University of Texas Bulletin
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W. M. WINTON AND GAYLE SCOTT

Bureau of Economic Geology and Technology
Division of Economic Geology
J. A. Udden, Director of the Bureau and Head of the Division


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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. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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## INTRODUCTION

Johnson County is rich in natural resources, many of which are as yet undeveloped. The purpose of this bulletin is to furnish to residents of the county and to others interested a constructive guide to the geology of the county, its influence on general development, and its possibilities for exploitation. As the Comanchean rocks of Johnson County illustrate many of the problems encountered in the other north Texas counties underlain by these rocks, this paper will furnish a brief summary of the economic geology of North Texas Comanchean-Cretaceous areas.

A second no less important object is to describe certain important transition phases in these rocks, notably the transition of the Goodland into the Edwards and Comanche Peak and the transition of certain Washita formations into the Georgetown formation.

## PHYSIOGRAPHY

Johnson County is near the center of the Grand Prairie physiographic province of Texas. The county is in the southeastern quarter of the quadrangle formed by the 32d and 33d parallels and the 97th and 98th meridians. The total area of the county is estimated at 744 square miles; the total population being about 54,000 of which 20,000 is concentrated in and around the city of Cleburne, the county seat and principal city. The official population within the city of Cleburne is 12,820.

Johnson County is bounded on the north by Parker and Tarrant counties, on the east by Ellis, on the south by Hill and Bosque, and on the west by Somervell and Hood. The county exhibits considerable topographic variety.

The varying surface features caused by the outcrop of gently dipping beds are clearly marked by soil, plant, and topographic peculiarities. Stratigraphically, the lower and older beds come to the surface in the western part of the county and progressing eastward the upper and younger beds outcrop.

The area of the county can be divided into four natural divisions or strips which cross the county from north to south. From east to west, these are as follows: 1. The Black Prairie; 2. The Eastern Cross Timbers; 3. The Grand Prairie; and 4. The Goodland Uplands.

1. *The Black Prairie* is a strip along the eastern part of the county having an average width of about eight miles. This level black land prairie is underlain by the clays and shales of the Eagleford formation. The strip is treeless, none too well drained, and the soil is the famous black land. The entire strip slopes gently to the eastward to the foot of the distant Austin Chalk escarpment, a topographic feature which can be seen from many points. Along its western border, the black land is very thin and excavations for cellars and shallow wells expose the red sandstone of the Woodbine formation. Along the divide and just within the Cross Timbers are a number of outliers of the black land. The positions of these are shown on the map which accompanies this bulletin.

2. *The Eastern Cross Timbers* comprises a broad strip which coincides with the outcrop of the Woodbine formation. The soil is reddish sand with some clay, and the surface is everywhere wooded with post oaks and black jack oaks. The country is rugged and sharply rolling and is much dissected by the streams. Just beyond the western border and in the next local topographic province are various outlying wooded peaks. These are familiar and characteristic features of the western border of the cross timber strip in North Texas, but are nowhere better exemplified than in Johnson County. Caddo Peak, northwest of Joshua, is one of the best known landmarks in this region and is visible from some places nearly thirty miles distant.

3. *The Grand Prairie.* Whoever first set foot upon the wide strip of open country to the west of the Cross Timbers and named it the Grand Prairie might well have gained his first view from one of the high points in central Johnson County. Nowhere else is there a finer exhibition of this broad gently rolling, grass covered, plain. The entire area

is underlain by the dip plains of the limestones of the Washita Division. The intervening marls form low escarpments connecting the successive uplands. Except for irregularities due to the drainage a perfect sequence of successive dip plains is formed, each dip plain ending at the foot of an escarpment. This "cuesta" type of topography comes nearer to the idealized condition in Johnson County than in most of the other North Texas counties. Strictly speaking, even here, the plains lie upon a succession of strata rather than on a single one in the case of each plain. The entire upland is well drained and forms some of the most productive agricultural land in the State. The soils are light brown in color and certain differences exist depending on the underlying formation. This is indicated by the variation in the wild flowers certain ones of which are definitely limited to the outcrop of certain formations.

4. *The Goodland Uplands.* About half of this strip is underlain by the hard upper cap (Edwards) of the Goodland formation and the other about equally by the softer lower part (Comanche Peak) of the Goodland and by the shell conglomerate cap of the Walnut formation. This dissected upland is marked by great numbers of juniper-cedars. To the eastward the strip merges imperceptibly with the Grand Prairie and to the west it ends abruptly in a high escarpment known locally as "the mountain." Outliers exist in the form of characteristic knobs such as Berry Knob, Barnard Knob and other lesser ones. Despite their similarity in shape and general appearance these knobs are fundamentally different from the outliers of the Woodbine, such as Caddo Peak and Brushy Knob.

Besides the four main local provinces listed above, the valley of the Brazos River might possibly be considered separately. In the two places where this valley is included within the boundaries of Johnson County (see map) it is extremely narrow and the Johnson County side of the floodplain is often not present at all as the river working against end faces of the dipping strata forms high escarpments which come to the water's edge.

*Drainage.* Johnson County is mainly upon the divide between the Trinity and Brazos drainage systems. Although the county as a whole is much nearer to the Brazos River, its drainage owing to the dip of the beds and the resulting effect on erosion is about equally divided between the Trinity and the Brazos. A line along the crest of the divide enters the county at the northwest corner, passes just north of Godley, through Joshua, thence out of the county to the southeast about half way between Riovista and Grandview. Much of the divide is in the Cross Timbers strip. The county is divided into three drainage divisions, as follows: *a.* the Trinity drainage area; *b.* the Noland's River drainage area (the Noland's River is a large tributary of the Brazos but in the county its drainage can be considered separately), *c.* the area of the Brazos laterals.

*a.* The Trinity drainage area includes the following creeks and their tributaries, all of which drain directly or indirectly into the Trinity River: Chambers, Cottonwood, Mountain, Valley, Quillmiller, and the northern of the two Mustang creeks. All of the Black Prairie, and the northern parts of the Cross Timbers and the Grand Prairie strips are drained by this system.

*b.* The Noland's River drainage is by far the most important in the county. Rising from two branches near Godley and one near Joshua, this stream runs south and passes out of the county just west of Riovista. Together with its tributaries it drains the entire western part of the Cross Timbers strip and the southern three-quarters of the Grand Prairie. For practically its entire length, the Noland's River lies just west of and directly at the base of a low escarpment composed of the upper Washita formations and capped by the resistant Mainstreet limestone. Its eastern tributaries expose the Mainstreet limestone in low bluffs, notable examples being within the city of Cleburne. In the southern part of the county, the flood plain of the Noland's River is wide, this being the only alluvial deposits of enough areal extent worthy of being shown on the geological map.

*c.* The Brazos laterals are narrow torrential streams largely affected by weather conditions. These drain the southwestern part of the county and a small area in the west where the Brazos River bends sharply within the boundaries of the county.

# GEOLOGY

## GENERAL STATEMENTS

The surface rocks of Johnson County, with the exception of the gravels and other alluvial deposits, are all of a single geological age, the Cretaceous. The western two-thirds of the county is underlain by rocks of Lower Cretaceous or Comanchean time and the eastern third by rocks of Upper Cretaceous time. All of these dip in a general easterly direction with certain minor variations as are shown on the structural map on page —.

In the following table the formations are listed in order, the oldest formation being placed at the bottom of the table. In the second column is given the probable equivalence of the terms used as applied to the Central Texas section, as given in Bulletin 44 of the Bureau of Economic Geology:

**Table of Geologic Formations in Johnson County**

| Johnson County Section | Central Texas Section |
|---|---|
| Cenozoic and Recent | Cenozoic and Recent |
| Upper Cretaceous | |
| Eagleford | Eagleford |
| Lower Cretaceous | |
| Woodbine | Buda ? |
| Grayson | Del Rio |
| Main Street, Pawpaw, Weno, Denton, Fort Worth, Duck Creek, Kiamitia | Georgetown |
| Goodland | Edwards, Comanche Peak |
| Walnut | Walnut |
| Paluxy | Paluxy |
| Glenrose | Glenrose |
| Trinity | Trinity |
| Pennsylvanian | |

The Brazos River which forms the southwestern boundary of Johnson County is a line along which many important changes take place in the Comanchean rocks. In a broad sense this may be considered as the boundary between the North Texas phase and the Central Texas phase of the Comanchean; but as will be detailed in the forthcoming discussion these changes are rather gradual, the actual physical gap caused by the Brazos erosion being the principal reason why this is considered as the boundary. North of the Brazos certain stratigraphic and paleontologic facts are clear and conditions near the Brazos are not conspicuously different from those further north. South of the Brazos an entirely new set of conditions appears, and to

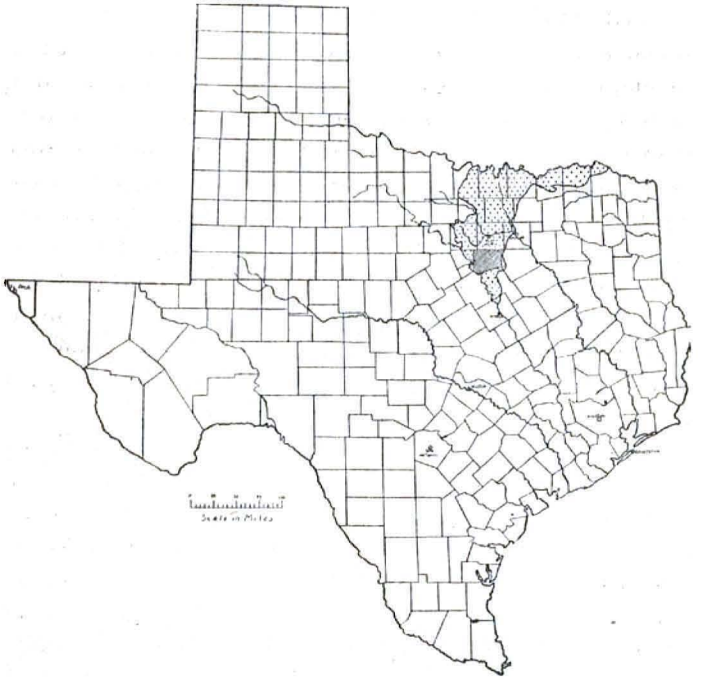

**Fig. 1:**—Shaded area indicates the location of Johnson County. The dotted area shows the extent of the outcrops of formations found in Johnson county (Eagleford to Glenrose) north of the Brazos River. Within the larger area indicated by dotting the economic geology is similar to that of Johnson county.

one who has not traced and observed the changes with care, the changes seem much more abrupt than they actually are. However, because of the above facts, the Brazos River is *de facto* the boundary between Central and North Texas Comanchean.

While it is not proposed to inject technical discussions in this bulletin, the following brief outline of the problems involved in correlating the North and Central Texas sections is presented.

In the order of their difficulty, these are as follows: first, the correlation of the upper Mainstreet, Grayson, and Woodbine formations with the Del Rio and Buda formations; second, the correlation of various Washita formations with the Georgetown; third, the correlation of the Goodland with the Edwards and Comanche Peak formations.

The last named being the simplest may be dismissed here. The development of the hard upper member of the Goodland of North Texas into the Edwards of Central Texas and the modification of the softer lower member into the Comanche Peak is a gradual transition and is demonstrated in a continuous line of exposures running from the northern part of Tarrant County southwest. The fossil sequence is perfectly preserved and while certain conspicuous changes take place in the way of disappearance of some forms and appearance of new ones, the correlation of the Goodland with the Edwards and Comanche Peak may be considered as proved.

The second problem, the correlation of the Georgetown formation of Central Texas with certain Washita formations of North Texas, is one which is also fairly simple in general. Many fossil horizons, especially of certain ammonites are continuous and unmistakable. The upper and lower limits are not clearly defined. All formation names are, of course, based on arbitrary distinctions. It would appear that more careful paleontological work needs to be done on the Georgetown formation. Dr. Emil Böse has informed one of the writers that he has found the large ammonite *Desmoceras brazoense,* belonging properly in the Duckcreek formation, in Edwards limestone in Central

Texas. From this it would appear that a paleontological parting should be established between the Edwards and the Georgetown in Central Texas. It would further appear that the North Texas Kiamitia is not represented in Central Texas despite the statements of earlier writers. The upper limit of the Georgetown formation is equally unsatisfactory being also based principally on lithology. The senior writer of this bulletin has examined classic sections of the Georgetown formation near Austin and Georgetown and places the top of the Georgetown formation in correlation with the middle of the Mainstreet formation of North Texas.

The third problem is separable into two, the correlation of the Del Rio and the correlation of the Buda. We believe that the paleontological evidence that the Del Rio corresponds in time to the upper fourth of the Mainstreet and the lower two-thirds of the Grayson is excellent. On account of its technical nature as well as its length, this evidence will not be presented here. The correlation of the Buda with the Woodbine is based on stratigraphic grounds and while placed in the correlation table in accordance with the general view, the writers herewith express reserve, as we believe that the limy upper member of the Grayson is identical with the Buda.

## GEOLOGIC MAP

The base map is composite, but is believed to be rather better than the usual county map. Drainage, railroads, and towns are from the U. S. Army Corps of Engineers' revisions of the topographic sheets covering this area (Reconnaissance maps, U. S. G. S.).

The roads are from a new (1920) road map kindly placed at our disposal by R. O. Whittaker, county engineer of Johnson County. The third-class roads are not shown, as the trace of these is being revised. The geological contacts are mapped as closely as the scale of the map will permit. Most of the original records were made from geological road logs with a scale of one inch to one mile. These were made

with a Gurley's Army sketching board with prismatic compass and measurements were made with a specially modified speedometer, reading to twentieths of a mile. Cross traverses were made along contacts and details were filled in by intersection. While this is primarily a reconnaissance method, with care the error of closure can be greatly reduced, and a geological map of scales of one inch to the mile or less can be produced which can not be approached except where the geologist is provided with a topographic map of high quality, something which is not yet available for most parts of Texas. In simple well defined strata and with prevailing open country as in this case, the geological map with this paper may be considered as a *detailed* map in the strictest sense.

All or parts of Johnson County are included in the following maps, those on which the geology is indicated being marked by an asterisk:

1887 Reconnaissance Map, U. S. G. S., Granbury Sheet.
1889 Reconnaissance Map, U. S. G. S., Cleburne Sheet.
*1892 Taff and Leverett: Cretaceous Area North of the Colorado River. 3d Annual Report, Texas Geological Survey.
1893 Reconnaissance Map, U. S. G. S., Weatherford Sheet.
*1898 Hill: Geological Map of the Black and Grand Prairies, Texas U. S. G. S., 21st Annual Report, Part 7.
1898 Reconnaissance Map, U. S. G. S., Fort Worth Sheet.
*1916 Udden, Baker, and Böse: Geological Map of Texas, Bureau of Economic Geology and Technology, University of Texas, Bulletin 44 (Third edition, 1919).
1918 Corps of Engineers, U. S. Army, Progressive Military Map, Advance Sheet 487 N, II and IV.
1918 Corps of Engineers, U. S. Army, Progressive Military Map, Advance Sheet 487 S, II and IV.
1920 R. O. Whittaker: Road Map of Johnson County.

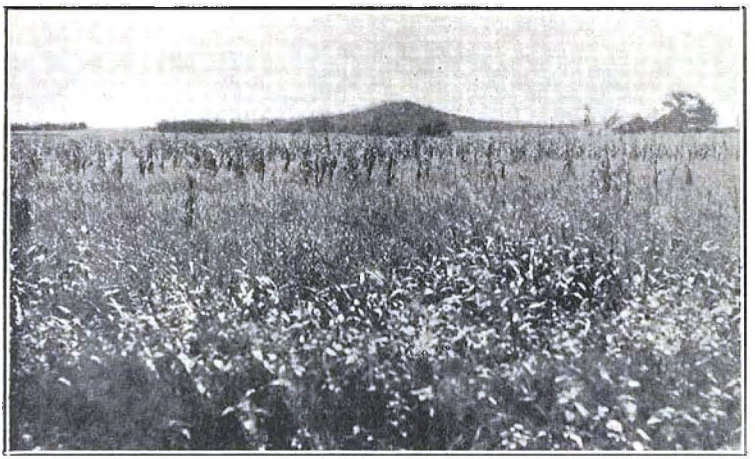

Fig. 1:—Caddo Peak from a distance of three miles.

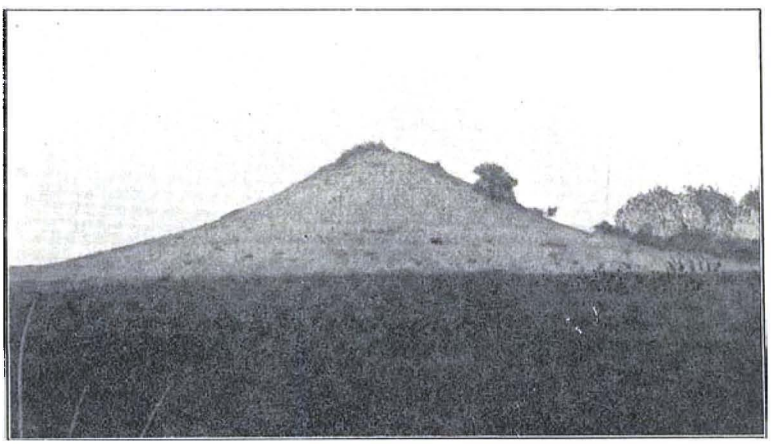

Fig. 2:—A Goodland Knob. One of many of these interesting outliers of the Goodland formation, of which Barnard Knob and Berry Knob are large examples.

## DESCRIPTION OF FORMATIONS

### PENNSYLVANIAN

Very little is known concerning the Pennsylvanian strata under Johnson County. From the log of the well at Joshua, lacking samples, it appears that the drill passed out of the Comanchean and into the Pennsylvanian at about 1390 feet.

Further data concerning the direction of dip of the top of the Pennsylvanian shales available from the records of the well at Mansfield just across the county line indicate a pronounced eastward dip. The deep well at Polytechnic in Tarrant County, at 4,600 feet according to samples examined by Dr. Udden had certainly not yet reached the Ellenburger This indicates a pronounced synclinal depression; and it is interesting to note that this depression is reflected, although feebly, in the attitude of the Comanchean strata in northern Johnson County (see map on page 47).

### COMANCHEAN

#### Trinity Formation

This formation, sometimes referred to as the "basement sands," does not outcrop in Johnson County although it underlies the entire county. The Trinity formation is of importance as the source of the best available underground water. Its approximate position can be computed from the structural map on page — by subtracting about 500 feet from the elevations given for the Walnut conglomerate in the western part of the county, about 550 feet for the central part, and about 600 feet for the eastern part.

From figures obtained in this way, it will be seen that much of the water in the county which is supposed to have its source in the Trinity formation is actually from the Paluxy. This is a common error throughout the North Texas Comanchean Cretaceous area. Examination of analyses made by different chemists of these two waters shows a number of important differences which need not be summarized here. The Trinity water as is well known is much purer and is enhanced by the presence of a fairly constant quantity of sodium bicarbonate (40-50 grains per gallon),

a feature which the natives of this region appear to miss most in waters found elsewhere.

The Trinity formation in this region is composed of alternating hard and soft sand layers, with a basal member of hard red sandstone, which is a conglomerate further north. The three water members or "reservoirs" are well known. Less well known is the fact that there is a petroliferous layer present. This is discussed in the section dealing with oil and gas possibilities.

### Glenrose Formation

The Antlers sand in northern Wise County is said to develop in its upper third, a thin limestone seam. This thickens rapidly to the south and east and becomes the Glenrose formation, the sand above being then called the Paluxy and that below the Trinity. The rate of increase at first is considerable, stated by Hill to be about nine feet to the mile. In Johnson County the rate is apparently not so great but seems to be about three feet to the mile in a direction a little south of east. As well as can be determined from well logs, the formation seems to be about 400 feet thick in the western part of Johnson County and about 500 feet thick in the eastern part. These figures are tentative and must be confirmed by samples from wells before being considered final.

*Surface Exposure:* The Glenrose formation can be barely detected along the valley of the Brazos River in the extreme western part of the county. In most places where the elevation is low enough to uncover this formation it is overwashed by the Paluxy sands which overlie it or is covered by the alluvial deposits from the stream.

The Glenrose is the lowest formation which is exposed in Johnson County.

### Paluxy Formation

This formation in Johnson County is about 90 feet thick showing only a slight thinning as it goes southward. A complete exposed section in the county is lacking, but the

following section from Tarrant County will illustrate certain important features:

**Section of Paluxy Formation in N. W. Corner of Tarrant County**

| | Feet |
|---|---|
| Red sandstone cap. Very hard, brick red in color | 0.6 |
| Soft red-streaked sand | 7.0 |
| Yellow iron-stained water sand | 30.0 |
| Extremely hard light colored quartzite ledge | 2.0 |
| Clean, white water sand | 40.0 |
| Lenticular sandstone ledges and cross bedded sands | 15.0 |
| (Basal portion, concealed, *estimated* at | 6.0) |
| Exposed total | 94.6 |
| Estimated total | 100.6 |

Certain parts of the above section appear to be constant over a wide area. These are the two water sands and the hard "flint" layer.

In the original naming of the formations, R. T. Hill did not make a clear distinction between the Paluxy sands and the white basal sands of the overlying Walnut. In a recent publication of the Bureau of Economic Geology,[1] the conspicuous red ledge nearly always present was selected as the parting between the Walnut sands and the Paluxy sands. This arbitrary parting lends itself to excellent mapping. The geological map of Johnson County follows this precedent.

*Surface Exposures:* The Paluxy sands are exposed in two small areas in Johnson County, one in the southwestern part along the Brazos River and the other in the west where the Decordova Bend of the Brazos turns within the county boundary. In each case only the red cap rock and a few feet of the underlying stained sands can be seen.

### Walnut Formation

This is the lowest formation of the Fredericksburg Division. In Johnson County the total thickness is 100 feet, of which the upper 25 feet form a shell conglomerate of the

[1]Winton and Adkins: Geology of Tarrant County, Univ. of Texas Bull. 1931.

fossil oyster *Gryphea marcoui,*[2] together with a number of other fossils.

Fossils are rare below the conglomerate proper, and the limy nature of the formation gradually becomes sandy progressing downward, the lower fifty feet or more being soft, light colored sands, with a few thin ledges of grayish sandstone. The sands are all more or less water bearing and some small wells in the western part of the county get their water from this source. Such wells are poor at best and fluctuate greatly with the seasons.

*Surface Exposures:* The Walnut shell conglomerate is well exhibited near the county line on the Bono-Glenrose road, just after going down the "mountain" travelling west. The sand members below the shell conglomerate may be seen in the deep stream cuts on either side of the road. In the deep hollow immediately west of the escarpment, the road culvert is placed on the uppermost part of the sand, here a firm sandstone. This same stream cut quickly reaches the Paluxy to the northwest. From this point southward, all roads running west and southwest from Cleburne cross the Walnut before passing out of the county. The area shown on the geological map as Walnut is in the main underlain immediately by the shell conglomerate, as the sands below have very little areal importance.

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[2]This fossil is the lowest of an important stratigraphic sequence which has been studied carefully. The importance of close attention to the fossils in doing geological work on the North Texas Comanchean can not be stressed too strongly. A paelontological basis is essential. The Bureau of Economic Geology has issued two publications giving details concerning the formations of the Fredericksburg and Washita divisions of North Texas. The first of these *The Geology of Tarrant County* (Univ. of Texas Bull. 1931) to which reference has already been made gives complete fossil lists and general descriptions of conditions. The second, *Correlation of Fredericksburg and Washita Formations in North Texas* (Univ. of Texas Bull. 1945) is a quarto volume including illustrations and descriptions of all the important horizon marking fossils. These bulletins may be purchased from the Director of the Bureau of Economic Geology and Technology, Austin, Texas.

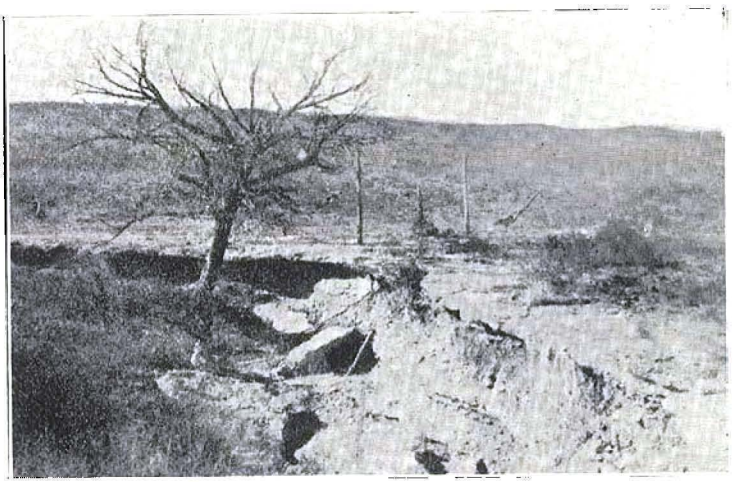

Fig. 1:—Walnut shell conglomerate on Cleburne-Granbury road.

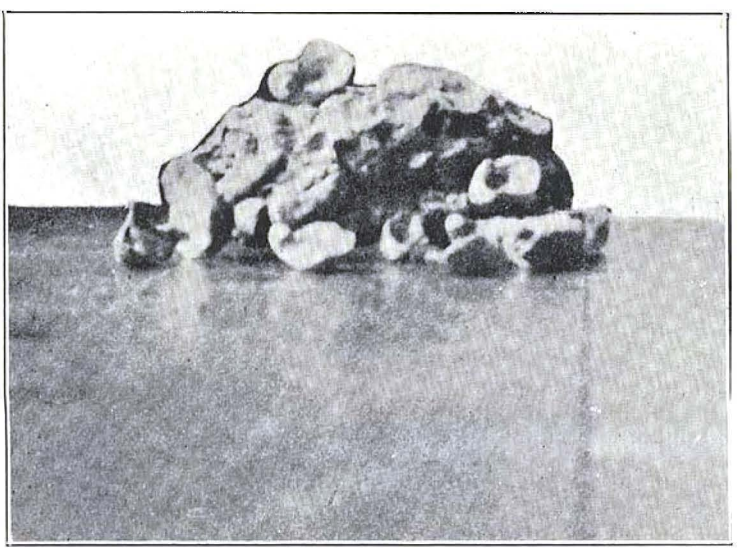

Fig. 2:—Near View of sample of shell conglomerate from exposure shown in Fig. 1.

**Goodland Formation**

As previously noted, the Johnson County Goodland exhibits the transition from the typical Goodland of North Texas to the Edwards and Comanche Peak formations of Central Texas. A suggestion of the distinction between the hard upper Edwards and the lower softer Comanche Peak can be detected as far north as Benbrook in Tarrant County. In the extreme southwestern part of Johnson County the combined formations make up a thickness of 140 feet, of which the lower 105 feet may be considered as Comanche Peak and the upper 35 feet as Edwards. Near Falls, on the Johnson-Hood county line, the total thickness of the Goodland is about 128 feet. The change in lithology and thickness is in a direction about southwest. The sequence of the fossil species is maintained. Details concerning this sequence may be obtained from the publications mentioned on page — but the following brief guide is worth bearing in mind: 1. Common fossils of the *upper third* of the Goodland formation are: *Cyprimeria texana, Enallaster texanus, Parasmilia texana* and other corals; 2. common fossils of the *middle third* are: *Pholadomya sancti-sabae, Salenia mexicana, Ostrea* (large species aff. *Johannae*) ; 3. common fossils of the *lower third* are: *Schloenbachia acutocarinata, Cerithium bosquense, and Pinna* sp.

Besides the above there are many others, some of which extend through the entire thickness and some found only in a definite sequence. In the Goodland emphasis should be placed on definite associations. That is attention should be given to groups of different species regardless of the range of individual species. This of course is for close and refined work, for ordinary stratigraphic purposes many well defined horizons of single species exists. Winton and Adkins used the term "syndrome" for such a group, borrowing from the language of the medical diagnostician.

*Surface Exposures:* The surface area of this formation is not very great, but the rocks are conspicuous as they form the high escarpment which runs through two-thirds of the length of the western part of the county. This escarpment

is locally referred to as "the mountain." Where isolated areas occur to the west of the main outcrop they take the form of the familiar knobs, which may be single or in groups. The typical form is the conical knob like Barnard Knob and Berry Knob and the many smaller knobs. Less typical is the famous Comanche Peak in Hood County one of the landmarks of this region and visible from all points on the uplands of western Johnson County.

#### Kiamitia Formation

This series of brownish clays and flaggy sandstones was originally classified with the Washita Division on purely lithological grounds. It has since been proved to be merely the final phase of the Fredericksburg Division. Aside from the usual characteristic Fredericksburg fossils this formation contains a species found nowhere else in the section, this is *Gryphea navia* which is readily recognized by its heavy shell, twisted beak, and other features. Following the precedent set in the geological map of Tarrant County, the map of Johnson County does not show the Kiamitia but includes it with the Goodland. The position of the Kiamitia formation can be approximated by setting off a band of extreme narrowness along the eastern margin of the Goodland outcrop as mapped.

The total thickness for most parts of the county is 18 feet.

*Surface Exposures:* The Kiamitia formation is exposed on nearly all the county roads running west and southwest from Cleburne. In most places the exposures are inconspicuous and badly overwashed. Perhaps the best is on the Bono-Glenrose road about four miles southwest of Bono. Here the formation is fairly well exposed in the road cut.

#### Duck Creek Formation

This formation is readily divisible into two members, marked in the northern part by lithological distinctions and marked throughout by strong differences in the fossils The lower member is a limestone and the upper member is

a marl (except in the extreme southern part). A guide to the two members is the presence in the lower one of the large ammonite *Schloenbachia trinodosa* to which member it is limited. Besides this fossil each member has a number of distinctive species. In fact the faunal "gap" between the two parts of the Duckcreek formation is one of the most marked in the entire North Texas Comanchean. The marl member contains much clay which in turn contains many important but minute fossils preserved in the form of hematite and pyrite.

The trend toward calcareousness in this formation as it approaches the Georgetown phase is marked by a considerable thinning of the whole formation but at a greater rate in the upper or marl member. This latter is over 100 feet thick at Denison and less than 20 feet thick in southern Johnson County.

Near the Brazos River, the lithologic distinction between the Duckcreek formation and the overlying Fort Worth formation is very slight. This is the beginning of the Georgetown phase. The mapping of the lower Washita formations in southern Johnson County was found rather difficult and a careful check needed to be kept on the fossils.

*Surface Exposures:* The outcrop of the Duckcreek formation in Johnson County is extensive as will be noted on the geological map. On previously published maps much of this was shown as "Fort Worth." Most of the area is due to the limestone or lower member. The conspicuous cliff about a half mile southeast of Godley, visible from the Cleburne-Weatherford road shows practically all of the lower member and the main part of the upper member. Along this same road between Godley and Cresson, the marl member is well exposed in the road cuts at the tops of the hills, which in most cases are capped by a thin remainder of the Forth Worth limestone. The same situation exists on the roads running west from Bono. At the base of the escarpment about one mile west of Riovista, this formation can be seen as well as the ones above it. In this escarpment, the strong tendency toward the Georgetown limestone is well exhibited.

### Fort Worth Formation

This formation is made up of alternating limestones and marls in layers of a few inches to a foot thick. The total thickness in Johnson County is about 27 feet in the northern part and 25 feet in the southern part. This is one of the most readily recognized formations in the entire section, both because of its characteristic and unvarying lithology and because of its distinctive fossils. The best and most abundant of these for ordinary work are the large ammonite *Schloenbachia leonensis* and the largest of the heart-shaped biscuit urchins of this region, *Hemiaster elegans*.

*Surface Exposures:* The Fort Worth formation can be seen exposed along the Noland's River west of Cleburne, on any of the roads in the northwestern part of the county, on the Meridian highway after crossing the Noland's River, also west of Riovista in the escarpment and many other places. This formation underlies much of the Grand Prairie and is characterized by its gently rolling topography and its well known chocolate colored soil.

### Denton Formation

This and the two succeeding formations are not mapped separately, but are shown on the accompanying geological map combined under a single symbol. This procedure is not meant to imply that they are not mappable separately, but is resorted to because of the relatively small areal extent of the formations. The position of the Denton may be approximated on the map by setting off a narrow strip along the western border of the area shown for the three combined. The Denton should be allowed about one-quarter of the area in question, the rest being assigned almost entirely to the Weno, as the intervening Pawpaw is extremely thin here and together with its soft character this makes its areal extent insignificant and too little to show except on a map of rather large scale.

The Denton formation is about 25 feet thick in the northern part of the county and about 20 feet in the southern part. The thinning is accompanied by a great increase in calcareousness and also by the appearance of a new fossil species of the brachiopod genus *Kingena* which is absent in the northern part of the formation and present in large numbers in the southern part.

The Denton formation is made up mainly of marls and clays which are capped by a shell conglomerate of *Gryphea washitensis.* This shell conglomerate includes large numbers of juveniles as well as adult shells and also includes an association of other fossils the most important of which is the angular *Ostrea carinata.* The clay portion includes a pyrite fauna.

*Surface Exposures:* The best of these is in the escarpment west of Riovista. Elsewhere parts of the formation may be seen. The uplands across the Noland's River from Cleburne are capped by the hard shell conglomerate, the slabs of which are used in this neighborhood in the construction of neat stone walls.

#### Weno Formation

This formation perhaps better than any other in the Washita Division exhibits the great changes in thickness and lithology which result in the Washita formations of North Texas becoming the single Georgetown formation of the central region.

Along the Red River the Weno, more than 100 feet thick, is almost entirely marl and clay with a thin cap (3 feet) of hard limestone known as the Quarry limestone. At the Brazos River, the Weno is rather less than 40 feet thick and is calcareous throughout, although even here the upper portion is distinctly more calcareous than the lower. These great changes in thickness and lithology are accompanied by a remarkable range in fossil forms.

*Surface Exposures:* The entire thickness may be seen in the escarpment west of Riovista, also in the bank of the stream cut of Mustang Creek about one and a half miles

southeast of Riovista. In the latter place a rich concentration of various fossils occurs.

On the A. L. Freeman farm on Martin Branch, nine miles northwest of Cleburne, the Weno formation is well exposed in the westward facing cliff. Here there is a conspicuous fissure due to a fault. This fissure is filled with a hard iron-stained limestone dike covered on one side by many crystals of pyrite and on the other side is marked by parallel scratches or "slickensides." The fissure and its dike are said by Mr. Freeman and others of the neighborhood to extend downward for thirty feet and to be about fifteen miles long. A careful study of the fossil forms on the two sides of the fissure has failed to demonstrate any considerable displacement of the strata despite the evidence of the "slickensides."

### Pawpaw Formation

The Pawpaw thins greatly between the Red River and the Brazos River and has not been observed south of the Brazos. At Denison this formation is about 55 feet thick and west of Riovista it is rather less than 9 feet thick. The formation is composed of reddish-brown clays with a distinctly sandy phase in the northern part. There is present throughout a peculiar fauna of dwarfed species preserved in pyrite.

*Surface Exposures:* The Pawpaw is exposed in those localities mentioned above for the Weno formation. Besides these, the rapid change in thickness can be observed by comparing the exposure in the westward facing bluffs overlooking Rock Creek, four miles northwest of Joshua, where the formation is 18 feet thick with the exposure near the top of the Riovista escarpment where it is less than 9 feet in thickness. The total areal extent of this formation in Johnson County as elsewhere is insignificant because of the softness of the material. The following section includes the Pawpaw and the overlying and underlying formations:

**Section on Martin's Branch, 9 Miles Northwest of Cleburne**

| | Feet |
|---|---|
| MAINSTREET— | |
| Massive limestone, containing *Pachymya* sp., *Turrilites brazoensis, Holectypus limitis, Pecten* aff. *5-lineatus* | 32.4 |
| PAWPAW— | |
| Reddish-brown clay containing fragments of *Turrilites hilli, Arca* sp. and other species in pyrite | 10.8 |
| WENO— | |
| Limy marl capped by a hard lime ledge 1 ft. thick, containing *Pecten georgetownensis, Nautilus texanus, Pinna* sp. and *Kingena* sp. | 7.8 |
| Marl containing *Nodosaria texana* | 1.0 |
| Massive limestone, containing *Schloenbachia wintoni, Nautilus texanus, Epiaster* sp., *Protocardia* sp., *Gervilliopsis invagin ata* | 7.4 |
| Concealed by bed of stream, *estimated* at | 10.0 |
| Soft white marl, no fossils | 10.0 |

**Mainstreet Formation**

A series of massive white limestones interbedded with thin seams of marl. Often the limestones contain small round nodules of hematite (and limonite), which on exposures break down and stain the surrounding rock. This formation differs from the Washita formations below it in that it *thickens* progressing southward, being 20 feet thick at Denison and 50 feet thick at Cleburne. Many fossils are preserved, being mainly in the form of mud casts. A conspicuous and favorable species for diagnostic purposes is the large spiral ammonite, *Turrilites brazoensis,* which is found everywhere in the formation in greater or less numbers except the extreme upper and lower portions where it appears to be totally absent. Near the top of the formation a large species of the brachiopod genus *Kingena* is present in great numbers.

The limestones of the Mainstreet formation break down into the typical dark brown soil of the Grand Prairie.

*Surface Exposures:* The city of Cleburne is built upon the outcrop of this formation. In the city itself, many excellent exposures can be seen in the cliffs of Buffalo Creek.

These cliffs are the best places to study this formation which are known in North Texas. By traversing westward out the creek past the Fair Grounds, nearly the entire thickness can be seen and examined in detail. The escarpment which runs along the east side of Noland's River from Riovista northward is capped by the basal members of the Mainstreet limestone.

#### Grayson Formation

This formation, like the preceding one, thickens toward the south being 50 feet[3] thick at the Red River, 75 feet thick in southern Denton County, and of an unknown thickness in Johnson County estimated at 100 feet.

Everywhere the Grayson is soft and marly with a few thin beds of limestone in the upper part and a fairly thick clay layer near the middle. The lower portion is a soft marl. These three principal members are fairly consistent lithologically and are also represented by definite horizons of fossils.

The outcrops, which are of slight areal extent, are usually abrupt escarpments connecting the Woodbine sandstone above and the Mainstreet limestone below, and are always badly overwashed and obscured by the sands of the overlying Woodbine formation. Fossils are abundant, the most consistent and abundant for the formation as a whole being *Gryphea mucronata* and the very large flat-ribbed variety of *Pecten texanus*.

The middle member contains a clay bed in which are many dwarfed ammonites and other small fossils preserved in the form of pyrite. This pyrite zone is the highest one of a

[3]This figure is the correct one. The thickness of the Grayson formation at the Red River is usually given as 25 feet following the error of an early writer and based on an incomplete exposure near Denison. The senior writer of this paper has made a careful examination of a complete section of the Grayson in an exposure one mile north of Durant in Bryon county, Oklahoma. Here the clear limits of the Woodbine (Silo) sandstone above and the Mainstreet (Bennington) limestone below can be seen. An excellent section is shown in the road cut in the south bank of the creek at this point.

series of five. The next lowest is in the Pawpaw, next in the Denton, next in the Duckcreek (marl), next in the Kiamitia. The superficial similarity of the members of these pyrite faunas is striking. The resemblance between the one occurring in the Denton with the one in the Pawpaw is especially close.

**Section of the Grayson Formation, Two Miles Southeast of Burleson, Johnson County**

| | Feet |
|---|---|
| Yellowish calcareous marl, few fossils | 12 |
| Shelly limestone band | 1 |
| Yellowish calcareous marl, some clay with gypsum, pyrite and limonite. *Gryphea mucronata, Turrilites* sp. (in pyrite) and many small pyrite fossils | 15 |

The lowest of the above is the middle member of the formation.

**Section of the Grayson Formation on Mustang Creek, Three Miles Northeast of Riovista, Johnson County**

| | Feet |
|---|---|
| Brownish-red clay and marl including many small pyrite fossils | 2 |
| Soft gray marl with a few thin ledges of crumbling limestone. *Engonoceras* sp. (very large), *Gryphea mucronata,* fragments of a keel-less ammonite, *Exogyra arietina,* etc | 30 |

The lowest of the above is clearly the lower member of the formation. The upper part of the section shows a small part of the middle member. The only complete section known in North Texas is in Denton County. The following record of this section is copied, with some additions, from University of Texas Bulletin No. 1931, *The Geology of Tarrant County: Section of the Grayson marl near Roanoke, Texas.*

**Section of the Grayson Marl near Roanoke, Texas:**

| | Feet |
|---|---|
| WOODBINE— | |
| Red ledge forming crown of hill. | |
| GRAYSON— | |
| Soft gray marl containing eleven limestone ledges each 3 to 12 inches thick, the uppermost lying in contact and conformable with the base of the Woodbine. *Lima* sp. (same as Weno sp.), Cidarid spines (very large), zone of *Hemiaster calvini* and *Enallaster bravoensis* (10 feet below the top), *Schloenbachia sp., Cyprimeria magna, Gryphea mucronata* (scarce), *Pecten texanus* (abundant), *Plicatula* sp. (abundant), *scaphites* ? sp. | 37.8 |
| Yellowish limonite-stained marl (and clay). Rich in *Gryphea mucronata. Turrilites* small sp. in pyrite and other small pyrite fossils | 15.2 |
| Soft gray marl. Fossils scarce, mostly *Engonoceras* sp. *Gryphea mucronata* and flattened *Exogyra arietina.* A number of red ironstone seams weathering black | 22.2 |
| MAIN STREET— | |
| Top. *Kingena* sp. very abundant. | |
| Total for the Grayson | 75.2 |

**Woodbine Formation**

The Woodbine formation outcrops over a large area in Johnson County in a strip about fourteen miles wide in the northern part of the county, where the formation is about 300 feet thick, and about five miles wide in the southern part, where the formation is less than 50 feet thick. The entire formation is distinctly sandy, acid, much iron-stained, and like other sandstone formations is rather difficult to work out in detail.

This formation shows a great thinning between the Red River and the Brazos River, and extends past the last-named river in a gradually thinning bed with a lessening outcrop and finally disappears in the northern part of McLennan County.

The outcrop in Johnson County coincides with the minor physiographic province known as the Eastern Cross Timbers.

Fossils are few and poorly preserved. In Johnson County no fossils have been found except in a thin bed near the top of the formation.

The sandy and flag-like nature of this bed and the abundance of minute teeth and scales of fishes present an irresistible suggestion of the lower beds of the Eagle Ford formation across the Brazos and into Central Texas. Unfortunately no detailed study of the paleontology of these small fossils is available. The idea that the lowest beds of the Eagle Ford in Central Texas correspond to the upper Woodbine as seen North of the Brazos is not new. This suggestion has appeared in print several times and we regret that the originator is not known to us. Of the many efforts to correlate the Comanchean-Cretaceous junction on the two sides of the Brazos valley, this seems to us the most plausible. The statement that the Buda corresponds to the Woodbine is the most unfortunate, as the Buda is the equivalent in the main of the upper lime member of the Grayson.

In Johnson County, as in Tarrant County, the Woodbine is composed of three massive sandstone ledges, marking the upper, lower, and middle parts of the formation; and two shaly-sandy members. The lower of the two soft members is markedly lignitic. Detailed sections are given in the bulletin on Tarrant County.

The sudden thinning of the Woodbine toward the South is a well known feature, and the same phenomenon was encountered in the wells drilled between Mexia and Groesbeck.

Most of the Woodbine, according to the usual view, represents a great river delta.

*Surface Exposures:* The western border of the outcrop is clearly marked by the line of trees and extends along an irregular line from about seven miles east of Riovista northward two miles east of Cleburne, then turns westward and passes about two miles west of Joshua. The eastern border of the outcrop is not as well marked by trees as is the western border. In fact due to the eastward dip of the beds

combined with an eastward drainage, the Woodbine overwashes the basal Eagleford and well defined contacts are rare. The entire outcrop is marked by low-lying hills, densely wooded. The soil is deep and sandy and none too productive. Where some of the lighter sand members are exposed, as north of Grandview on the Grandview-Alvarado road, the sand blows about freely and forms drifts and dunes. Often where fences occur across the direction of the prevailing winds the sands drift up to such an extent as to obscure and conceal the fence. Cattle are able to walk from field to field over the fence which is now represented by a long low-rounded mound.

Along the western margin of the outcrop are many outliers. These take the form of wooded knobs. The counties of the North Texas Comanchean area each have from one to a dozen "Brushy Knobs," all of which are of this nature. Johnson County has only two which are so called, but Caddo Peak is a topographic feature of this type.

**Section on Grandview-Cleburne Road, One Mile West of Grandview. Section taken Along North Side of Road**

| | Feet |
|---|---|
| EAGLEFORD— | |
| Light colored shales, compressed, laminated | 10.0 |
| Pale yellow and white sandy clays containing thin ledges of sandstone and many white rounded concretions | 5.0 |
| Soft yellow sandy shale | 26.0 |
| WOODBINE— | |
| Massive red sandstone, much cross-bedded, containing lenticular bodies and a few seams of gravel | 13.0 |
| Iron-stained shales and clays | 7.5 |
| White sandstone ledge | 0.5 |
| Reddish clays and shales containing red ironstone, the upper four inches being almost a vermillion in color. Ironstone friable and soft in fresh form | 5.4 |
| Iron-stained shell conglomerate of *Barbatia* sp., *ostrea carica*, *Ostrea* sp. | 0.2 |
| Soft yellow to red sands with sandstone ledges | 5.0 |

## UPPER CRETACEOUS

### Eagleford Formation

This formation is composed in the main of shales with a

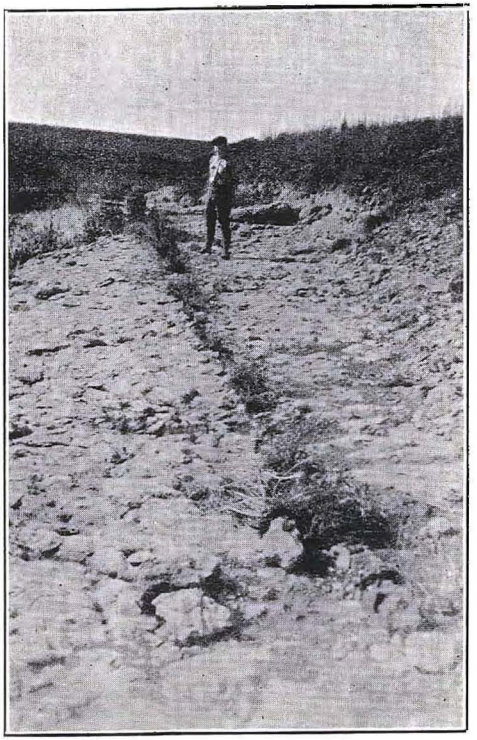

Fig. 1:—Deep fissure in western part of Johnson County.

Fig. 2:——Sample showing "slickensides" from the fissure illustrated in Fig. 1.

few acidic sandy layers at the base. The resulting soils are a part of the famous Black Prairie which includes some of the best farming land in the State.

Only the lower part of the Eagleford outcrops in Johnson County. The total thickness in the eastern part of the county, near the town of Venus, is estimated at 350 feet. There is considerable thinning southward but the rate is not known.

*Surface Exposures:* The Eagleford outcrops along the eastern edge of the county in a strip five to ten miles wide. In much of this area the deposit remaining is very thin as is shown by the fact that excavations for storm cellars, etc., uncover the red sandstone of the Woodbine. Small streams cut through to the sandstone for a considerable distance back from the outcrop boundary.

## CENOZOIC AND RECENT

The Cenozoic and Recent deposits in Johnson County are made up of gravels. These are of two main-time periods, represented both by the topographic position of the gravels and their trade names. The older gravels are the upland or "pit gravels" which form terraces, many of which are far above high water. Shells of Pleistocene fresh water molluscs have been found in these gravels as high as sixty feet above the present high water level of the streams. In Johnson and neighboring counties, various mammal remains have been found in these upland gravels, by far the most common being the bones and teeth of the southwestern mammoth, *Elephas imperator*. Other forms which have been found are a small species of *Elephas, Megatherium, Equus francisii,* etc.

The younger gravels are the so-called "stream" gravels which are in flood-plain deposits, contain much clay and sand, and have a much lower commercial value than the "pit" gravels.

The gravel deposits are further discussed in the following section on economic geology.

## ECONOMIC GEOLOGY

The geology of Johnson County illustrates most of the problems encountered in North Texas which involve a consideration of geological conditions. In many cases a thoughtful study of the geology may result in the saving of considerable sums; and, by the same token, it often happens that a disregard of the geology may involve a disastrous expense. These general facts are known to many engineers, geologists, and other technically trained persons, but the idea of applying an understanding of the geological conditions to certain every-day problems is totally new to the average citizen.

For this reason a brief review of some of the conditions illustrated in Johnson County will be given.

The subject matter on economic geology will be discussed under the following headings:

1. Highways and Railways.
2. Limestone Industries.
3. Clay Industries.
4. Building Foundations.
5. Water Supply.
6. Soils.
7. Oil and Gas.

### HIGHWAYS AND RAILWAYS

*Trace or Location*

The geology is an important feature often overlooked in the laying out of the trace of a new road. The usual considerations of towns, bridges, and other factors are important; but sometimes the geology is equally so. During the winter of 1919-1920, the daily papers of Fort Worth and Dallas carried bulletins concerning road conditions in North Texas. Certain well known stretches of important

roads frequently were impassable for days at a time, despite frequent and costly repairs by the counties concerned. We carefully compiled the information thus furnished and the following unqualified statements can be made.

In the areas under consideration, the worst possible base for a road is the upper marl member of the Duckcreek formation. This marl has such a capacity for holding water that in late summer its outcrop forms a clearly defined green band around certain hills in southern Tarrant and northern Johnson counties. This quantity of water, together with the soft and sticky nature of the surface, result in a set of conditions against which the road builder must use his greatest ingenuity. Drainage is very bad and the road metal has a tendency to sink into the soft base, sometimes disappearing. Specific examples in Johnson County are the notorious stretches just west of Godley along the Santa Fe tracks and just east of Cresson. In many cases, both in Johnson County and other counties in this area, such conditions are avoidable by changing the trace of the road slightly to the east. The Duckcreek marl is of small area even where thickest and the overlying Fort Worth limestone furnishes one of the finest possible road bases. An amusing but quite convincing illustration of this argument is the informal trace made by the drivers themselves detouring on side roads and through farms along the road mentioned above. This informal road, a very excellent one even in bad weather, kept strictly to the Fort Worth outcrop.

Almost as bad as the Duckcreek marl are certain clay members near the base of the Woodbine formation. The unbelievable "quag holes" on the Cleburne-Burleson-Fort Worth road, particularly those north of Joshua were due to these clay members. Where the road turned enough to the west or went down enough in elevation to strike certain of these layers, the impassable holes above mentioned were formed in wet weather. Here again the obvious relief is the changing of the trace as has been done in the new plan to keep the road on the overlying hard rock, in this case a

sandstone. Other unfavorable outcrops for the location of roads are the various marl members of the section.

In all cases roads crossing these outcrops should cross them in the most direct manner and roads paralleling the direction of outcrop should be placed to one side or the other on the nearest hard rock base.

Certain of the sandstone areas are distinctly unfavorable in dry weather as they break down into a soft mobile sand. This problem is simply one of the routine problems of the highway engineer.

Closely allied to the problems involved in highway building are those faced by railway constructors. Practical experience has brought the majority of the large railroads to the point where they consider it an economy to maintain a staff of geologists.

In dipping alternately hard and soft strata, sometimes errors are made which are quite startling. The writers know of a certain place where a railway running near the top of the outcrop of a hard limestone member which is underlain and overlain by soft marls, turns on reaching a hill and swings up the dip. The resulting cut is entirely through the hard limestone (nearly 20 feet) and the road base is on the soft marl. By swinging the same number of degrees down the dip, the cut, although much deeper, would have been entirely through soft marls, removable with a steam shovel, and the road base would have been the hard limestone. A contrast showing an example of scientific laying out of a railway is the case of that part of the main stem of the Santa Fe Railway between Cleburne in Johnson County and Gainesville in Cooke County. This road runs almost in its entirety over Comanchean rocks of varying thickness and varying degrees of dip and takes advantage of all possible geological conditions.

### Road Materials

Road building material in Johnson County and other counties in the Comanchean area is abundant, consisting mainly of gravel and limestone, the latter being used in the form of crushed rock.

*Gravel:* Gravel deposits in this part of the State are along the lines of medium to large sized streams. They have been deposited by these streams in the past and with respect to them are found at two main levels: 1. In those gravel beds which lie about on a level with the present alluvial plain. They have been laid down rather recently by the stream. 2. In the "terrace" or upland beds which lie just at the edge of the uplands, usually on a low escarpment overlooking the stream. These gravels were deposited many years ago when the stream had a slightly different course so far as its numerous meanderings are concerned and before the country around had been worn down to its present levels by the numerous centuries of action of rain, wind, and other eroding factors. Some of these beds were preserved, many others of course were washed away. Such deposits as the two mentioned above are found along the Red River, the Trinity, Noland's River, etc. They are being worked extensively and profitably in many parts of North Texas.

The commercially valuable gravels of Johnson County are all of a calcaceous nature and are merely fragments of limestone.

The grading test consists in determining the per cent of clay, sand, pebbles of different sizes, etc., which the gravel contains. The clay and fine sand which represents the binding material in the gravel will pass through a number 200 sieve (usually this test is made by suspension in water and afterward drying and weighing). The dried gravel is sorted by sieves of meshes with various fractions and multiples of an inch.

The cementation test is made with the fine clay part of the gravel and with some of the ground up pebbles in a machine constructed for the purpose.

The identification test of material is made at the pit to determine the consistency and changes of material excavated.

Gravel worth developing should be clean. A test is readily made by rubbing the gravel in the hands. It should be

comparatively free from clay also. A third primary consideration is that the range of the pebbles should be between one-quarter of an inch to two inches in diameter.

For road building the fine points of classification of gravel have no special significance. The pebbles must not be too soft or they will wear too readily; there must not be too much clay and sand (7 per cent is enough according to Nash), and there must not be large boulders present.

The areal extent and cubic contents of gravel pits can not be determined by geological methods. There must be direct prospecting in as many test holes as possible.

In Johnson County gravel is obtained from various deposits along the Noland's River. The supply is rather limited and the county officials have turned to the more abundant supply of limestone as the principal source of road building material.

*Limestones:* The limestones of the Comanchean area, according to Mr. James P. Nash of the Division of Engineering of the Bureau of Economic Geology and Technology, are only fair as road material. While tests of material from Johnson County are lacking, considerable information may be derived from tests on the same beds in neighboring counties.

In general, these limestones have been found to have medium resistance to wear, low toughness, fair cementing value, and fair resistance to compression.[4] They are recommended as satisfactory material for bituminous macadam roads.

The best of these limestones is the Edwards (the upper part of the Goodland) but in Johnson County this outcrop is not accessible to any railway. The next best is the Weno limestone, especially the hard, thick, upper part which in Johnson County represents the "quarry limestone" of Cooke and Grayson counties. The Weno limestone in Johnson County is readily accessible in practically unlimited quanti-

[4]The quantitative value or limits of these terms based on physical tests is explained by Nash: Road Building Materials in Texas, Bureau of Economic Geology and Technology, University of Texas Bulletin, 1839, pages 146 to 159.

ties near the Weatherford branch of the Santa Fe Railway. A particularly favorable place is the escarpment along the east side of Martin Branch. A limited use has been made of this supply at this place.

For unsurfaced roads, the writers wish to suggest the shell conglomerate of the Walnut formation. This material is composed of a matrix of marly clay containing enormous numbers of the fossil oyster *Gryphea marcoui.* The thickness of the conglomerate in Johnson County is 25 feet. Throughout the North Texas Comanchean counties, this conglomerate forms an important and readily recognized geological land mark. For some reason it is usually rejected as a possible road material, perhaps because of the impression that it is marly. On exposure, slabs of this material harden at first, then gradually break down releasing the included shells. The resulting loose shells make a road material which is unsurpassed for light and medium traffic. We have observed this possible resource for some years. Where roads are carried across or along this conglomerate, the road builder after establishing grades and drainage usually depends on the natural base already present. The superb western portion of the "meandering road" along Lake Worth in Tarrant County is an example of this kind of road building. Another example is the Cleburne-Glenrose road in the extreme western part of Johnson County. The excellent qualities of these two stretches of road illustrate the possibilities. Other similar examples occur. So far as is known to the writers, only one case of the use of this conglomerate of shells[5] other than in its natural position exists. This is the portion of the new highway northwest from Fort Worth passing through Rhome in Wise County and extending a few miles each side of this village. Here where the road

[5]In Oklahoma, in Bryan county, on the Caddo-Durant road, there is a stretch of highway for a few miles west of Caddo which is built of the shells from the conglomerate near the top of the Denton formation. These shells are of *Gryphea washitensis* a fossil oyster similar to the one in the Walnut formation. There may possibly be other "shell roads" made of fossil shells, although the idea does not seem to have made much headway in the Southwest.

base is the unfavorable Duckcreek marl and where until recently there was one of the most notorious road stretches in North Texas, the builders have brought the shell conglomerate from the nearby outcrops and used it as a road surface. This stretch of road is now a veritable joy to the motorist. The travelled driver on first encountering this stretch usually exclaims: "This is just like the shell roads of the Gulf Coast!" This frequently repeated exclamation is more true than the motorist suspects, for here more than three hundred and fifty miles from the sea is a genuine shell road made of the shells of oysters which lived before the days of human history.

Immediately underlying the Walnut shell conglomerate is the soft white sand of the same formation. Overlying it is the marly base of the Goodland (Comanche Peak). Quarrying the Walnut shell conglomerate would be prohibitively expensive except where natural erosion has removed the overlying Goodland. In other words, only the outcrop is workable. Ordinary quarry methods would be required to extract the material which should then be broken in a crusher but not to fragments small enough to break up many of the individual shells.

The supply is inexhaustible. In Johnson County alone there are approximately four hundred and five million cubic yards of this material.

## LIMESTONE INDUSTRIES

Under this general heading may be included such industries as portland cement plants, quarries, rock crushers, lime kilns, etc.

In the manufacture of portland cement, besides the limestone, a quantity of good clay or shale equal to about one-third the amount of limestone used must be available. In this area, experience has shown that the best combination of natural factors is present at the contact of the Austin chalk and the Eagleford shale. This contact is not included within the boundaries of Johnson County, although the town of Venus in the northeast part of the county is near the

contact just across the line in Ellis County. In this part of the country the Austin chalk forms a conspicuous escarpment visible from many miles distant known usually as the "White Rock Mountain." Other combinations within the county are possible, such as the Weno limestone and the Pawpaw clay, the Goodland limestone and the Kiamitia clay, and similar combinations, based on actual contacts of limestones and clays; but, as before noted, the Austin chalk and Eagleford combination has been found to so outclass the other possible combinations as to make such ventures of doubtful value. The most promising possibility is the Weno-Pawpaw contact along the Santa Fe about nine miles northwest of Cleburne.

The following analyses are of material from Tarrant County. The lithology of these limestones and marls is practically unchanged in Johnson County. The analyses which are by Professor F. W. Hogan give the aluminum and iron oxides as $R_2O_3$.

| Key to the analyses | $CaCO_3$ | $SiO_2$ | $R_2O_3$ |
|---|---|---|---|
| 5½′ of the rock out of the top 8′ of the Weno (Quarry) | 85.70 | 8.44 | 3.66 |
| 2½′ of marl from the crevices of the top 8′ of the Weno (Quarry) | 60.28 | 22.58 | 12.48 |
| Lower 35′ on the Main Street limestone | 90.08 | 3.44 | 2.81 |
| 3′ of marl from the crevices in 18′ of Ft. Worth limestone | 59.20 | 21.62 | 13.74 |
| 15′ of rock out of 18′ of the Ft. Worth limestone | 91.65 | 3.59 | 2.15 |
| Top 30′ of the Duck Creek (marl) | 83.66 | 9.90 | 6.06 |
| Top 27′ of rock out the lower 35′ of the Duck Creek limestone | 90.06 | 3.08 | 2.87 |
| 4′ of marl from the crevices in the Duck Creek limestone | 69.65 | 14.12 | 9.82 |
| Top 50′ of the Goodland limestone | 90.75 | 4.48 | 2.83 |
| Upper 20′ of rock, only, of the Ft. Worth limestone | 90.73 | —— | —— |
| Bottom 25′ of Weno shale, next above the shell conglomerate layer of the Denton | 31.90 | 37.46 | 20.46 |
| 20′ of Denton shale, next below the shell conglomerate | 26.00 | 43.81 | 18.71 |

| Key to the analyses | $CaCO_3$ | $SiO_2$ | $R_2O_3$ |
|---|---|---|---|
| Top 10′ of the Denton shale, next below the shell conglomerate. Sample taken from Cobb's brick yard shale pit | 18.95 | 47.36 | 22.92 |
| Top 12′ of the Pawpaw shale | 13.80 | 48.08 | 25.74 |
| Lower 20′ of the Kiamitia shale | 40.80 | 34.32 | 14.38 |
| 20′ of Weno shale, next below the Weno Quarry limestone | 13.91 | 49.82 | 25.02 |
| Surface gumbo soil from various points north of the City of Ft. Worth. These samples were thoroughly mixed, and a sample for analysis taken from the mixture | —— | 55.92 | 17.72 |
| Top 25′ of Eagle Ford shale, under the Austin chalk | 3.20 | 56.47 | 23.88 |
| 5′ of Grayson shale from about the middle of the formation | 46.65 | 29.63 | 15.77 |

The following samples were taken from a drill hole 5 miles S. W. of the City of Ft. Worth, on the Frisco R. R.

| Key to the analyses | $CaCO_3$ | $SiO_2$ | $R_2O_3$ | Ignition loss other than $CO_2$ |
|---|---|---|---|---|
| Lower 11′ of Weno shale | 24.29 | 45.54 | 20.88 | 7.47 |
| 22′ of Denton shale | 50.78 | 27.23 | 13.39 | 4.81 |
| 23′ of the Ft. Worth formation | 78.50 | 11.46 | 5.95 | 1.00 |
| 30′ of the Upper Duck Creek (marl) | 68.50 | 16.55 | 10.54 | 2.38 |
| 28′ of the Lower Duck Creek limestone | 83.43 | 8.00 | 4.96 | 0.50 |
| 4½′ of the top of the Kiamitia shale | 34.81 | 41.28 | 15.28 | 3.08 |
| 3′ of top soil near the drill hole | 40.67 | 37.96 | 14.52 | |

(Courtesy the Fort Worth Chamber of Commerce)

Lime kilns of any extent are not present in the county, although certain of the limestones have been found valuable for this purpose, the best being the Goodland limestone and the Weno limestone. These make "fat" (good slaking) limes. The Duckcreek limestone has been used by certain small kilns in neighboring counties, but because of its clayey content it makes a hydraulic lime, in other words a rather

poor natural cement. So far as is known to the writers, the other limestones have not been tested in kilns. The Mainstreet limestone would seem promising.

As a source of crushed rock for roads, concrete aggregates, and other purposes, the best limestones in this area are the hard upper part of the Goodland (Edwards) and the upper part of the Weno (Quarry) limestones. The outcrops of these upon the map indicate certain favorable sites for their exploitation in the central and western parts of Johnson County. The Weno has the additional value of offering possibilities as a building stone, although no test has been made of it in this connection.

In general, the limestones of the Comanchean have not proven very satisfactory when used as building stone. In the extreme northern part of the State, the upper part of the Weno, the so-called Quarry limestone has been used to some extent; and in the west-central part, certain ledges of the Glenrose limestone also have been used as a source of building stone. The sandstones of the Comanchean because of their cross-bedding, gypsum seams, and other disadvantages, may be considered out of the question as a source of building material.

## CLAY INDUSTRIES

In Johnson County the principal clays of commercial value are those in the Woodbine formation. Many practical experiments indicate the value of these clays for brick making. Small brickyards throughout North Texas in this strip are being conducted on a profitable basis. The most extensive plant of the sort known to us is the plant of the Acme Company at Denton. The material used here is a light colored clay layer near the base of the Woodbine formation. This same member has been found to persist in Johnson County, and can be seen along the uplands to the east of Cleburne. The overlying and underlying red clays are also used. The mixture of the light and the red clays produce a spotted "de-luxe" brick of the finest quality. Based on the necessary factors of accessibility to raw material, market, fuel, transportation, water, etc., the most favorable locations in

Johnson County would seem to be various points just east of Cleburne, the town of Alvarado, where the upper red clays are accessible, and the town of Grandview. Of these the most favorable appears to be the first named.

Other clay members of the Comanchean have been used. Along the Red River, as at Gainesville, the Weno contains clay members which have been found valuable, these members have thinned to such an extent in Johnson County as to be barely perceptible and of no commercial value. The Pawpaw clays are used extensively in various plants to the north, but here again the thining has been carried to such an extent as to make exploitation of doubtful value. The Pawpaw clays might possibly be used in connection with the Weno limestone in the making of cement as noted in the preceding section on limestone industries.

Occasionally a very white clean clay is found near the top of the Denton formation. This is almost a pipe clay and seems to be the only one in the Comanchean of North Texas which offers possibilities as a pottery clay. No experiment on an extensive scale has been made with this material. Exposures are known in the northern part of Johnson County, in Tarrant County, and in Grayson County. In the last named locality, the clay contains red ironstone seams some of which are a vermillion in color. In fact, it is worth mentioning here, that these seams of red ironstone are found in all of the clay members of the series; are very abundant and much in evidence in the northern part of the section and gradually disappear to the south. The clay members containing these peculiar red seams appear in a series and contain the interesting series of small dwarfed pyrite fossils to which reference has already been made.

In the making of brick, the clays of the Comanchean have been found to have a considerable range in burning temperatures ranging from 1700 to 2100 degrees, the higher temperatures being required by the clays of the Woodbine.

## BUILDING FOUNDATIONS

The city of Cleburne is the only one in Johnson County which bids fair to have large buildings in the near future.

Fortunately, Cleburne is situated on the outcrop of the Main-street limestone near the upper part and has under it nearly 50 feet of hard massive limestone. As the problems encountered in foundations for large buildings are also encountered in the erection of dams and other heavy structures and the rocks of this county illustrate general conditions in the North Texas Comanchean area, a brief discussion of some of the more important facts will be taken up here.

The surface rocks of this region are in the main limestones and marls in alternation. The rocks all have some dip and the thickness of the formations change in certain directions. A further consideration is that the relative thickness of any limestone ledge and its underlying or overlying marl bed may change from place to place.

The limestones of this region do not have solution channels, caves, caverns, etc., and do not form sink holes. In fact it is doubtful whether any other area of similar extent underlain by calcareous rocks is so free from this feature, certainly none is known to the writers. Limestones of the same age in Central Texas often have solution channels, caves, etc. Near Georgetown caves of such extent exist that at one time they were exploited for the large quantities of bat guano which they contained. This, the most common and familiar hazard in erecting massive structures in limestone regions, may be disregarded in North Texas Comanchean areas.

Another important feature which is often overlooked is the fact that the limestone members are of varying thickness and certain ones are quite thin. For some unaccountable reason, despite the evidence of wells, stream cuts, railway cuts, etc., many experienced contractors are obsessed with the idea of a "bed rock." In other words they confidently fancy that after the excavation has been sunk through the mantle of soil and any marl layers which may be present and limestone has been met, that this limestone extends downward to an indefinite depth. They sink the excavation into the hard rock to the depth justified by the size of the building to be erected and feel safe. In certain

cases which we have observed, a consideration of the geology indicated that the building was erected on a base founded on the merest shell of hard rock. Aside from the possible danger, the constant expense of maintaining repairs on a sagging building may cause a loss on an otherwise profitable investment.

Another important point is that even where the dip is gentle as in this region it is entirely possible in wet weather to have "skating" of heavy limestone masses on the underlying marls if the original support has been removed, either by artificial works or by natural erosion. The movement of this sort is what gives rise to the famous slides in the Culebra Cut. An example much nearer home is the constant expense to which the City of Fort Worth is put by repairs to shearing water pipes along such streets as North Street and others. Here the "skating" is an almost imperceptible movement of the overlying Fort Worth limestone on the Duckcreek marl.

## WATER SUPPLY

### Underground Water

The principles of accumulation of undergound water, including artesian water, have been fully discussed in various publications of this Bureau, of the U. S. Geological Survey, and similar organizations. Sanitary conditions governing water supply are discussed in various publications of the Texas State Board of Health. Much of this information has been spread among the citizens. It is gratifying to observe the wide diffusion of knowledge concerning the sanitation of farm wells. We found the majority of these wells correctly protected against surface wash. More than once in filling our water bags, we were pleased to note that the members of the family, especially those of school age, were anxious to see that water was not slopped around the mouth of the well.

The existence of underground water in profitable quantity is determined by a study of the factors of rainfall and drainage, the geology of the region, and of the natural and

mechanical means of obtaining the water. In spite of the general and wide diffusion of knowledge concerning underground water, certain incorrect ideas prevail, the most persistent and popular belief being that an abundance of water will be encountered if the well is simply drilled deep enough. Except where the geology is well known a deep well must be regarded as an experiment.

The most important and fundamental factor in development of underground water resources is a knowledge of the water bearing formations, their nature, their attitude, and their relation to the rest of the geological section. The nature of the rocks bears directly on the problem, because

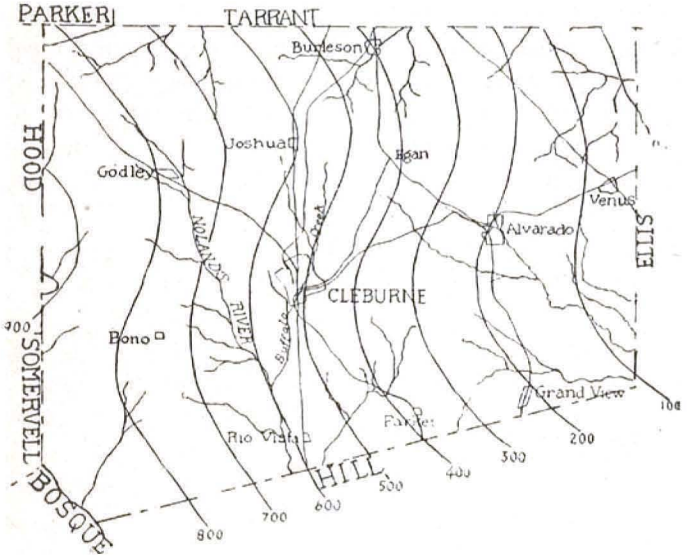


**Fig. 2:**—Map of Johnson county showing structure contours on the top of the Walnut shell conglomerate.

Scale one inch to ten miles.

Data from well records at Polytechnic, Mansfield and other points in Tarrant county, from well records at Joshua, Cleburne, Alvarado, and Grandview; also barometric elevations on the key horizon itself in Johnson and Hood counties; and, in a few cases, by computing from elevations on other horizons, principally the top of the Goodland.

Published by courtesy of Mr. Jon A. Udden, Geologist of the Sinclair Consolidated Oil and Gas Company

certain ones, as granite and marble, absorb little or no water; others such as sandstones and gravels take up large quantities. Also coarse textured rocks, aside from their absorbing ability, allow water to pass rapidly between their particles and consequently yield more. As a comparison, according to Fuller, a clay may absorb as much as 45 per cent of its volume in water and an open textured sand 25 per cent of its volume, yet the sand will yield an abundant supply while the clay will give up very little of its absorbed water.

The attitude of water bearing strata is important. The most favorable position, according to the experts, is a gentle and uniform dip. The water will then sink into the sands at their outcrop and will flow into the wells. Also the approximate depth can be predetermined for any locality. Some such attitude is essential for flowing artesian wells. The outcrop of the beds is referred to as the catchment area, and this area is decreased as the angle of dip is increased.

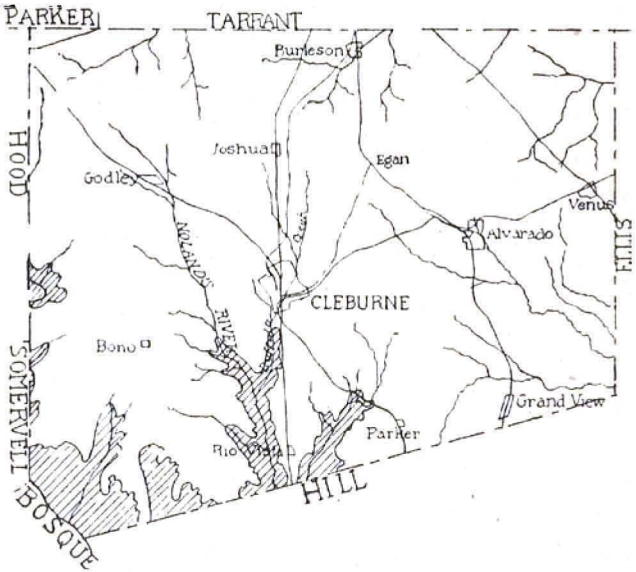


**Fig. 3:**—Map of Johnson county showing areas in which flowing wells from the Trinity system may be obtained.

Scale one inch to ten miles. Adapted from a similar map by R. T. Hill, in U. S. G. S. 21st Annual Report, part 7, 1900.

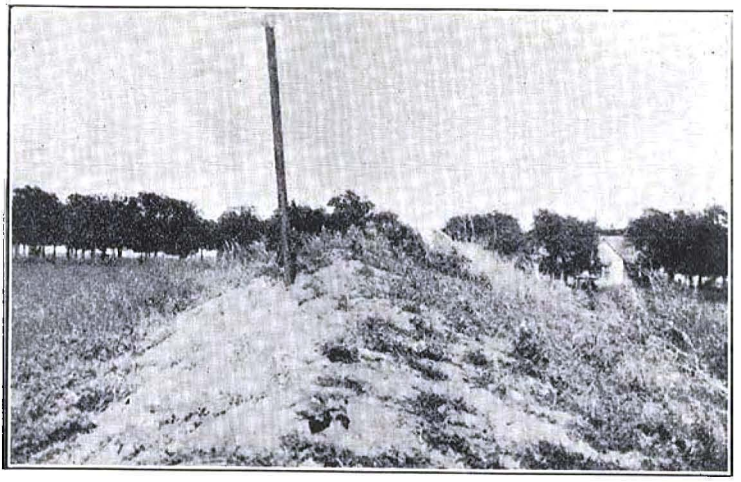

Fig. 1:—Fence covered by drifting sand. An extreme case.

Fig. 2:—Fort Worth limestone on Cleburne-Glenrose road.

Underground water problems in Johnson County are typical for the North Texas Comanchean areas. The principal water bearing formations are, from below upward, the Trinity, the Paluxy, the Walnut, and the Woodbine. A wealth of data for Johnson County and other counties in this area was collected and published by R. T. Hill in his, now classic, report on the geology of the Black and Grand Prairies of Texas.[6] No revision of this accurate and extensive work so far as it bears on water supply has been attempted and none is required. But the experiences of twenty years have thrown light on certain problems.

*The Trinity Formation.* The entire county is underlain by this formation which has here a thickness of rather more than 300 feet. There are three distinct water bearing members. Each is composed of a fine grained, poorly cemented, white sand, known in the outcrop area as "pack sand." It has been estimated that a cubic yard of this sand will absorb 80 gallons of water.

Where compressors are used in pumping water from these sands a certain quantity of the sand is blown out with the water. Considerable quantities of this material can be seen around the pumping plant of the Cleburne City Water Works. That this procedure affects the life of the wells is beyond question. Of the six wells at Cleburne, only one still flows into the underground pumping station (300 feet below the surface), the water from the remaining five being obtained by powerful compressors at the surface pumping station. Although reliable logs of these wells are lacking, a careful study of the situation by the writers has indicated that these wells have been sunk only to the uppermost of the three Trinity reservoirs. The life of the wells might be extended and the use of compressors avoided by drilling down to the second or third water sand, and casing off the upper. The well which still flows into the underground station delivers about 100 gallons per minute.

The parts of Johnson County where flowing wells from the Trinity may be obtained are shown on the map on page 48.

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[6] U. S. G. S., 21st Annual Report, part 7.

A significant feature in connection with the Mead system of underground pumping such as that at Cleburne is that the level to which the water rises may be subject to considerable seasonal variation. E. H. Sellards[7] mentions a maximum recorded variation at San Antonio of 36 feet.

*The Paluxy formation* which underlies most of the county has here two water bearing members. The position and approximate thickness of these can be ascertained from the section on page —

The lower is far the better both in quantity and quality of the water produced. The hard flinty layer between the two is apparently wide spread in area, as determined in many conversations which we have had with drillers and well owners. Sometimes with a small outfit a day or more may be required to drill through this quartzite bed of less than two feet.

A commentary on the general unreliability for scientific purposes of well logs which are not supported by samples is the fact that this striking member is often not recorded on the log; although its depth, hardness and thickness are usually recalled by some one associated with the drilling. In fact, although many hundreds of wells have been drilled in the Comanchean area of North Texas, in no case so far as known to us has a geologist with adequate training in paleontology carefully checked the progress of the drill. In this connection, in our opinion one of the most deplorable scientific losses was the neglect to give some paleontologist an opportunity to study the 300 foot shaft at Cleburne. The circumference of this would have given the equivalent of a cliff face nearly thirty feet wide extending downward through the following formations: Mainstreet, Pawpaw, Weno, Denton, Fort Worth, Duck Creek, Kiamitia, and part of the Goodland. The shaft is now faced throughout with cement.

*The Walnut formation* includes considerable sand in its basal part, some of which is water bearing, and is some-

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[7]Geology and Mineral Resources of Bexar County. Univ. of Tex. Bull., 1919.

times referred to as Paluxy. Many of the smaller wells in the western part of Johnson County obtain their water from the Walnut sands. The water is not of high quality and the flow fluctuates with the seasons. An interesting feature is

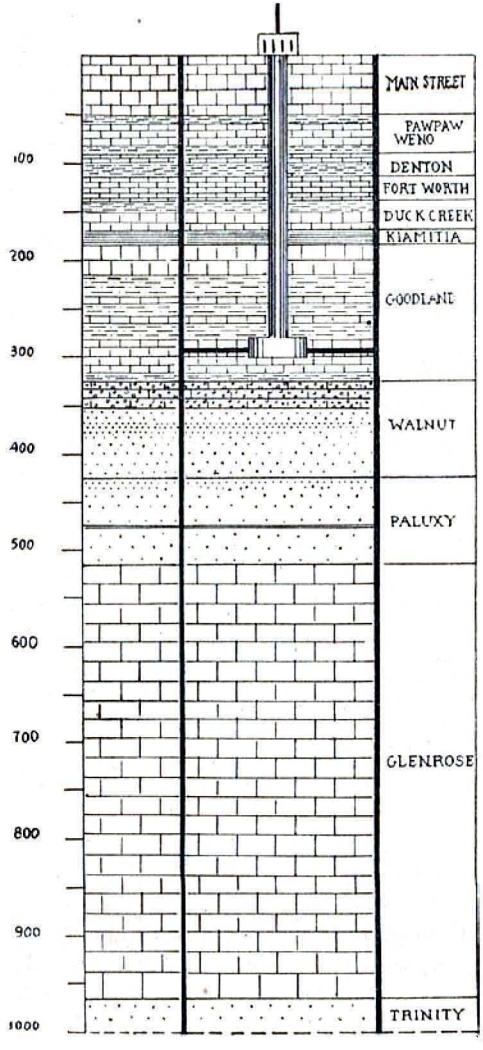


**Fig. 4:**—Diagrammatic representation of the Cleburne City Water Works, showing the underground pumping station, two of the six wells, and the geological section.

that near the deep fissure in the western portion of the county these wells are markedly sulphurous.

*The Woodbine formation* underlies the eastern third of the county. Its water members are the source of an abundant but often impure water supply. There are several of these water bearing members, usually considered in two groups, the upper and the lower. The water from the upper group is very poor being contaminated by gypsum, organic matter, iron, etc. Some of this water is distinctly injurious.

The lower group contains some members which furnish reasonably pure water which is used considerably in the counties of Ellis, Dallas, and Fannin.

Because of the thinning of the Woodbine in Johnson County, the importance of all of these members is greatly decreased. At best the water is poor, and the presence of good water at slightly greater depths should be stressed, at least so far as Johnson County is concerned. Further to the north, the greatly increased thickness of the Woodbine together with a corresponding increase in thickness of the Eagleford formation practically forces the use of Woodbine water in certain cases.

Besides the above, further north occasionally water is obtained from the Kiamitia, from the Duckcreek marl, and from the sands in the Pawpaw. These water bearing beds are nowhere of any great importance and are negligible in Johnson County.

### Surface Water

The use of impounded water is increasing in north Texas. Although pure underground water is available, the unwelcome fact that the supply for certain purposes is inadequate is constantly appearing. The growth of certain cities formerly using underground water has forced them to resort to a more abundant supply. Many cities which now use underground water must soon follow the example of Fort Worth and Dallas and fall back upon surface waters. Among these is undoubtedly the city of Cleburne. In fact

it is merely a tribute to the rapid growth and excellent future before this city that such a statement is made here. Cleburne uses about 100 gallons of water per person daily.

It has been estimated that 12 gallons per person per day are sufficient for all needs of ordinary man. In spite of this, American cities will use much more. Certain cities require as much as 250 gallons per day, as compared with a low figure of 13 gallons per day used in certain European cities. It is useless to point out the fact that American cities waste enormous quantities of water, the fact remains that American temperament is such and American enterprise so well developed that the citizens in no town or city will willingly permit a reduction in the amount of water issued per capita.

Very few American cities of any size now get their water from underground. The city of Memphis, Tenn., is the largest one which obtains all of its water from underground. It is especially well located for such a supply. No North Texas city could expect to reach a size anything like that of Memphis and still depend solely on underground water.

In the location of dams for the impounding of water on a large scale, many factors must be considered. The interests of the city concerned sometimes require a compromise. Very seldom does an ideal situation exist.

Consideration must be given to the geology of the catchment area in figuring on the rate of run-off, in figuring on the quality of the water, and sometimes in determining a suitable base for the dam.

The variation in the run-off in this region is considerable. The greatest rate is from the Eagleford outcrop. The surface in this case after a little preliminary wetting "sheds water like a rubber sheet." More than one dam has come to a disastrous end because the run-off from the Eagleford surface proved to be so much greater than was suspected by the constructing engineer. The least run-off is from the Trinity outcrop; although the other sand formations of the section, the Paluxy and the Woodbine, have a run-off only slightly greater than the Trinity, as does also the Duckcreek marl after it is once thoroughly saturated.

A further consideration is the chemical quality of certain formations, notably the Woodbine. Surface water from some members of the Woodbine is strong with gypsum and other salts.

The best conditions are met when the area from which the water is impounded is largely within the outcrop of the Fredericksburg formations, the Walnut and the Goodland. The city lake at Gainesville is of this type. Lake Worth in Tarrant County draws a little water from the outcrops of certain lower Washita formations and even more from the Paluxy outcrop, but in the main its drainage area is within the Fredericksburg. The water from neither of these lakes contains any important quantity of soluble salts. The suspended material is at times high, but this is readily removed. Soluble salts in city water can not be removed in an inexpensive manner.

The usual engineering factors not having a geological bearing will not be discussed here. Mention should be made of the sanitation of the area from which the water is drawn. Perfect control should be secured and relentless regulations should be enforced. In this connection, the spreading custom of using such waters as a city playground should be opposed. The temptation by the uninformed to use the city reservoir as a pleasure resort is very strong. In one city of North Texas, the present mayor was elected partly on the strength of a promise to establish bathing beaches, driveways, etc. at the city reservoir—a promise which has been kept in a whole-hearted manner. The spectacle of ten thousand persons bathing in one afternoon in the city reservoir is not reassuring.

## SOILS

No soil map of Johnson County has been published. The accompanying geological map of the county is in broad terms also a soil map. Despite the differences in the technical terms used and the greater detailed differences made by soil experts in alluvial deposits, soil maps and geological maps are much alike. A comparison of the geological and soil

maps of Bexar County, Grayson County and others in Texas and of Bryan County in Oklahoma, will demonstrate this close similarity.

The most elaborate soil map covering an area in which geological conditions are at all similar to those in Johnson County is the soil map of Bryan County, Oklahoma. Here in a section similar to that found in Johnson County, thirty-one different soil types are recognized. Besides the different kinds of alluvial material which are distinguished, this map recognizes three different soil types from the material of the Woodbine (Silo) formation. These three types appear to be first, the upper and middle hard red sandstone outcrops, second, the red clays, third, the light colored clays.

The best farms in Johnson County are those in the Black Prairie strip in the eastern part of the county, being valued at from $270 to $320 per acre. These soils are due to the broken down material from the Eagleford shales. Usually the part of the Black Prairie originating in the Austin chalk outcrop is valued more highly than that originating in the Eagleford. This is because of the poor drainage of the Johnson County, because of the thinness of the Eagleford which remains and the nearness to the underlying Woodbine sand. The Eagleford surface in some places appears to be wearing away rather rapidly by erosion. In the outlying "islands" of Eagleford to the west of the main outcrop (see map), the farms in many cases have a "red edge" which should be disturbing to the land owner. It would appear that terracing would be worth while in this part of the county. In some places the Eagleford black land surface can not be more than a few feet thick and is being washed away rapidly, converting the most valuable land in the county into the poorest.

The Grand Prairie strip has a variety of soils as is evidenced by the wild flora. In fact this variation of the flora is a subject to which we have given considerable attention. The general topographic conditions and the appearance of the soil in the Grand Prairie strip exhibit very little variation from formation to formation, but the difference exists. Besides the differences, respectively, between the various

limestone members and the various marl members; a marked difference always exists between the soil resulting from any limestone member and from the overlying or underlying marl. A further difference is observable between the soils of the westward cuesta faces or escarpments and the eastward dip-plains.

The poorest soils, or at least the lowest priced farms in the North Texas Comanchean, are those situated on the outcrop of the Woodbine sands. These, however, offer possibilities which have not been thoroughly tested; particularly for the growing of peaches and certain small fruits. The prosperous peach orchards in Tarrant County, north of Mansfield, furnish a practical example of the one; and the abundant and rich development of wild dewberries along the roads across the sand strip between Cleburne and Alvarado offer an example of the other.

## OIL AND GAS

The Trinity formation is the only one of the north Texas Comanchean formations which might by any possibility be exploited for petroleum products.

This formation contains a definite asphaltic or bituminous layer which seems to be widely spread. This member where exposed in Oklahoma is a little less than twenty feet thick. In Comanche County, Texas, this member is exposed and is here eighteen to twenty inches thick. In the Llano-Burnet area of the Central Mineral Region of Texas, there is near the Trinity base a calcareous member known locally as "ichthyol rock." Water wells in Tarrant, Johnson, Hood, and Parker counties sometimes encounter this member and develop a strong showing of oil. In southern Tarrant County the oil is sometimes present in sufficient quantity to be objectionable and must be skimmed off before cattle will drink the water. We have examined a large number of logs of deep wells in the North Texas Comanchean area and nearly all of these show a record of "showing of oil" or sometimes the more optimistic "nice showing of oil and gas." In fact in the cases of the wells drilled at Handley and at Kenedale

in Tarrant County, when this member was encountered considerable excitement ensued. At the time this is written, approximately a million and a quarter dollars have been expended in the search for oil in Tarrant and Johnson counties alone, and more projects are under way. When one company strikes this Trinity asphaltic member, enough momentum of excitement can be developed to finance another company, and the vicious chain continues.

While we have been unable to obtain official and reliable analysis it appears that the small quantity of oil in the Trinity contains a certain amount of ichthyol. This is an elaborate compound of ammonium, sulphur and organic matter. It is used in medicine. It has at one time been an important commercial article. In medicine it is or rather was used in two ways,—externally as an ointment in the treatment of boils and carbuncles and internally as an intestinal disinfectant.

Ichthyol is rapidly losing its popularity with the medical profession. As far as its external application goes, it may be said that boils and carbuncles are now treated almost entirely by means of other applications or by the use of autogenous vaccines. The internal use of ichthyol is also on the wane from the development of a synthetic substance called thiol which lacks the disagreeable taste and smell of ichthyol. The principal source of ichthyol has been the distillate obtained from certain shales.

The question of developing this member of the Trinity for its ichthyol content as has been suggested by some is seen to be a most precarious venture, leaving out the geological problems involved.

Despite the fact that the small oil wells near Madill, Oklahoma, get their oil from this member the situation in the North Texas counties, including Johnson County, is distinctly discouraging. At best the target for the driller is a small one. A further complication is the divergence caused by the thickening of the Glenrose formation above the Trinity. Until these thickness changes are better understood structural features in the overlying Fredericksburg and Washita formations (and minor structures are admittedly abundant)

could not be depended upon for the accurate location of wells. Drilling through to the underlying Pennsylvanian on the guidance of structures in the Fredericksburg and Washita has been found by costly experience to be useless. A notable case is the series of wells drilled along the Preston anticline in Grayson and Cooke counties.

In view of the above conditions, the writers feel that the time has come to broadly condemn the entire North Texas Comanchean as a possible source of oil or gas.

## DECLINATION, ALTITUDES, WELL LOGS, ETC.

### DECLINATION

The U. S. Coast and Geodetic Survey, in its magnetic tables for 1915, gives the magnetic declination at Cleburne corrected to January 1st, 1915, as 9° 22′ East. The nearest new station is a 1918 station and is twenty-five miles north of Cleburne.

### ALTITUDES

The following elevations are taken from the U. S. G. S. Dictionary of Altitudes and from the records of the County Engineers:

| | Feet |
|---|---|
| *Alvarado*, M. K. and T. track at station | 693 |
| *Alvarado*, B. M. on north abutment of bridge south of M. K. and T. station (U. S. C. & G. S.) | 678 |
| *Burleson*, M. K. and T. track at station | 708 |
| *Cleburne*, Santa Fe track at station | 764 |
| *Eagan*, Santa Fe track at station | 838 |
| *Godley*, Santa Fe track at station | 895 |
| *Grandview*, Santa Fe track at station | 695 |
| *Joshua*, Santa Fe track at station | 923 |
| *Meredith*, Santa Fe track at station | 781 |
| *Parker*, T. & B. V. track at station | 815 |
| *Ponetta*, Santa Fe track at station | 753 |
| *Riovista*, Santa Fe track at station | 745 |
| *Venus*, Santa Fe track at station | 658 |

The following elevations in Johnson County are taken from U. S. G. S. Bull. 637, Spirit Leveling in Texas:

| | Feet |
|---|---|
| *Burleson.* In brick building used as the postoffice, in the east front 4½ feet above the sidewalk, in a panel north of the northernmost window, top of copper bolt (C. &. G. S., B. M.—U3) | 715.064 |

*Eagan.* Siding at, in the M. K. & T. right of way at the left and 7 feet below the track, 50 feet northeast of the south switch and 3 feet from the telegraph pole, the second one south of the station sign; bottom of square cut in top of limestone post. The railway company reported in May, 1903, that on account of grading necessary for the construction of new tracks the bench mark was covered 6 feet. The following bench mark was then established, "R. R." (C. & G. S., B. M.—V3 ..... 827.308

*Eagan.* In the ground in front of the ticket window established by the M. K. and T. engineers, the end of the ball of the top of the rail is 10 feet above bench mark V3; piece rail (C. & G. S., B. M.—R. R.) ..... 837.308

*Alvarado.* ¼ mile south of the station, in north stone abutment of the railway iron bridge, on the lowest step west of the track and 3½ feet below its level, 8 inches from the south and 10 inches from the west edge of the stone; square cut on the stone (C. & G. S., B. M.—W3 ..... 678.240

*Conley.* 25 feet east of the railway track, in the right of way near the first telegraph post north of the south switch; bottom of the square hole cut in top of limestone post (C. & G. S., B. M.—X3) ..... 745.602

*Grandview.* In the west wall near the northwest corner of the brick building occupied by the postoffice, on the south side of Main Street and across from the M. K. & T. Ry. tracks about 300 yards south of the depot, 4 feet above the sidewalk, and 10 inches from the corner of the building; copper bolt let into stone or brick (C. & G. S., B. M.—Y3) 699.175

Elevations of various landmarks in Johnson County are given by the U. S. G. S. topographic sheets and the U. S. Army Engineers' Progressive Military Maps as follows:

Caddo Peak ..... 1050
Brushy Knob (Joshua) ..... 950
Brushy Knob (Burleson) ..... 900
Berry Knob ..... 900
Uplands overlooking Cresson ..... 1050

## LOG OF JOSHUA WELL

**(Furnished by Mr. A. H. Woodfin)**

| | To | |
|---|---|---|
| 30 feet yellow clay | 30 | |
| 70 feet blue shale | 100 | Grayson |
| 25 feet gray shale | 125 | Main Street |
| 25 feet brown shale | 150 | |
| 50 feet blue shale | 200 | Paw Paw<br>Weno |
| 25 feet Lime | 225 | Denton |
| 25 feet blue lime | 250 | Fort Worth |
| 60 feet blue lime | 310 | Duck Creek<br>Kiamitia |
| 30 feet Lime | 340 | Goodland |
| 10 feet blue lime | 350 | |
| 80 feet lime | 430 | |
| 20 feet blue lime | 450 | |
| 40 feet shell | 490 | Walnut |
| 25 feet Pyrites and lime | 515 | |
| 10 feet white sand | 525 | |
| 10 feet blue shale | 535 | |
| 10 feet white sand | 545 | |
| 5 feet blue shale | 550 | |
| 55 feet white sand | 605 | |
| 5 feet red sand | 610 | Paluxy |
| 15 feet white sand, showing of oil | 625 | |
| 10 feet blue shale | 635 | |
| 60 feet lime | 695 | |
| 15 feet lime | 710 | Glenrose |
| 5 feet sand | 715 | |
| 10 feet blue shale | 725 | |
| 80 feet lime | 805 | |
| 20 feet blue lime | 825 | |

| | | |
|---|---|---|
| 125 feet lime | 950 | |
| 20 feet blue lime | 970 | |
| 10 feet sand | 980 | |
| 7 feet gravel | 987 | |
| 2 feet white sand | 989 | |
| 6 feet soap stone | 995 | |
| 25 feet white sand | 1020 | |
| 25 feet blue shale | 1045 | |
| 18 feet sand | 1063 | |
| 12 feet blue shale | 1075 | |
| 10 feet sand | 1085 | Trinity |
| 15 feet shale | 1100 | |
| 10 feet sand | 1110 | |
| 10 feet shale | 1120 | |
| 30 feet sand | 1150 | |
| 10 feet blue shale | 1160 | |
| 30 feet sand, showing of oil | 1190 | |
| 110 feet red brown sand | 1300 | |
| 20 feet blue sand | 1320 | |
| 2 feet lime | 1322 | |
| 16 feet brown sand | 1368 | |
| 2 feet sand | 1370 | |
| 10 feet shale | 1380 | |
| 10 feet sand and salt | 1390 | |
| 5 feet lime | 1395 | Pennsylvanian |
| 23 feet blue shale | 1418 | |
| 2 feet blue lime | 1420 | |
| 228 feet lime | 1648 | |
| 2 feet sand | 1650 | |
| 8 feet shale | 1658 | |
| 30 feet lime | 1688 | |
| 20 feet sand | 1708 | |
| 7 feet blue shale | 1715 | |
| 15 feet sand | 1730 | |
| 25 feet blue shale | 1755 | |
| 15 feet sand | 1770 | |
| 30 feet blue shale | 1800 | |
| 18 feet sand shale | 1818 | |
| 137 feet blue shale | 1955 | |
| 38 feet sand | 1993 | |
| 40 feet blue shale | 2033 | |
| 12 feet sand | 2045 | |
| 3 feet shale | 2048 | |

| | |
|---|---|
| 1 feet iron | 2049 |
| 2 feet shale | 2051 |
| 22 feet sand, showing of gas | 2073 |
| 3 feet blue shale | 2076 |

## COMPOSITION OF CLEBURNE CITY WATER

**A Typical Trinity Water. Analysis by Dr. Harper, University of Texas**

| | Parts per million | Grains per U. S. gallon |
|---|---|---|
| Nitrites ($NO_2$) | none | none |
| Nitrates ($NO_3$) | none | none |
| Ammonium ($NH_4$) | .0326 | .001749 |
| Potassium (K) | 3.405 | .1983 |
| Sodium (Na) | 166.2 | 9.7051 |
| Magnesium (Mg) | none | none |
| Calcium (Ca) | 33.08 | 1.9296 |
| Chlorine (Cl) | 32.0124 | 1.8737 |
| Sulphates ($SO_4$) | 140.625 | 8.2028 |
| Carbonates ($CO_2$) | 12.6 | .1762 |
| Bicarbonates ($HCO_3$) | 415.885 | 24.2546 |
| Alumina ($Al_2O_3$) | 2.9 | .1688 |
| Iron ($Fe_2O_3$) | none | none |
| Silica ($SiO_2$) | 14.00 | .8166 |
| Total | 820.74 | 74.3 |

*Hardness*, less than 35.

## DESCRIPTION OF GEOLOGY ON THE CLEBURNE-GLENROSE ROAD

The writers have a large number of descriptive road logs of the following type. The fascination which these logs have for the average non-technical motorist is remarkable. The following log has been selected as the Cleburne-Glenrose road is traveled more by pleasure seekers than perhaps any other road in North Texas. The language is the familiar language of the motorists' "blue books."

0.0 Start, northwest corner of Courthouse Square, Cleburne. Go out street to the west, passing city water works on the right.

0.2 Cross iron bridge over branch of Buffalo Creek. Note the lime-bluffs to the left. These are of Mainstreet limestone, a formation fifty feet thick which underlies the city of Cleburne.

0.5 Swing left.

0.8 Jog right, then left, on out main road. This is the Meridian highway.

1.3 Cross stream on cement bridge. The limestone exposed in the stream bed is the Weno limestone. Very few fossils.

2.8 The hill crest here is the upper end of a typical dip-plain which has just been ascended. The woods visible to the rear (east) along the horizon mark the Woodbine formation. Passing over the crest note how much steeper the descent is than the ascent. We are passing rapidly through the Mainstreet formation. The escarpment here may be considered as the "end" of the dipping Mainstreet formation. A gently dipping dip-plain ending in an abrupt escarpment forms the topographic type known as a "cuesta."

3.0 Swing right.

3.3 Swing left.

3.9 Cross iron bridge over branch of Noland's River.

4.0 Cross iron bridge over Noland's River. The limestone cliff visible to the left is of the Weno formation, and can be distinguished from the Mainstreet formation only by the fossils.

4.2 Cross iron bridge. The base of the Weno limestone is at the hill top.

4.6 Cross roads, sign post "Bono road one mile." Turn right. The Meridian highway just left goes on to Waco.
Road is now on Denton marl formation.

4.9 The house (with windmill) to the left is just at the contact of the Denton marl above and the Fort Worth limestone below. Note a distinct topographic break at this point and note that it can be traced by the eye for some distance. By means of slight topographic differences of this sort geologists are able to trace contacts between formations from one exposure to another.

5.0 Cross iron bridge. Note the limestone cliff at the south end of the bridge. This exposes nearly the entire Fort Worth formation. The view shown in plate 6 was taken from this bridge. This cliff is rich in fossils typical of the Fort worth formation. Some of the large ammonites and echinoids can be seen from the bridge.

5.1 Swing right, left, right.

5.4 The road along this upland is back on the Denton marl.

5.6 Cross roads. Road to left goes back to Cleburne. Go straight ahead.

5.7 Turn left. Road is back on Fort Worth formation. Note the many exposures.

6.2 Cross small wooden bridge, Fort Worth limestone in cliff to the left.

6.3 The cut at the hill top here is in Denton marl. Note the large number of fossil oysters *Gryphea washitensis.*
6.6 Turn right. Road is back on Fort Worth limestone.
6.7 Turn left.
7.2 Swing left, The rolling topography visible on every side here is typical of the Fort Worth limestone. This is the typical Grand Prairie country. Note the chocolate colored soils.
8.3 Cross cement bridge over Robinson's Branch. Pass into village of Bono.
8.4 Turn right—gin on the left—turn left and right at the store, then left following main road. At end of village street turn left.
8.7 Pass two storied school house.
9.0 Turn left.
9.1 Turn right.
9,2 Cross small iron bridge.
9.6 Jog left and right.
10.6 Swing right with road. Turn marks contact between the Fort Worth formation above and the Duck Creek below.
10.8 Cross small bridge.
11.2 At the hillcrest look ahead and slightly to the right, for Comanche Peak which looms up conspicuously although over fifteen miles distant.
11.4 Swing left.
11.8 Curve around hill. Road cuts along here are in Duck Creek marl, the upper part of the Duck Creek formation.
14.3 The yellow-brown clay at the side of the road is of the Kiamitia formation. It contains many fossils, but this particular exposure is rather poor.
14.7 Goodland limestone. Note the hard upper part which becomes the Edwards formation of Central Texas.
15.2 Road here runs along the top member of the Goodland. Note the characteristic development of juniper cedars. Curve right and left with road. Brazos Valley ahead. Note the many peaks and bluffs of the Goodland formation. This view is famous.
15.5 Curve left with road and begin descent of the Goodland escarpment called locally "the mountain." Drive slowly, this hill is dangerous.
15.6 Curve right.
15.9 Curve left.
16.1 The large conical hill to the right is Barnard Knob. It is distant about five miles although it appears quite near.
16.3 Swing right. Looking back and to the right from this point Berry Knob can be seen, almost hidden by a part of the escarpment. Distant about one and one-half miles.

17.1 Walnut shell conglomerate. Note that it includes enormous numbers of curved oyster-like shells. The species is called *Gryphea marcoui,* and this conglomerate is an important geological landmark.

17.2 Culvert at base of hill. COUNTY LINE between Johnson and Somervell counties. The line passes from this point just about half way between Barnard Knob and Berry Knob both of which are still clearly visible to the right. The culvert is on a sandstone below the shell conglomerate.

From here to Glenrose the road passes next over the Paluxy red sandsone then over the hard Glenrose limestone, which is reached shortly after passing the village of Nemo.

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