8
disconformity: 32, 34, 56, 72, 75
disrupted beds: 86
driftwood: 38
Dumble, E. T.: 7, 34
Durham, C. O., Jr.: 5

East Texas embayment: 108
  oil field: 7
echinoids: 82
Ectinochilus: 75
elevations: 30
Ellisor, A. C.: 7
Emmaus: 6, 38, 39, 42
  Cemetery: 39, 46
  Church: 12, 35, 88
epidote: 86
exposures of ferruginous sandstone, Arp member: 87

facies, Arp member: 91, 92, 93
  Carrizo formation: 32
  Newby member: 75–78
  Omen member: 98–99
fault, threshold: 111
faults: 78
feldspar: 87
Feray, Dan E., Jr.: 5
ferruginous conglomerate: 75
ferruginous sandstones: 25, 35, 72
  Arp member: 87, 113
    exposures of: 87
  Carrizo formation: 113
  Queen City formation, microscopic description of: 87
fire clay: 112
fishes, teleost, vertebrae of: 75
F. J. Vallanova survey: 12
fossils: 78
  invertebrate and vertebrate: 75
Fountain, H. C.: 5, 82
Freestone County: 72
funnel-shaped pits: 32

Gardner, Julia: 72
gastropods: 75, 82
General Land Office: 7
General Refractories Company: 11, 15, 17, 19, 23, 25, 27, 28, 30, 31, 32
  description of clay pit: 112
geomorphology: 105–107
geophysical shot holes: 32, 41
glauconite: 27, 28, 30, 37, 38, 52, 75, 78, 81, 82, 86, 90, 96
glauconitic facies: 34
glauconitic part of Carrizo formation: 27–28
Glenfawn: 40, 71
Glyptorhynchus: 75
Goldsberry School: 28, 40, 68, 72
gravels, upland: 100–101
Gregg County: 95
Griffin: 8, 19, 26, 27, 32, 35, 40, 44, 76, 81, 83, 87, 88, 104, 114
Grissom Creek: 19, 22, 35, 37, 72, 82, 102, 103, 104, 106
ground water, perched: 13
Gulf of Mexico basin: 108
Gulf Refining Company pipe-line pump station: 29, 40, 66, 103

Halymenites: 55
Hamilton survey: 11
Hampton Creek: 11, 19, 22, 35, 82, 102, 103, 104, 112
Harris, G. D.: 34
Harrison County: 34, 72, 95
hematite: 25, 27
Henderson: 6, 19, 29, 35, 40, 50, 66, 70, 78, 88, 98
Henrys Chapel ball clay: 14
  microscopic description of: 19
hexacorals: 76
Hogpen Branch: 40, 52, 54, 55, 58
Homer Lacey country store: 83, 86, 90, 96, 98, 99

inface: 8
inliers: 19, 20, 27, 28, 35
iron-silicates: 27
iron-sulfide: 79
invertebrate fossils: 75

Jacksonville: 6, 29, 108
James Hamilton survey: 11
joint clay: 79
joints: 18, 25
Jones Creek: 40

koalin: 86
kaolinite: 96
Kennedy, William: 83
Knebel, G. M.: 7, 8, 34, 75, 78, 83, 94, 95, 96, 98
Knoxville: 84
  Cemetery: 84, 86, 87, 88, 97, 98
  Spring: 84

lagoon: 78
Lacey country store: 83, 86, 90, 96
leaf imprints: 86
Leon County: 72, 78, 90, 95, 108
lignite: 15, 17, 18, 19, 25, 38, 114
Limacina: 50, 82
limonite: 23, 25, 38, 87, 96
Lindale: 112
Longview: 70
Louisiana: 78, 79, 108
lower terrace deposits: 101—104
Lunulites: 60
Lunz, G. R., Jr.: 38
Lyth, A. L., Jr.: 5, 79, 104

magnetite: 86
Magnolia Crossing: 72
marcasite: 15, 16, 17, 23, 25, 80
Marquez: 78
  —Arp boundary: 91, 94
  member: 78–83, 91, 95
    clay-ironstone beds: 113
Marshall: 34, 72
Martin Chapel: 12, 28, 40, 50, 100, 101
microcline: 87
microscopic description—
  claystone in Carrizo formation: 25
  clay-ironstones of Marquez member: 81
  ferruginous sandstone: 25, 27
    in Queen City formation: 87
  Henrys Chapel ball clay: 19
  Omen member, sandstone in: 97
  siltstone in Arp member: 86
Mill Creek: 11, 12, 13, 28, 103, 104
Mississippi embayment: 108
Moody, C. L.: 8, 83, 94, 95
molluscan fossils, Carrizo formation: 28
mollusks: 52, 82
montmorillonite: 86
morass: 13
mounds: 79, 80, 102
Mount Selman formation: 7
Mt. Enterprise: 40, 60, 62, 75, 108, 111
Mud Creek: 8, 28, 39, 41, 74, 75, 83
mudstones, sideritic: 81
Murray, G. E.: 111
muscovite: 25, 38, 81, 86, 87
Myliobatis: 75

Nacogdoches: 52, 56, 58
  County: 34, 72, 75
    thickness data: 40
Natica: 28, 45, 75
National Geophysical Company: 28
natrojarosite: 80
natural gas: 112
Nemocardium: 75
Newby cuesta: 102, 105
Newby glauconitic sandstones: 101
Newby member: 34–78, 95, 100, 113
  detailed sections: 40–72
  —Marquez contact: 82–83
New Salem: 40, 71
New Summerfield: 6, 40, 44, 50, 66, 85, 88
northern facies: 78
Nuculana: 82

Oak Flat Cemetery: 52
  Church: 58
Odontaspis (Synodontaspis): 75
Omen: 95
  member: 89, 94, 95–99, 113
    —Arp contact: 98
    —upper member contact: 100
    section of: 97
  outlier: 87
  sandstone: 8
    microscopic description of: 97
orthoclase: 87
outlier: 34, 35, 79, 83, 84, 85, 94, 95
  Queen City: 105
oysters: 76

paleontology—
  Arp member: 88
  Carrizo formation: 28–30
  Marquez member: 82
  Newby member: 72
  Omen member: 98
  Wilcox group: 19
Parker survey: 12
pebbles: 31
pelecypods: 75, 82, 86
Pelseneer, Paul: 82
Pence, F. K.: 5, 8, 112
perched ground water: 13
Periploma: 75
petroleum: 112
pH—
  Arp member: 84, 85
  Carrizo soil: 20, 21
  Marquez member: 79, 80
  Newby member: 37
  Omen member: 96
pimple mounds: 80, 102
  structure: 79
pipe-line, Gulf Refining Company: 103
  Pure Oil—Liberty: 12, 101, 103
pipes: 25
placing sand: 113
planctonic animal: 82
planicosta, Venericardia: 29, 34, 46, 54, 64, 66, 72, 75, 78
Plicatula: 75
Plummer, F. B.: 8
podsol soil: 20, 35, 79, 84
Polydora: 76
Pratt survey: 27
previous geological work: 7
profile, soil: 20, 21, 37, 79, 84, 85, 96
  terrace exposure: 102, 103
pseudosinistral hyperstrophic coiling: 82
pteropod: 82
pump station, Gulf Pipe Line Company: 29, 66
Pure Oil—Liberty pipe-line: 12, 101, 103
Pycnodonte: 76
pyrite: 15, 16, 17, 23, 80
pyritohedra: 15

quartz: 25
Queen City: 83
  formation: 83–100
    section of: 90
  outliers: 105

Ray, S. W.: 7
ray teeth: 75
Red Oak Flat Church: 35
Reklaw: 5, 8, 28, 34, 40, 41, 62, 64, 74, 75
  formation: 5, 34, 94, 113
    —Arp contact: 88, 90
    section: 90
    type locality: 64
Reliance Brick Company: 13, 14, 15, 16, 17, 23
  description of clay pit: 112
Renick, B. C.: 7
resin: 18, 19, 114
Rio Grande embayment: 108
ripple-mark bedding: 23
road metal: 113–114
roots: 15, 17, 18, 19, 31
rubble: 95
ruptured bed: 86
Rusk: 39, 41, 60, 62, 75
  County: 72, 78, 95
    thickness data: 40
rutile: 25

Sabine uplift: 11, 108, 109, 111
salt dome, Butler: 72
Sampson Creek: 39, 42
sand: 114
  bed: 24
  member, unnamed, in Queen City formation: 99–100
Sanders Cemetery: 11
sandstone: 27, 38, 95
  Carrizo formation, microscopic description of: 25, 27
  ferruginous: 25, 35, 72
    Arp member: 87, 113
    Carrizo formation: 113
    Queen City formation, microscopic description of: 87
  ledge: 112
  Omen: 8
    microscopic description of: 97
  rock: 37
  rubble: 96
San Marcos arch: 108
Schizaster: 82
section—
  columnar: 10
  detailed: 40–72
  Omen and Arp members: 97
  Reklaw—Queen City: 90
  terrace deposit: 103
  Wilcox group: 18
seeps: 13
selenite: 80
shale pebbles: 85
  conglomerates: 22, 31
shark teeth: 75
shipworm: 75
  bore-holes: 38
shot holes, geophysical: 18, 27, 28, 32, 41
shrinkage crack: 31
siderite: 15, 37, 52, 81
  balls: 15
sideritic mudstones: 81
siltstone: 25
  in Arp member, microscopic description of: 86
sinistral coiling: 82
Sinum: 75
sliding, subaqueous: 24
slippage planes: 15, 16, 18
Smith County: 83, 95, 108
soil creep: 16
soil profile—
  Arp member: 84, 85
  Carrizo formation: 20, 21
  Marquez member: 79
  Newby member: 37
  Omen member: 96
soils—
  Arp member: 84—85
  Carrizo formation: 20
  Marquez member: 79
  Newby member: 35
  Omen member: 95
  pH of: 20, 21, 37, 79, 80, 84, 85, 97
  podsol: 20, 35, 79, 84
  unnamed sand member of Queen City formation: 99
spherulitic siderite: 15
Spiratella: 82, 85
sponge, boring: 76
springs: 13
Stephenson, L. W.: 75
stone: 87, 114
stratigraphic column: 14
stratigraphic position of contorted layer of Carrizo formation: 24
stream capture: 106, 107
Striker Creek: 8, 29, 40, 50, 66
String Prairie: 79
structural geology: 108, 111
structure contour map: 110
subaqueous sliding: 24
sulfuric acid:: 79
Summerfield: 35, 111
swamps: 13
swordfish rostrum: 75
Synodontaspis (Odontaspis): 75

T. A. Pratt survey: 27
teleost fishes, vertebrae of: 75
Teredo: 75
terrace deposits, lower: 101–104
  section of: 103
test well: 111
Thermo Fire Brick Company: 11, 15, 17, 25, 28, 32
  description of clay pit: 112
thickness data—
  Arp member: 88
  Carrizo formation: 27–28
  contorted layer of Carrizo formation: 24
  Newby member: 38–40
  Omen member: 97–98
Thomas, E. P. 111
threshold facies: 78
  fault: 111
topographic features, outline of: 8
  maps: 7
topography—
  alluvial bottoms: 104
  Arp member: 83–84
  Carrizo formation: 20
  Marquez member: 79
  Newby member: 35
  Omen member: 95
    unnamed sand member of Queen City formation: 99
tourmaline: 25, 81, 86, 87
Trawick: 40, 56, 58
Trinity River: 72
Troup: 5, 6, 40
  Works: 11
turneri. Turritella: 72, 78
Turritella: 29, 66, 75
  turneri: 72, 78
Tyler: 40, 70
  basin: 11, 78, 108, 109, 111
    facies: 78
type locality, Reklaw formation: 64

unconformity, angular: 74
Union Grove Church: 8
unnamed sand member, Queen City formation: 99–100
upland gravels: 100–101

Vallanova survey: 12
vegetation, Arp member: 84–85
  Carrizo formation: 20
  Marquez member: 79
  Omen member: 95
  Wilcox group: 12–13
Venericardia planicosta Lamarck: 29, 34, 46, 54, 64, 66, 72, 75, 78
  rock: 34, 72
vertebrate fossils: 75
Volutospina: 75

Wait survey: 12
Wendlandt, E. A.: 7, 8, 34, 75, 78, 83, 94, 95, 96, 98
Wesley Dikes survey: 12, 27
Wilcox-Carrizo contact: 30–32
Wilcox group: 11–19
  exposures, description of: 17–18
  paleontology: 19
  section of: 18
Willis Ditch: 104
wood imprints: 98
Woodville Church: 28

Xiphiidae: 75

zircon: 25, 81, 86, 87