University of Texas Bulletin

No. 1818: March 25, 1918

THE GEOLOGY OF DALLAS COUNTY

By

ELLIS W. SHULER

Professor of Geology, Southern Methodist University

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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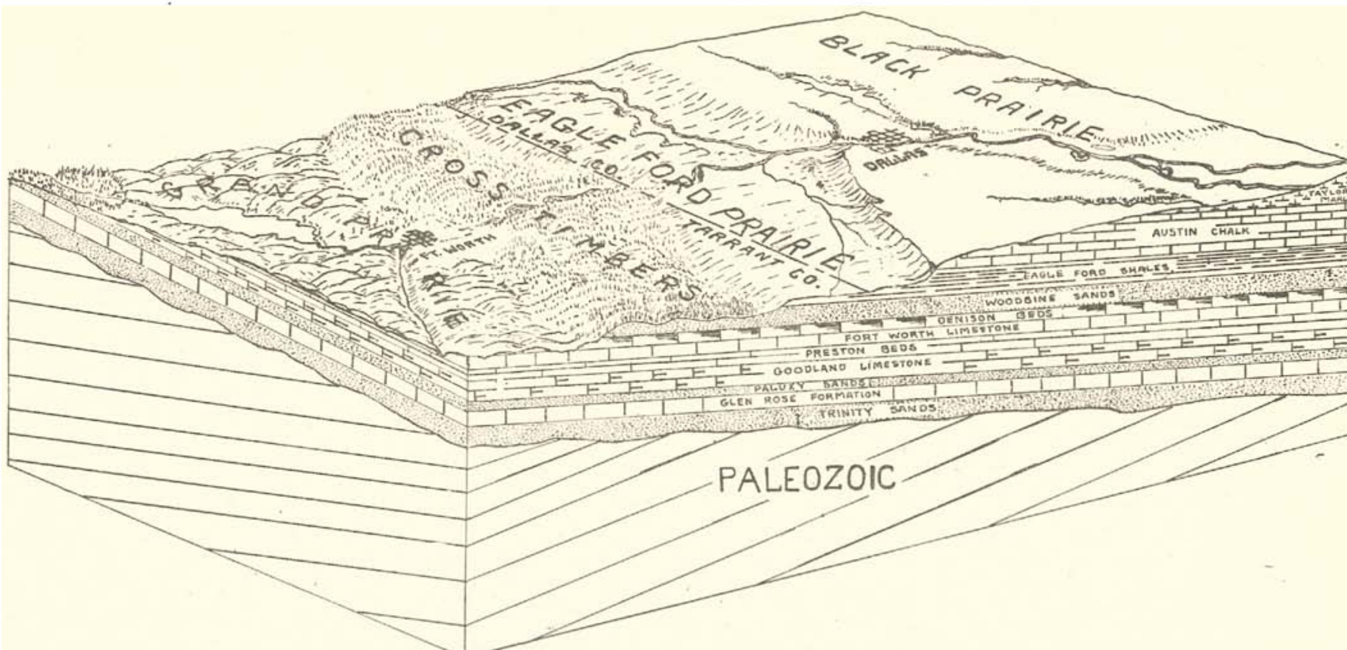


Figure 1. Block diagram showing cuesta topography and underground structures in Dallas and Tarrant Counties, Texas

THE GEOLOGY OF DALLAS COUNTY.

BY ELLIS W. SHULER

INTRODUCTION

This bulletin is written primarily for the benefit of the citizens of Dallas County and that it may reach the largest audience possible, the language is as simple and non-technical as is in keeping with scientific exactness.

To the casual observer the geologic interest of the county is somewhat commonplace and the economic resources few; but on closer examination much of geologic interest is found and the economic products, while limited in number, have a large place in the commercial world of Central Texas.

ACKNOWLEDGMENTS

The writer desires to express his obligation to the following drilling firms who have furnished information as to wells drilled in various parts of Dallas and near-by counties: R. H. Dearing and Sons, Dallas, Texas; T. E. Shutt, Dallas, Texas; J. F. Swadley, Grand Prairie, Texas; J. L. Finch, Irving, Texas.

To Mr. J. F. Witt, County Engineer, for the base map used in working out the geology of the County, and for the location of its chief gravel deposits; and to Mr. George B. Dealey, who furnished most interesting data concerning early geologic work in Dallas County, the writer wishes also to express his appreciation.

GEOGRAPHY

Dallas County lies in the North Central part of Texas, approximately between the parallels 33° and 37° 30′ North latitude, and the meridians 96° 30′ and 97° 5′ West longitude. Its shape is that of a rectangle each side of which is about thirty miles in length, including an area of slightly more than nine hundred square miles.

This area was included in the Peters' Colony grant of 1841 and its first settler, John Neely Bryan, came in that year. The territory was at first under the jurisdiction of Nacogdoches County. Dallas County was created March 26th, 1846.

The first settlers in the county were largely from Kentucky, Tennessee and Wisconsin. In 1855 a colony of French, Belgian

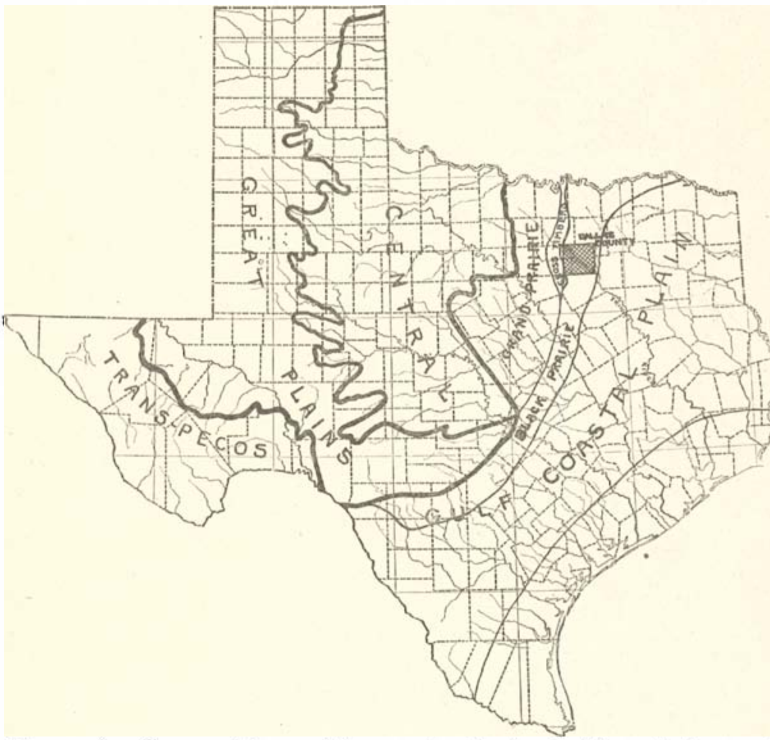


Figure 2. Geographic position and physiographic relations of Dallas County, Texas

and Swiss political refugees, expatriated by the Napoleonic *coup* in 1851, settled on the west side of the Trinity River, west and southwest of the section now known as West Dallas.

The history of Dallas County is closely linked with that of the city of Dallas, which is situated near the center of the county and which was the site of the initial settlement of the county. The village of Dallas was located at a widely known road crossing of the Trinity River, just below the junction of two of its important branches, on a broad white rock terrace along the river, which offered favorable building sites. Peopled by a virile and cosmopolitan colony, the village of Dallas had many geographic advantages which make possible the growth and development of great cities. Fully has the city of Dallas measured up to those opportunities, both in the loyalty and high ideals of her citizens, her banking facilities, the size of her manufacturing and distributing industries, her educational interests, and in city planning, until today she ranks as one of the most important and cosmopolitan cities in the southwestern part of the United States.

TOPOGRAPHY

In a region where the underlying beds of rock dip at a low angle in one general direction, if there is a difference in the resistence of certain of the beds to erosion—that is, if they are harder than others, such resistant beds will stand up as hills while the valleys will be etched out on the softer beds. The hills will have on the side toward which the beds dip, a long gentle slope, often spoken of as the dip plain, and on the other side, a short, steep slope. Such an unsymmetrical hill is called a *cuesta*.

The cuesta type of topography is typically developed along the landward margin of a coastal plain across which consequent streams carry the drainage to the ocean. As the main stream cuts its way downward into the plain across the hard and soft beds of rock, across the grain of the country, lateral tributaries, in general at right angles to the main stream, attack the softer belts of rock, etching out valleys along the grain of the country and leaving the harder beds standing in relief.

Dallas County lies within the area of the Black Prairie, which with the Grand Prairie to the west forms the outermost landward margin of the Gulf Coastal Plains in Texas. The topography of the county is dominated by the underlying rock structure.

White Rock Cuesta

The outstanding topographic feature of the county is the well-defined cuesta developed on an indurated chalk and limestone marl formation commonly known as the "white rock." This cuesta occupies a broad belt ten miles wide running east of north and south of west across the middle of the county. At its highest point near Cedar Hill in the southwestern part of the county the cuesta crest reaches an elevation of 820 feet. It has an average relief of about 300 feet above the valley to the west.

The southwestern face of the cuesta, along which runs Mountain Creek, is steep and rough. It is known as the cedar brake country. Streams finger back into the edge of the escarpment, forming steep, narrow gulches, covered with heavy scrub timbers, which even yet form a haven for wolves and other wild animals.

The northwestern slope of the cuesta, north of the juncture of the branches of the Trinity, is much more gentle; so gentle, in fact, that east of Farmer's Branch and Carrollton the white rock, instead of forming a cliff, wedges out over the shale so gradually that it is difficult to determine its western boundary line.

Trinity Valley

Near the center of the county the cuesta topography is interrupted by the broad valley of the antecedent Trinity River which runs approximately at right angles to the general direction of the White Rock cuesta and the strike of the rocks within the county. The valleys of both the West and the Elm Fork of the Trinity have a breadth of three to five miles in width. The two branches join west of the White Rock cuesta. The valley of the combined streams narrows, hour-glass fashion, where the river cuts across the white rock at Dallas, until the flood plain is less than a mile wide. Having passed this constriction, the river again meanders over a broad flood plain.

Black Prairie

The country east of the White Rock scarp which forms the western margin of the White Rock cuesta, lies within the province of the Black Prairie. The soils over this area are finely

Plate I-A. Gentle eastern slope of the White Rock cuesta, looking west from Beckley Road

Plate I-B. Western scarp of the White Rock Cuesta from Grand Prairie. Often called the "Mountain" divided clays containing a large amount of triturated carbonaceous material and are known as the "black waxy" soils.

The Black Prairie is an open, rolling plain which dips slightly but gradually to the southeast. It is cut by narrow, shallow, sluggish streams with steep banks which are rather widely spaced over the area. These streams, with the exception of White Rock Creek, follow the general slope of the dip plain. In the eastern part of the county the streams flow into the East fork of the Trinity River which is a lateral tributary of the Trinity to the east in Rockwall County.

Eagle Ford Prairie

Descending the western slope of the white rock scarp and crossing Mountain Creek to the south and Elm Fork to the north, one passes up along a dip plain, developed on soft shales, which is a part of the Eagle Ford Prairie.

West of Mountain Creek the area is that of a gently rising plain so smooth, even, and treeless that it seems almost artificial in its character. The ascent from the Elm Fork, however, is abrupt across low rounded shale hills from which one passes to a sloping upland which in many places is covered with ancient alluvium of the Trinity and a dense forest of scrub oaks. South of Denton Creek, around Coppell, the open prairie again appears in typical form.

GEOLOGY OF DALLAS COUNTY

The rocks outcropping in Dallas County are Upper Cretaceous in age and include practically the whole of this series in North Central Texas. The uppermost division of the Woodbine formation, the Lewisville beds—sands and sandy clays—outcrop in a small area about six miles long and a mile wide along the western boundary of the county north of the Trinity River flood plain.

Three broad belts of rock running slightly east of north divide the remainder of the county into sub-equal divisions. The western belt is underlain by bluish-black and gray shales, the Eagle Ford formation; the middle belt is underlain by the indurated chalks and shaly limestones of the Austin formation;

and the eastern belt by the soft shales, marls and clays of the Taylor formation. If the Navarro beds are represented at any point along the eastern boundary of the county they do not occur as a recognizable, mapable unit.

Structure

The structure of the Cretaceous rocks underlying Dallas County is simple. It consists of imbricated underlapping layers of rock all dipping toward the southeast at a low angle. Such a mass of bedded rocks, all dipping in the same direction has been termed a "homocline."* The dip of the beds everywhere is gentle, varying from 40 to 100 feet per mile, with an average dip of 50 to 60 feet. Block faulting on a small scale has produced occasional small reversions of dip, especially within the area of the Austin chalk, but such reversions are only for short distances and the structure is readily detected. The most notable reversion of dip within the county seen by the writer was found about two miles east of De Soto where the dip was 1 foot in 40 to the west. About a quarter of a mile west of this outcrop the dip was normal, that is, to the southeast, but unusually steep, 1 foot to 24 southeast.

The structure of the Paleozoic rocks which underlie the Cretaceous is unknown. Red shales lying underneath the basement sand have been penetrated in at least two deep wells in the city of Dallas, but no clue as to the dips of the shale was given.

Geologic Map

The location of the outcrops of the different formations is shown on the Geologic map, Plate I, accompanying this bulletin. Boundary lines of the outcrop of intergrading formations are always more or less arbitrarily drawn, and it is probable than another geological observer would shift somewhat the boundary line between the Woodbine sands and the Eagle Ford shales, or between the Austin Chalk and the Taylor formation. Certain minor errors were found also in the base map which affects the accuracy of the geologic map.

*R. A. Daly: Memoir 68, Geological Survey of Canada, 1915. Page 53.

Geological Formations

Woodbine Formation

While the Woodbine Sands underlie the whole of Dallas County and may be reached in drilling at comparatively shallow depths, about 1600 feet along the eastern boundary of the county, they come to the surface within a limited area along the western boundary where the broad belt of sand crosses the eastern part of Tarrant and overlaps into Dallas County. Only the uppermost division of the Woodbine formation outcrops within the county.

The Woodbine formation in this section of Texas is divisible into two parts: a lower division characterized by highly ferruginous sands, known as the Dexter sands; and an upper division of interlaminated shales and sands, lignitic sands and clays, and ferruginous and calcareous sandstones, some of which are highly fossiliferous. The upper layers are known as the Lewisville beds.

Dexter Sands

Although the lower division does not outcrop within Dallas County, on account of its importance as a water-bearing strata it is deserving of special description.

The Dexter sands rest on top of the Comanchean series of rocks. Good exposures in Tarrant County are to be found along the Interurban Railway about two miles west of Arlington and also in the hills capped with ferruginous sandstone west of Handley. The most interesting phase of the outcrop west of Handley is the lenticular character of the sands. This is of interest to the driller for water or oil since it shows that there will always be an unknown value to be taken into account in calculating the depth of the water or oil sands. Most of the sand lenses show steep cross-bedding. The sands are interbedded with shales and shaly sands. The base of the Dexter sands is highly ferruginous, but becomes less so in passing upward. The water in the sands of the Dexter division is generally better in quality than that from the Lewisville beds above.

Lewisville Beds

From the coarser ferruginous cross-bedded sands of the Dexter division the transition upward into the Lewisville beds is a gradual one. In the Lewisville division the shale and sand beds are thinner and show more rapid alternations until they lie in thin laminated beds near the top. Lignitized bands of clay, fossil wood, and calcareous layers containing an abundant molluscan fauna occur. The best outcrops of the Lewisville beds in Dallas County are found along the road west of Sowers and at the bridge crossing Bear Creek near the Tarrant County line.

It is probable that the Lewisville beds outcrop along the Elm Fork in the northwestern corner of the county, but the area is so covered with timber and alluvium that it could not be mapped with confidence.

The water from the sands in the upper part of the Lewisville division is the least desirable of all the Woodbine waters since it is highly impregnated with salts. Some wells in the eastern part of Dallas County and in counties to the north have been abandoned on account of this salty water, when by drilling into sands at a small depth below, good potable water could have been secured.

The position of the water sands in the Woodbine formation is highly variable within the formation, and estimates of depth for drilling wells should take account of such variability. Drillers refer to the water sands serially as first, second, or third Woodbine. The lenticular character, anastomosing relations, and variability of the water sands is strikingly shown by the varying interval between the first and second water sands. Eight wells within the area of the city of Dallas show the following intervals between the "first" and "second" Woodbine: 196, 106, 167, 56, 202, 114, 288 and 197 feet. This would show a variation of from 56 to 288 feet. This does not mean that there are no sandy layers between the water-bearing sands, but that the sand lens at that particular section was not sufficiently thick to carry notable quantities of water.

Eagle Ford Formation

Overlying the yellow and brown shales and sandy clays of the Woodbine there is a transition of 30 to 40 feet of gray shales which pass upward insensibly into predominantly blue and bluish-black shales.

These shales were named Eagle Ford by R. T. Hill because of their excellent exposure near the town of that name situated on the T. & P. Railroad six miles west of Dallas.

The formation is predominantly blue shale with an occasional thin bed of sandstone and carries at intervals from bottom to top lime concretions of various sizes, both in layers and as isolated individuals. The shales carry a high content of bituminous and carbonaceous material to which they owe their blue-black color. Fossils are rare, but occasional layers carrying fragments of fish bones and teeth early gave the designation "Fish beds" to the formation. The shales are soft and weather rapidly to a brownish-to-black soil. Fresh exposures of the shale are found at rare intervals.

Exposures of Eagle Ford Formation

Near Eagle Ford, the type locality, the following section is to be seen at Harry's Brick Plant.

SECTION AT HARRY'S BRICK PLANT, WEST DALLAS

	Feet
Austin Chalk	
Chalk, deeply weathered and yellow in color	10
Eagle Ford Shale	
Shale, laminated, bluish gray, occasional sandy and pyritiferous laminae	20
Shale, with large lime concretions, up to four feet in diameter, with numerous fossils	2
Shale, bluish gray to gray, laminated	11
Shale and standstone, alternating slabby layers with occasional concretions	3
Shale, gray, laminated, uniform in texture	14

The section at Harry's brick plant gives the characteristic features of the top of the Eagle Ford formation. The basal beds are seen in a good section below the iron bridge crossing Bear Creek near the Dallas-Tarrant county line. This section was early described by Taff* as follows:

BEAR CREEK SECTION

3. Laminated sand and sandy clay, interstratified with indurated

*J. A. Taff, Geo. Survey of Texas, 4th Ann. Rept., p. 292.

sandy flag stones, one to three inches thick, at intervals of nearly two feet.

2. Arenaceous and calcareous clay, finely laminated, which contains numerous clay segregations, and nodular concretions bearing many beautifully preserved *Buchiceras iniquiplicata* which are peculiar to the Eagle Ford formation.

1. Stratified brownish sand and sandy clay, locally indurated, which contain in their upper portion an abundant Timber Creek fauna (Lewisville beds), of which Ostrea is most numerously represented.

At a sharp bend to the north in the Trinity River, north of Grand Prairie, an excellent exposure of the middle division of the Eagle Ford shales occurs. The section consists of a vertical wall of 50 feet of thin laminated blue shales. No concretions and very few fossil fragments were noted at this locality.

Blue shales are exposed at Bachman's Dam, at California Crossing, Record Crossing, and at the iron bridge north of Eagle Ford. Below the dam at California Crossing, west of Letot, the shale is thickly crowded with small nodular concretions.

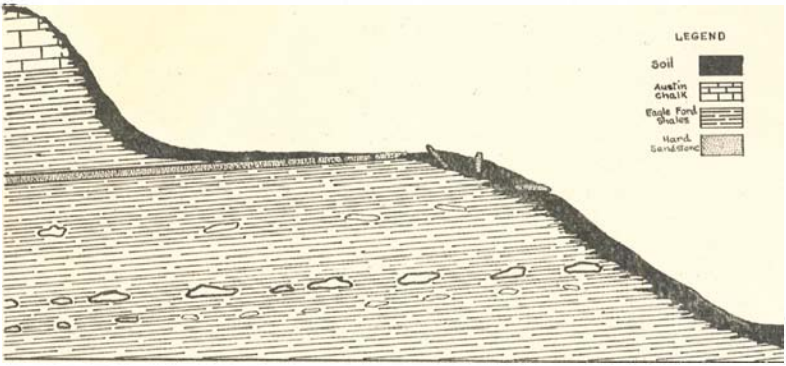


Figure 3. Section along western edge of White Rock hill, showing loose slabs of rock falsely indicating reversal of dip

The following section is exposed below the dam northwest of Carrollton:

	Feet
Light blue shale in thin laminated beds..........	8
Blue-black shale in thick layers................	6

The western face of the "White Rock" cuesta overlooking the valley of Mountain Creek has numerous exposures of the shale in the gulleys which trench the face of the scarp. Huge con-

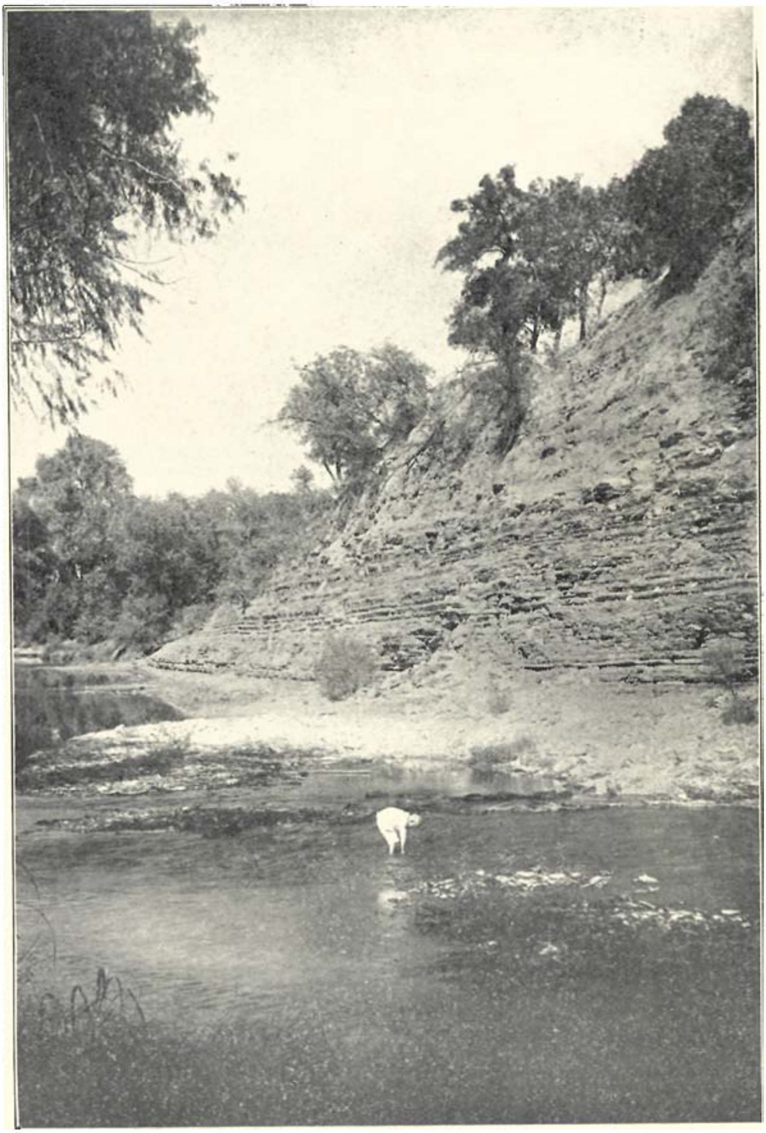


Plate II. Eagle Ford shales, bluff of the Trinity River north of Grand Prairie cretions project from the steep slopes or form a talus at its base. Plate IIIA shows such an example.

Along the face of this scarp there is a hard layer of sandstone with calcareous cement which makes a broad bench along the slope. The bed dips gently to the southeast under the chalk, but along its outcropping edge there occurs a minor phenomena which is somewhat puzzling to the uninitiated. Down the steep slope below the bench are to be found big slabs of rock sticking out of the ground and dipping at various angles, most often steeply to the west. On casual glance this gives the appearance of a distinct reversion of dip. The slabs of rock are partially buried in the surface soil and their position is due to soil creep along the slope. Since the top soil moves faster than the subsoil, the slab of rock is slowly rotated on its journey down the slope, and hence the varied position and angles in which the rock is found. Figure 3 illustrates this phenomenon.

Concretions in the Eagle Ford Shales

One of the most striking features of the Eagle Ford formation is the numerous and varied concretions which occur at intervals throughout its mass. These rounded "boulders" vary widely in size, shape, and pattern, and resemble various objects such as dumb-bells, biscuits, clubs, bombs, etc. A common type is that of the septaria, a flattened, disk-shaped concretion from five to fifteen or more inches in diameter, which because of the intricate polygonal cracking over the surface bears a striking resemblance to a turtle's back and is often mistaken for a fossil turtle.

Concretions appear to be the result of the deposit of mineral matter from solution,—in the Eagle Ford shales, calcium carbonate or iron sulphide, around a central nucleus, often a fossil. (See Figure 4, Plate IV.) The concretion grows by constant addition of the mineral matter to the surface of the mass; and since the water also circulates through the concretion, at times interstitially, this latter process causes an expansion circumferentially and a wedging apart of the interior, resulting in the formation of a series of cracks in polygonal patterns throughout the mass. The cracks, initially minute, are pulled wider apart as the concretion grows.

Most often the circulating water fills the cracks with calcite which in crystallizing probably aids in the wedging process through the force of crystallization. Pyrite and selenite are also deposited in the cracks.

Occasionally it happens that no deposit is found in the cracks (Fig. 6, Plate IV); or the cracks may be partially filled (Fig. 9, Plate IV). Generally the crack is completely filled, as in Figures 5 and 8, Plate IV. In Figure 5, two generations of crystal growth are seen.

When exposed to weathering it often happens that the main mass of the concretion is more soluble than the material which filled the cracks. When the main mass is dissolved a curious honeycomb pattern remains, as in Figure 10, Plate IV.

Aside from their scientific interest, concretions have a very practical interest to the well driller, by whom they are called "boulders." Delay in drilling due to the hardness of the boulder, or a crooked hole, are often the result of striking the larger lime concretions.

Austin Chalk Formation

While the beds of the Austin Chalk are conformable on those of the Eagle Ford shales, the transition is abrupt. This transition is well shown in the deep cut of the Fort Worth and Dallas highway where the road descends the steep face of the White Rock cuesta. A view of this cut is shown in Plate V. The section at the locality is given below:

SECTION AT WHITE ROCK HILL

	Ft.	In.
Austin Chalk		
Chalk, massive	10	
Gray marl		3
Eagle Ford Shale		
Indurated ash-gray layer containing much sand, fragments of fish bones and teeth, and occasional quartz pebbles up to 1 inch in diameter		10
Shell layer with occasional small concretions		2
Laminated brown and gray shales with abundant needle-like selenite crystals	3	
Sandy layer, hard, brown, with occasional boulders	1	4
Shale, bluish-gray	10	
Shale carrying concretions	1	6
Shale, blue		

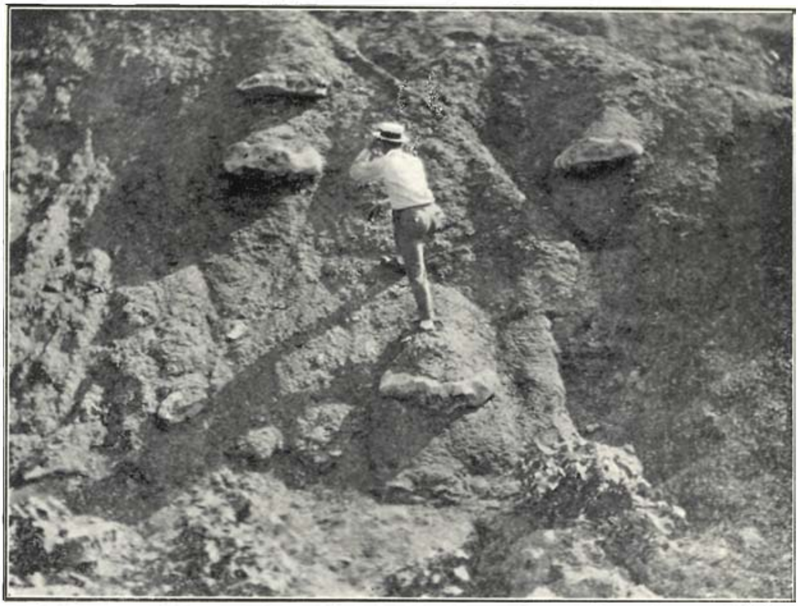


Plate III-A. Concretions in Eagle Ford shales, Mountain Creek Valley

Plate III-B. Contact of Eagle Ford shales and Austin chalk at White Rock hill on Dallas-Fort Worth pike

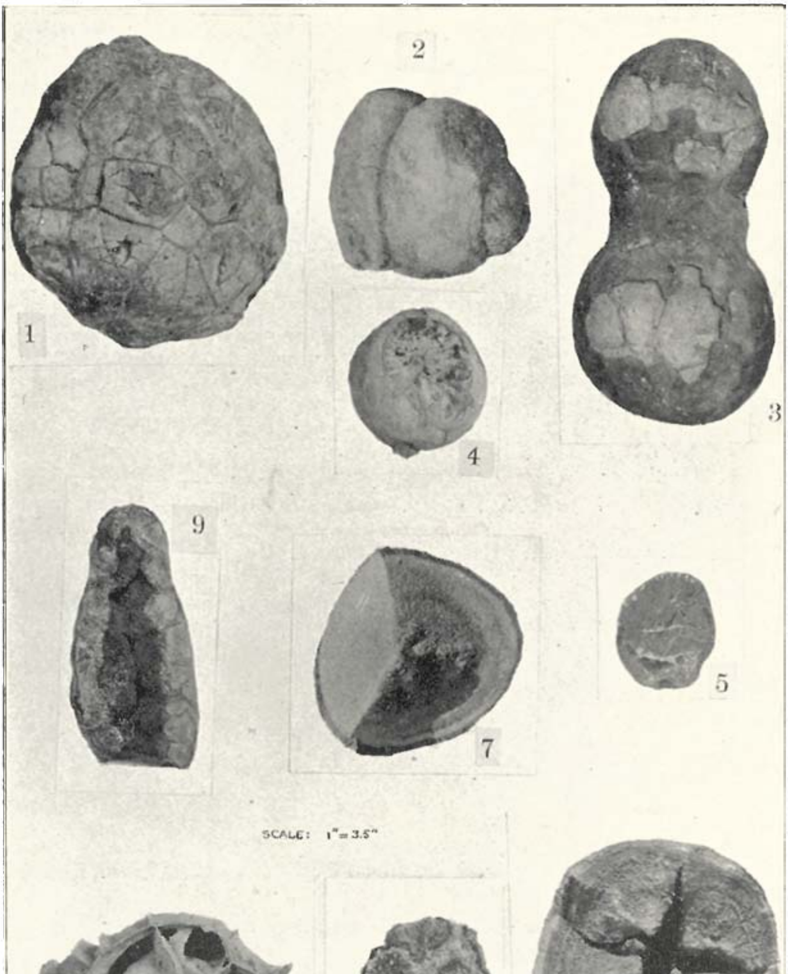


Plate IV. Concretions from the Eagle Ford shales

Plate V. Contact of Austin chalk and Eagle Ford shales. Deep cut at top of White Rock cuesta. Dallas-Fort Worth pike.

The outcrop of the Austin Chalk or "White Rock" has in the vicinity of Dallas a width of 13½ miles. It was named by R. T. Hill who in his preliminary work called the formation the Dallas-Austin chalk. Later when he fully described the formation as it occurs around the city of Austin, he gave it the single title, Austin Chalk. The formation consists of a thick series, about 500 feet, of alternating beds of chalk and shaly limestone and marls which have a blue color when saturated with underground water, but which are cream-colored or glaring white upon exposure to weathering.

Although the formation is called the Austin Chalk, in Dallas County only a few layers near the base are properly termed chalk, and even these beds carry only about 85% of lime carbonate. A typical chemical analysis of the chalk is as follows:

	Per Cent
*Calcium carbonate	82.512
Silica and insoluble residue	11.431
Zinc oxide and aluminia	3.618
Magnesia	1.189

When freshly quarried the rock is soft and easily cut with a knife or saw, but on exposure to air many layers develop considerable hardness.

In Dallas County the formation may be given, somewhat arbitrarily, a threefold division. For about 150 feet from the bottom the formation consists of heavy bedded, massive chalk layers separated by thin, shaly layers, the most resistant beds being included in the basal fifty feet. A typical section within the city of Dallas is given below:

SECTION IN AUSTIN CHALK

at Michel Lime Co., Oak Cliff. Section about 30 feet above the Eagle Ford shales.

	Ft.	In.
Limestone, hard, white	1	4
Limestone, crumbly	1	8
Limestone, gray	1	
Limestone, shaly, gray	4	
Chalk, soft, gray	3	2
Chalk, gray	1	2

*U. S. G. S., 21 An. Rept., Pt. VII, p. 329. R. T. Hill.

	Ft.	In.
Chalk, white	1	
Chalk, gray		1
Shale marl (weathers rapidly)		2
Chalk, white and blue mottled	5	
Shale marl		5
Limestone, gray	2	9
Shale marl		5
Limestone, blue	2	10
Shale marl		3
Chalk, blue	2	4
Shale marl (weathers rapidly)		3

The lower division is also characterized by an abundance of nodular, spherical or cylindrical concretions of iron pyrites, "fool's gold", which on weathering gives rise to streaks of rust stain down the chalk wall.

On exposure to weathering the thin shale layers are etched back more rapidly than the massive chalks. This gives rise to a rippled or ledge appearance along the walls of the narrow canyons which the small streams have cut into this division. This is seen in Plate VI.

The middle division of about 250 feet has fewer massive layers and is characterized by thick, and often indurated shaly layers which show remarkable lamination, many layers to the inch. The walls of the canyons cut in this division do not show as marked rippling as those of the division below.

In the uppermost division the proportion of shaly limestone is larger and the chalk layers are rare. The colors are predominantly blue and yellow. Occasionally sandy layers are found.

The transition into the Taylor formation is again somewhat abrupt, but not so marked as that from the Eagle Ford below. The following section was taken north of Wilmer:

SECTION AT BRIDGE ONE-HALF MILE NORTH OF WILMER

	Feet
Taylor Marl	
Yellow clay	3
Yellow shale, bedded	3
Gray shale, laminated	3½
Gray limy shale	
Austin Chalk (contains Inocerami)	4½
Massive flaggy chalk in bottom of creek with large Ammonite 2½ feet in circumference.	

The following thicknesses of the white rock have been reported

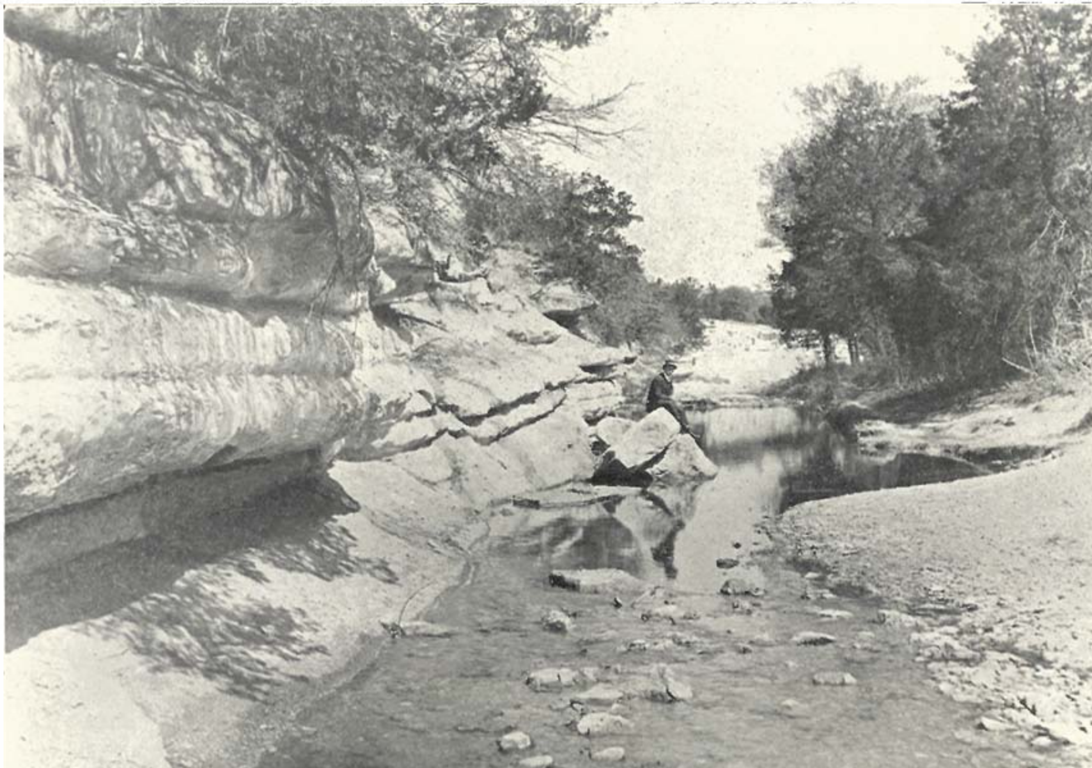


Plate VI. Typical outcrop of the lower division of the Austin chalk along Cedar Creek, Forest Park, Dallas from well logs in or near Dallas County: Cole Press Brick Co. at Ferris, 425 feet; at Henry, Ellis County, 504; Orphans' Home, Dallas, 487; making an average of 472 feet. This average is probably low, since while it is easy to determine the base of the chalk, determination of the top would be difficult.

Good exposures of the chalk are abundant both along the white rock scarp in the White Rock cuesta and along the streams flowing down its eastern slope which have cut out narrow trenches often found along the banks. The cedar is the predominant tree

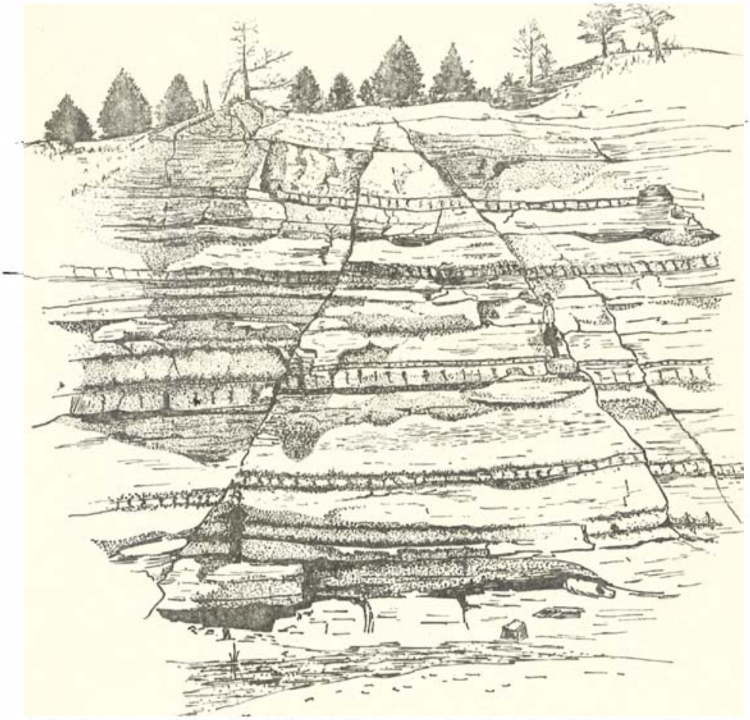


Figure 4. A-shaped fault block on Cedar Creek, Forest Park

in the rock. Good examples of such outcrops are seen along Cedar Creek in Forest Park, Dallas.

The chalk weathers into a productive, typical black prairie soil. Tree growth is confined to stream margins where the cedar tree has shown itself splendidly adapted to such conditions and is in the cedar brake country along the White Rock scarp.

Faulting in Austin Chalk

One of the most characteristic features of the chalk as it occurs in Dallas County is the remarkable small-scaled faulting. The chalk has been broken into innumerable irregular blocks by fissure planes along which most often slight movements have taken place. The faulting may be barely perceptible, or as much as two or three feet at a maximum. The faulting is normal. *Horst* and *graben* structures alternate in rapid succession. These structures are illustrated in Figures 4 and 5. The blocks vary in size

Figure 5. V-shaped fault block on Cedar Creek, Forest Park

from 50 to 100 and more feet in length. The plane of faulting varies from 40° to 80°, the larger number varying from 45° to 60°. The dip of thirty fault planes is shown in Figure 7.

The strike of the fault planes is interesting in connection with the well-known Balcones fault line. The writer expected that a study of the strike of the fault planes would line up with the Balcones trend. Such, however, was not the case. The plotting of the direction of 33 fault planes, Figure 6, shows that they run to almost all points of the compass instead of prevailingly northeast and southwest. In this connection it may be noted that a study of the faults around the town of Rockwall, in Rockwall County, to the east of Dallas County, and of the sandstone dikes from which the county is named, also showed a wide variation from the trend of the Balcones fault line.

Jointing of the Chalk Rock

Two types of jointing are found in the chalk: ordinary joint planes at right angles to the bedding planes; and particularly in the more massive beds, curved joint surfaces which look as if they

Plate VII-A. Faulting along a curved surface simulating an unconformity. Austin chalk, Cedar Creek near Beckley Road

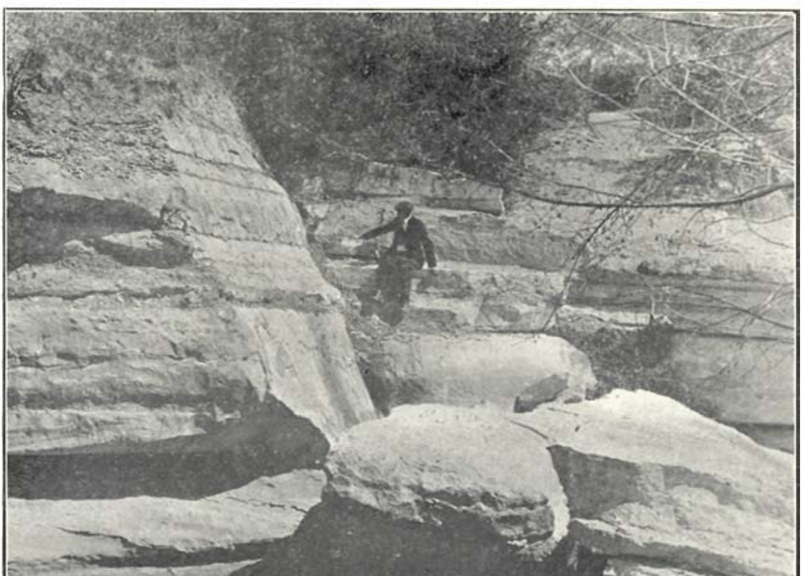


Plate VII-B. Slickensided surface along a fault plane. Cedar Creek

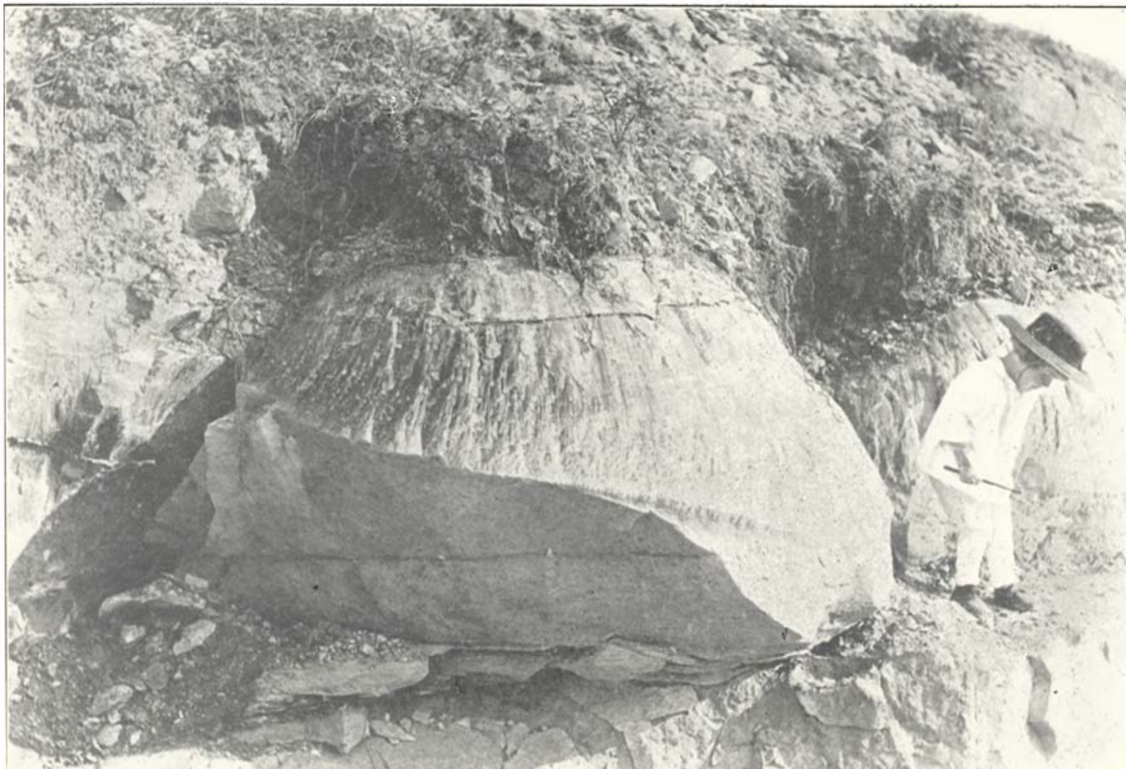


Plate VIII. Curved joint surface in Austin chalk, Oak Cliff.

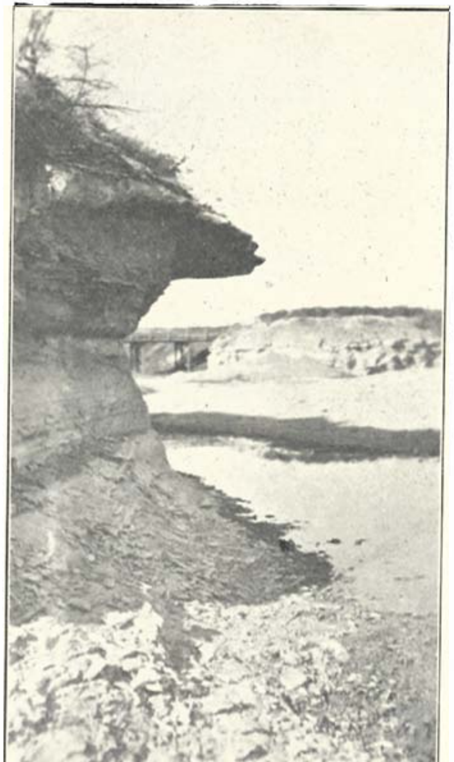


Plate IX-A. Curved jointing in the Austin chalk near University Boulevard and Turtle Creek bridge.

Plate IX-B. Austin chalk. Near University Boulevard and Turtle Creek bridge.

were made by localized pressure on small areas—such surfaces as would be made by a punch in a uniform mass. A good example of this is shown in Plate VIII.

Taylor Formation

The transition from the Austin Chalk into the Taylor formation is a gradual one and the mapping of boundary lines somewhat arbitrary. At few outcrops was the writer sure that a contact phase was seen. At several localities along the stream beds on the eastern margin of the chalk, yellow clays contain-

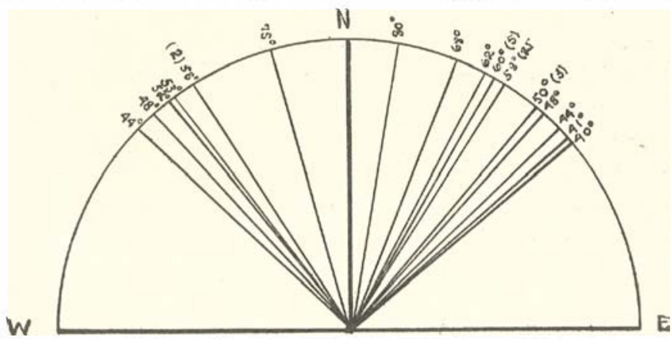


Figure 6. Diagram showing the direction of strike of 33 fault planes. Block faulting in Austin chalk

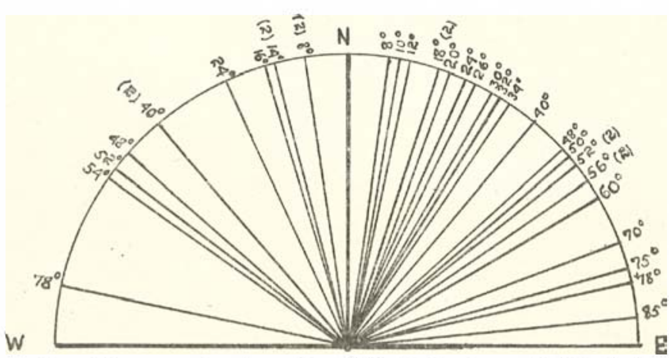


Figure 7. Diagram showing dip of 29 fault planes in block faulting of Austin chalk

ing small nodular concretions of lime are found lying on chalk beds, but since similar clays were found well within the chalk area the writer has classified them as stream deposits. Such clays occur along White Rock Creek and east of Garland. For mapping purposes the disappearance of the white rock in stream bottoms and the change in color of the soil from black to chocolate brown was used.

On the road from Dallas to Forney, one mile east of the Orphans' Home, the chalk is thin-bedded and shaly. To the west of the Home two-thirds of a mile in a ravine by the roadside occur brownish shaly marls which theoretically lie only a few feet above the chalk.

The best exposure of the contact phase between the chalk and Taylor marl is that seen north of Wilmer which has been given in the preceding description of the Austin Chalk. Within the area mapped in this report the base of the Taylor formation consists of 3½ to 4 feet of gray marl. This is followed by about 100 feet of blue shale which weathers to a yellow shale or clay much used in brick-making. Although spoken of as a marl, the Taylor formation carries in its lower division a low percentage of lime.

Further consideration of outcrops of the Taylor formation will be found under the heading of Brick Clays.

The soft shales of this formation weather rapidly and give origin to deep residual soils chocolate-brown to black in color. These soils are highly productive and form excellent farm lands.

ALLUVIAL DEPOSITS

Almost one-sixth of the area of Dallas County is covered by stream deposits. These not only make some of the most valuable soils in the county, but the gravel and sand deposits are of much economic importance.

One of the largest undertakings within the county is the recovering by levees of a broad acreage of overflow lands along the Trinity river bottoms. Much work has already been done and in the near future a large and valuable portion of land will be added to the resources of the county. See plates XA and XB.

Trinity River Flood Plain

The Trinity River flood plain at Dallas has a width of about one mile, but both east and west of this point it is much broader.

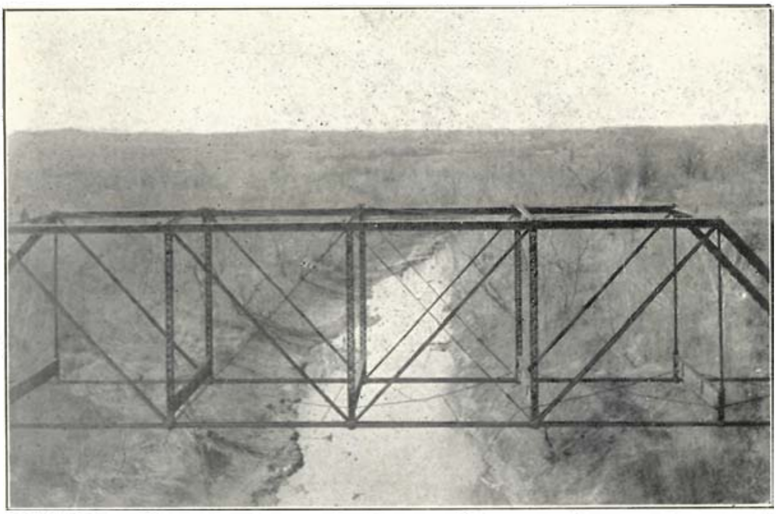


Plate X-A. Trinity River at normal stage. View from Dallas-Oak Cliff Viaduct

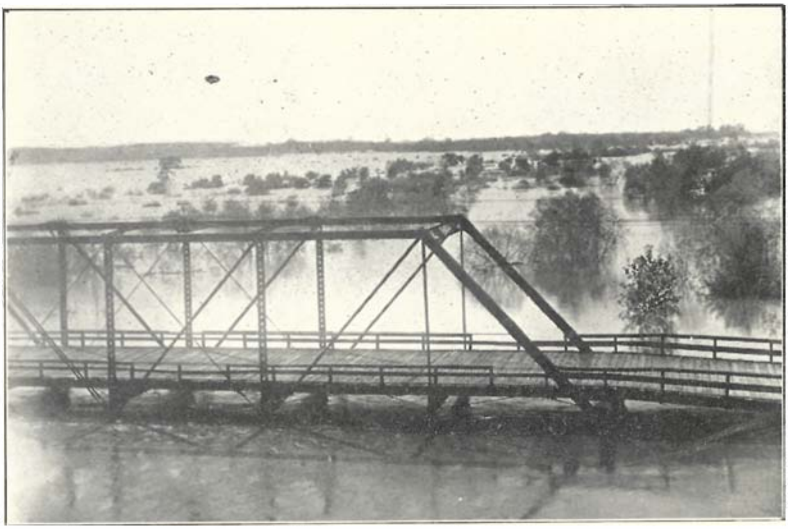


Plate X-B. Trinity River at flood. View from Dallas-Oak Cliff Viaduct

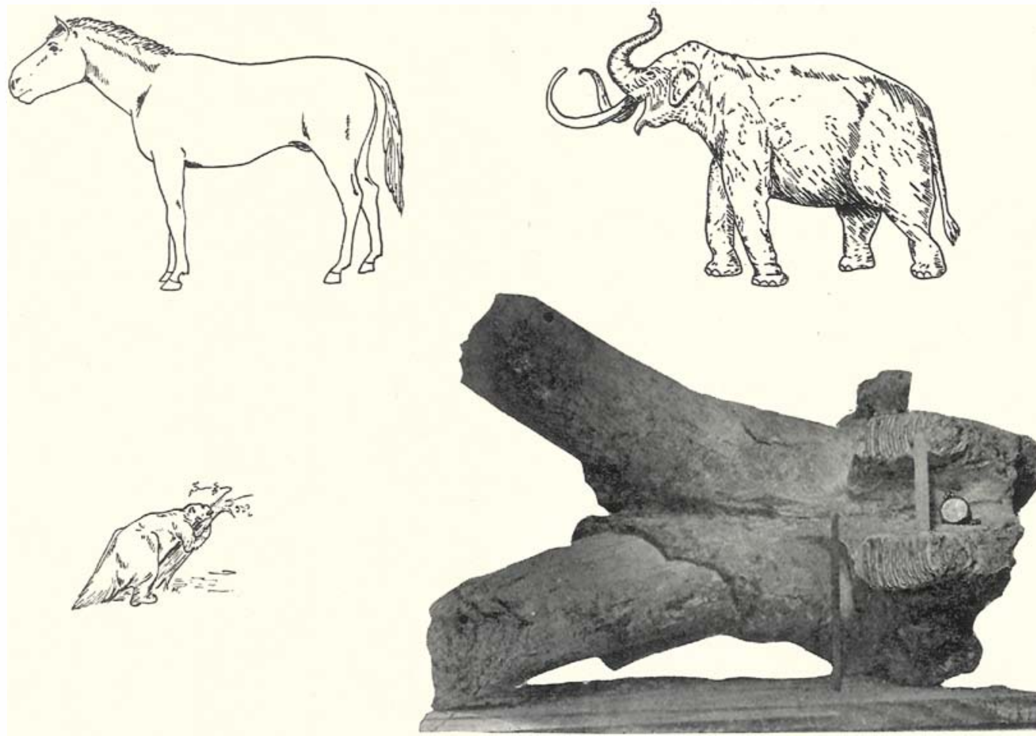


Plate XI. Fossils from the sand and gravel pits around Dallas

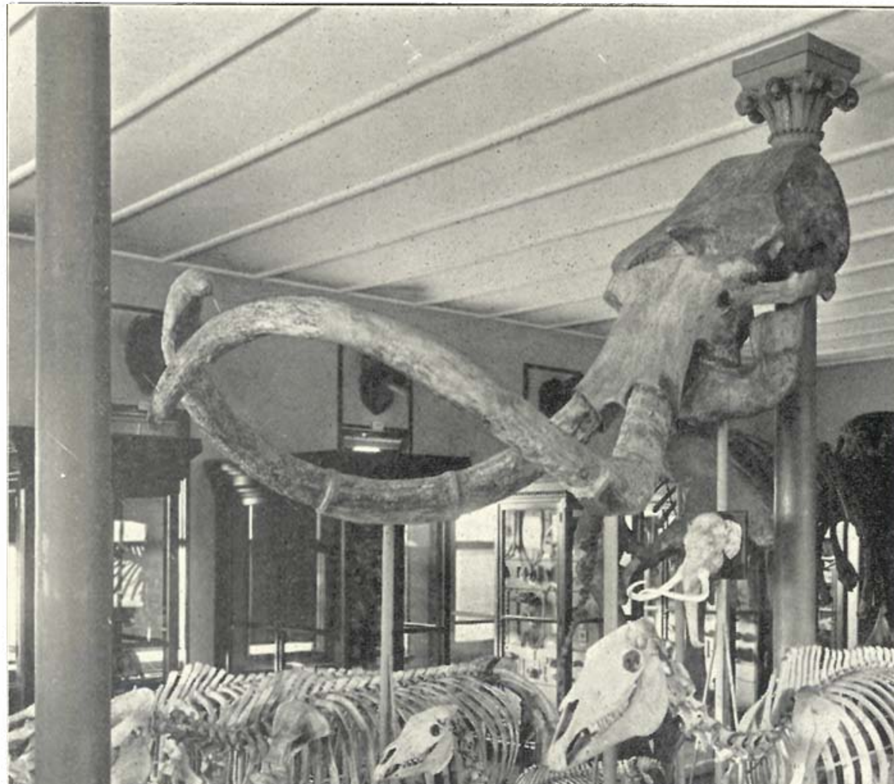


Plate XII. Skull of Elephas imperator from Dallas, Texas. Yale University Museum. Courtesy of Dr. R. S. Lull

The alluvium has a depth of about 14 feet. It is a mixture of gravel, sand, and clay, common to river deposits.

The Trinity River is slow and sluggish and the stream seems to be undersize compared to its valley and flood plain. This undersize relation and the fact that the size of material transported by the stream is apparently smaller than was carried formerly seem to indicate that the present volume of the stream is less than during Pleistocene times.

Terraces

Remnants of ancient flood plains are to be found on both sidse of the valley of the Trinity, high above the flood plain. The highest of these terraces is found in Oak Cliff as seen northeast and southwest of Cliff Park. The gravel and clay of these deposits has a reddish color. The gravel contains considerable clay and broken fragments of chalk rock. This contrasts sharply with the condition of the clean gravel and sand of the present flood plain.

River deposits east and north of Forest Park and along Turtle Creek in the city of Dallas hold a slightly lower position. East Dallas, beginning somewhat west of the Santa Fe Railroad is built on a terrace largely underlain by sand. Several sandpits have been opened up east of the Fair Grounds. These have been operated many years. Besides yielding excellent grades of sand they are remarkable for the numerous finds of fossils.

Pleistocene Fossils in the Alluvium

Fossil skulls, more or less complete, of thirteen elephants have been found in the sand and gravel pits around the city of Dallas since the first specimen was noted in 1887. With each skull has been found bones from other parts of the skeleton. From time to time many single bones are found. Most of these skulls have been thrown aside on the dump heap to be destroyed by weathering. Three have been preserved in northern universities. One occupies a place of honor in the Peabody Museum at Yale University. See Plate XII. One of the largest specimens is to be seen, as yet unmounted, at Southern Methodist University, Dallas. Texas. Plate XI.

Besides the fossil remains of the Imperial elephant have been found bones of Equus scotti, the Texas horse; an ancient bison, species undetermined; bones of smaller animals, as yet undetermined; and bony scutes from the skin of the giant sloth. Most of the specimens are found in the sand pits just underneath the covering of clay or near the base of the pit.

GEOLOGIC HISTORY

PALEOZOIC

The rocks and well logs of Dallas County throw little light on the geologic history of the area earlier than the beginning of Cretaceous time. The Trinity sands mark a great unconformity and were presumably laid down upon a land area which was being slowly submerged beneath the great Continental sea of later Mesozoic time. During all of Comanchean time the area was the site of continued deposition, prevailingly of lime deposits.

CRETACEOUS

A second period of deposition was inaugurated with the widespread deposition of the Woodbine sands and clays at the beginning of Cretaceous time. Coincident with, or possibly preceding the deposition of these sands, was the probable elevation of lands to the north and northwest. It seems inprobable that the areas within Dallas or Tarrant counties were actually above sea level during this time, since although the Woodbine sands are cross-bedded and lenticular in character, the transition from the beds below, as seen in Tarrant County, seems to be a gradual one with no visible evidence of an erosion interval. The cross-bedded lenticular sandstones, clays, and lignite deposits would seem to fall within the littoral zone of deposition. From the coarseness of the sands and the rapid change in the character of the beds from point to point it seems equally probable that the water was shallow over this area and that the current action was strong.

Upon the Woodbine sands were laid down the Eagle Ford series of black shale and blue shales, containing a high percentage of finely divided bituminous material. The waters in which the shales were deposited were probably shallow since at times arenaceous layers were swept out over the territory. But the sea was deep enough to sustain fish life in marvelous numbers, from the numerous remains of which these shales were early called the "Fish beds." The muds came from areas of erosion to the north and northwest.

The uppermost beds of the Eagle Ford shales become more arenaceous, yet they contain much lime and large quantities of selenite crystals,—in some layers almost a tenth part of the volume. The topmost bed of the shale just beneath the chalk contains much arenaceous material, rounded fragments of fish bones and an occasional flattened quartz pebble in size up to one inch in diameter. Upon this layer and conformable with it are the massive chalk layers of the Austin formation.

Whatever may have been the conditions elsewhere for the deposition of chalk, it seems certain that in this area the conditions favorable for its deposit were brought about abruptly and not in gradual transition.

The organisms of the Austin Chalk give no positive evidence of the depth of the sea in which they were deposited. They do, however, show that the waters were sufficiently quiescent to permit the development of a molluscan life of very large, thin-shelled animals and of myriads of minute animals housed in fragile shells, the remains of which make up the bulk of the deposit. The mainland was so far distant that little sand, and that of the finest, was swept out into this area of deposition.

But the Great Cretaceous Sea did not always encroach on the land, and on its retiring it brought back with it over this area another period of deposition of lime muds which form the Taylor formation. Again the change from the limestone to the marl is abrupt.

Tertiary

At what time during the Tertiary this area became land is a matter for speculation. As the sea retreated, the rivers followed across the new-made lands. The belts across which they ran varied much in hardness. The chalk did not cut down so fast as the softer shales. Lateral branches of the streams reached out along the softer beds, and the typical cuesta topography was developed.

There yet remains to discover the date of the present topography and whether more than one cycle is represented in the landscape. Unfortunately the area does not offer critical testimony. The relief of the area has probably been little changed since early or Mid-Tertiary time. The high level gravels of Oak Cliff lie about 100 feet above the Trinity River flood plain. The sand pits of East Dallas are 50 feet above the Trinity. The date of deposition of these sand pits may be taken as Pleistocene (in the sand pits the fossils are found under 5 and 8 feet of clay), since they are the highest river deposits in which fossils of Pleistocene mammals have been found and in which the skeletons were found more or less complete. Fossils are found occasionally in the lower sand and gravel pits, but such specimens show the effects of transportation by stream action. The Trinity River has thus cut its flood plain to a depth of about 50 feet since the Pleistocene.

The terraces along the Trinity show no alignment on opposite sides and may easily have been the result of a continuous downcutting of the Trinity without consecutive elevations and downcuttings. The area is too limited for a critical study.

Since Pleistocene time the landscape has been almost the same. What change has taken place in the flora is unknown. The change in the animal life has been a notable one. Giant elephants, mastodons, giant sloths, and the Texas horse grazed and died along the Pleistocene valley of the ancient Trinity, leaving only an occasional skeleton to show they ever existed. Slowly the river cut down its valley floor. Fifty feet or more has been excavated since this passing pageant of Pleistocene life.

Even the bulk of the animal life of early historic time has disappeared. Gone are the great herds of buffalo, descendants of the ancient Bison; and gone is the tepee of the red man; gone too is the lowing of the Texas "long horn."

Oil mills now stand near the site of the ancient quicksands in which the Imperial elephant floundered to his death; the skyscraper is located on the pasture lands of the buffalo; while above the river drone the great machines of the bird-men.

ECONOMIC PRODUCTS

Soils

Unquestionably the most valuable economic resource of Dallas County is her rich, varied and productive soil. The study and technique of soils is a highly specialized branch of knowledge and special reports on soils alone are written, so that it is outside the general scope of this bulletin to undertake a technical description of the soil types within the county. However, it seems of value to note certain characteristics which are intimately associated with the underlying rock structure. Soils are derived from the disintegration of rock by the agents of weathering and erosion. The term residual soil is used to designate a soil which is derived from the rock beneath it. Transported or alluvial soils have been transported from their place of origin and deposited in a new locality, generally along the slope of a valley or the flood plain of a river.

The residual soils within Dallas County, derived from the Taylor formation, the Austin chalk and the Eagle Ford shales, are in many respects similar and belong in general to the "black land" group. The soils over the area of the Taylor formation are chocolate brown in color; soils of the Austin chalk are prevailingly black; while the soils over the area of the Eagle Ford are prevailingly grayish black. All these soils are composed of finely comminuted particles of clay and silica with a coloring of finely divided carbonaceous material. Their productivity is excellent and is modified only by the depth of the soil and the climatic conditions of rainfall.

The alluvial soils cover the areas marked as alluvium on the geologic map, with one exception. The hills and uplands west of Owen's Lake around the general area of Finley are covered by a light sandy soil which is the remnant of an ancient Trinity river flood plain.

The alluvial soils vary from point to point in texture and composition from black, yellow and sandy clays carrying various quantities of loam, to sand and gravel beds. Properly protected from the flood waters of the Trinity by levees, thousands of acres of the fertile flood plains of the Trinity may be put into profitable cultivation and added to the agricultural wealth of the county.

Sand and Gravel Deposits

In regions covered by deep fine textured soils and underlaid by soft limestones or shales, deposits of sand and gravel assume an importance in the economic development of the country such as is unknown in an area where hard rock for building or road making is everywhere available. The resources of sand and gravel within Dallas County are abundant and of large economic value. Excellent railroad facilities give an open market to adjacent counties in north central Texas.

In addition to the use of sand and gravel in mortars and cements for structural purposes, the importance of gravel for road making in the black land belt is far reaching and can only be estimated by a visit to counties in which no gravel is available.

Origin of the Sand and Gravel Deposits

The gravel and sand along the Trinity and its tributaries came from the disintegrated and broken fragments of the hard limestones and sandy formations of the Comanche and Carboniferous rock to the west. This is shown by the character of the material and by the fossils found in the gravel. This material, largely at flood tide, was worked downward along the stream in which it was rounded by constant movement and sorted by current action so that from point to point pebbles or grains of sand practically uniform in size lie together.

Throughout the history of the Trinity in its down-cutting it has flowed over different outcrops of rock which have varied much in the amount and kind of material contributed to the stream load. This is seen in the difference between the upland gravels and those of the Trinity River flood plain. The upland gravels as seen for example, in Oak Cliff, carry a considerable

Plate XIII. Lagow sand pit in East Dallas. Seven feet of clay overlies the sand. Most fossils are found just beneath the clay

Plate XIV. Near view of the crossbedded sands in pit shown in Plate XIII-A

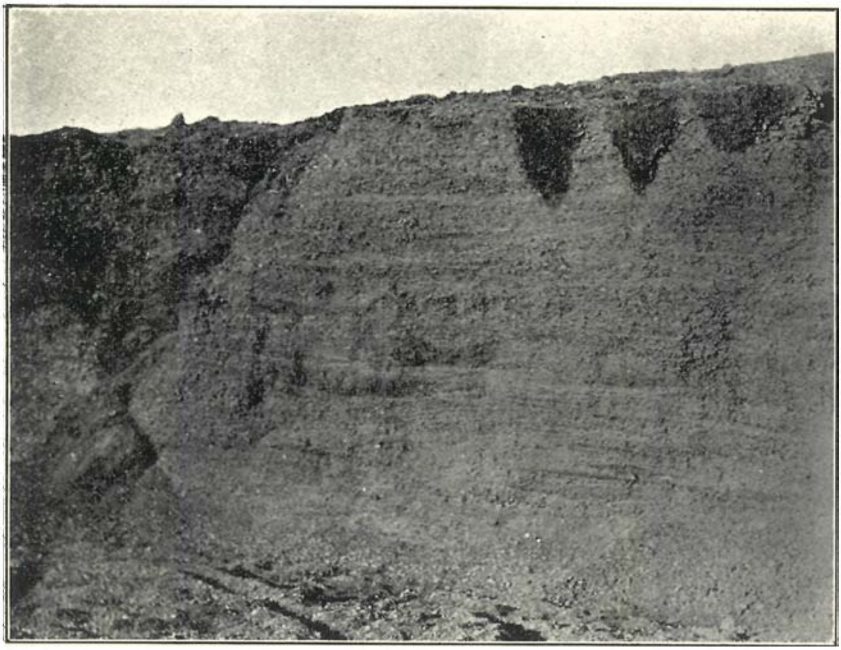


Plate XV-A. Wall in Vilbig's gravel pit, West Dallas, showing clay fillings

Plate XV-B. Near view, showing the intimate mixture of gravel and sand amount of red clay. The sorting is usually poor, sand, clay, and pebbles being mixed. Chalk pebbles are abundant. In the gravel deposits of the present flood plain there are few chalk pebbles, the sorting of material is sharp and definite and the gravel and sand usually free from mud.

Prospecting for Gravel

Upland gravel is usually detected in the surface soil or in gulley washes or along the small streams draining the high ground areas. On the terraces or the flood plain of the Trinity the sand or gravel may be located by deep post holes or in wells. In the flood plain the gravel is usually covered with six to nine feet of clay. Under such conditions the location of the gravel may be determined by a long hand augur two to four inches in diameter. This, however, determines only the presence of the gravel. It is necessary to know the size, depth and quality of the gravel. To determine this it is necessary to dig pits or to sink pipes of large diameter into the gravel so that samples free from mixture with materials from above can be secured as the pipe is gradually lowered into the deposit. The latter method is cheaper than digging pits. Thorough tests should be made over the whole area before the property is set aside for its gravel. A poor gravel pit is a sorry return for the total destruction of good agricultural land.

Specifications for Gravel

Not all gravel deposits in Dallas County are available for building purposes, though practically all can be used for road material. The most serious objection is the presence of fragments of the Austin Chalk. Gravel beds north and west of Dallas are naturally free from chalk fragments, but they occur in the pits along White Rock Creek and to the east of Dallas.

The following engineering specifications are included to aid in estimating the value of a gravel deposit.

A primary consideration in gravel deposits is that the gravel should be well graded, clean and free from clay. If the clay occurs in small amount it may be washed, but this is at considerable expense. A simple test for cleanness of gravel is that of rubbing it in the palm of the hand. Clean gravel will not discolor the hand. The pebbles forming the gravel range in size from a pea up to boulders. For rough concrete work, gravel which will pass through ½ to 3 inch rings is taken; for better grades of concrete work ½ to 2 inch rings. For roofing purposes gravel should be not less than ¼ inch, nor larger than could pass through a ⅝ inch ring. (Barrett Specifications.)

In concrete work about 40 per cent sand and 60 per cent gravel is mixed with the proper proportion of concrete. A common ratio is one part portland cement; two parts sand; and four parts stone or gravel. Other ratios are 1:2:5 and 1:3:5. If in a gravel pit the ratio of the sand and gravel is 2:3; 2:5; 3:5, a natural aggregate is already formed and can be mixed directly with the cement; otherwise the sand must be screened from the gravel and later added again in its proper proportion. It is thus evident that the most valuable of all gravel deposits would have clean gravel and sand already mixed in the proper proportions. Fortunately this ideal condition is frequently found in gravel pits. Plate XIVB from a sand pit in West Dallas shows such an intimate mixture of gravel and sand in the pit.

The following analysis, No. 2783, made by Jas. P. Nash of the Division of Engineering of the Bureau of Economic Geology and Technology, on a sample of gravel from Farmer's Branch submitted by J. Fred Smith Gravel Co. shows a typical analysis for a good gravel:

MECHANICAL ANALYSIS

Material retained on	Per cent	No. of sieve	Size of opening	Per cent
2 in. diam. ring sieve..........	0	10 mesh	.065 in.	71.5
1½ in. diam. ring sieve..........	2.9	20 mesh	.0328 in.	77.8
1¼ in. diam. ring sieve..........	5.1	28 mesh	.0232 in.	82.5
1 in. diam. ring sieve..........	12.6	35 mesh	.0164 in.	90.5
¾ in. diam. ring sieve..........	24.4	48 mesh	.0116 in.	97.0
½ in. diam. ring sieve..........	40.3	65 mesh	.0082 in.	98.6
¼ in diam. ring sieve..........	56.5	100 mesh	.0058 in.	99.3
⅛ in. diam. ring sieve..........	66.4	200 mesh	.0029 in.	99.8
Passing ⅛ in..................	33.6	...	....	...

Passing No. 200 mesh		
By analysis	.3%	
By washing	%	
Total		100.1

Weight per cubic foot, shoveled loose..................122½ lbs.
Weight per cubic foot, shaken to refusal...............129¾ lbs.

Specific gravity	2.63
Voids in loose gravel	25%
Voids in packed gravel	22%

The mechanical analysis or sizing test shows this to be an exceptionally well graded gravel, from 1½″ to dust, for a mixed sand and gravel.

The aggregate consists of rounded and flat particles of limestone, ferruginous sandstone, and some shells, well-graded. The finer particles are quartz and calcareous sand, free from clay. To a number of the larger particles, a layer of sand is cemented with a calcareous deposit.

Compression tests, 28 days
1:4 mix by volume
1 part cement: 4 parts this gravel as received
Total load, 101,935 lbs. (Avg. 2 spec.); unit load, 3,600 lbs. per sq. in.
1:6 mix by volume
1 part cement: 6 parts this gravel as received
Total load, 63,500 lbs. (Avg. 2 spec.); unit load, 2,240 lbs. per sq. in.

Tension tests were made on a specimen of 25 sq. inch cross-section, made at the same time and under the same conditions as the compression specimens, at 28 days, as follows:

1:2:4 mix by volume
1 part cement: 2 parts sand under ¼″: 4 parts gravel over ¼″
Total load, 6,170 lbs. (Avg. 1 spec.); unit load, 247 lbs. per sq. in.

Concrete made, using this gravel in a 1:4 mix, contains about the same cement as would be in a 1:1½:3 mix if the material were screened and remixed, while a 1:6 mix would be about the same as a 1:2½:5 mix of screened and remixed materials.

Specifications for Sand

Comminuted sub-angular, more or less rounded or oviform fragments of quartz, less in size than a pea, are termed sand.

Sand must be clean. Clean sand will not soil the hands when rubbed upon them. By a clean sand is meant one which if shaken with water in a bottle and then allowed to settle, will leave no scum on the surface of the water and no layer of fine mud on the surface of the sand. Sands should be free from salts. This can be determined by the taste. Sand should be sharp: that is, composed of rough angular grains.

Engineers classify sand into three different grades: coarse, medium, and fine. If the sand is retained on a sieve having 20 wires to the inch, it is coarse; it is classed as fine sand if it passes through a sieve having 30 wires to the inch. Sand for brown mortars for plastering or common brick work is ordinarily run through a No. 4 screen having 4x4 meshes to the inch. For sand finishing and mortar for pressed brick, either a No. 10 or 12 screen with 12x12 meshes to the inch is used. For rubble stone work, sand is not ordinarily screened unless it contains much gravel.

Methods of Working Sand and Gravel Deposits

Gravel pits are worked by hand with pick and shovel, by steam shovel or by drag line. When the demand is large, such as for road metal, or where screens are used, drag lines or steam shovels are generally installed. The drag line may be used profitably where the gravel runs uniformly in the pit. If, however, the gravel shows considerable variation, the careful picking by hand labor produces more satisfactory results.

Cost of Sand and Gravel

The cost of sand varies from \$ .20 to \$ .50 per cubic yard on cars or carts at the bank, subject to wide variation in special cases. Gravel in the pit, exclusive of screening, loading and hauling, sells from \$ .50 to \$ .75 per cubic yard.

Portland Cement

Portland cement is made by burning to a fused mass or clinker a finely ground artificial mixture of lime, alumina, silica, and iron oxide, in definite proportion. In the selection of the raw materials the aim of the manufacturers is to produce a raw mixture which runs approximately 75% carbonate and the balance clay. In burning this mixture, which must be done at a high temperature, the clinker is formed. This consists largely of 3Ca O

Plate XVI. Drag line in pit of J. Fred Smith Gravel Co., near Letot

Plate XVII. Vilbig's gravel pit, West Dallas. Texas Portland Cement plant in distance

$Si\,O_2$; $3\,Ca\,O\,Al_2O_3$; $5\,Ca\,O\,.\,3\,Al_2\,O_3$. (Rankin and Wright, Amer. Jour. Sci. Jan. 1915) with a little free lime. The finely ground clinker, which is the Portland Cement, is blue to gray in color and has a specific gravity of 3 to 3.25.

Among other raw products available for the manufacture of cement are limestone and shale, which together have the requisite chemical constituents. But since limestone and shale are abundant in many localities it is evident that other factors must be taken into consideration in locating a cement industry. The initial capital invested in a cement plant is large, and to pay returns the volume of business done must be in proportion.

Ideal conditions for the location of a cement plant are close proximity to a market sufficiently large to absorb the products of the plant, available fuel and raw materials, limestone and shale, for example, in close proximity and with a gravity haul to the grinding plant. North central Texas offers a large market for cements and desirable local conditions for plant sites are found along the edge of the Austin Chalk scarp in West Dallas. Along this scarp two cement plants have been located, the Trinity Portland Cement Company at Cement City, and the Texas Portland Cement Company at Eagle Ford. These plants have together a total output of about 150,000 barrels per month.

That conditions were favorable for the making of cement in Dallas County was early pointed out by Prof. Remond of the French colony. The noted Texas geologist, R. T. Hill (U. S. G. S. An. Rept. 21, Pt. VII) gave further elaboration and emphasis to the desirability of West Dallas for the location of a cement industry.

Here, along the steep bluff, twenty to thirty feet of the basal division of the Austin Chalk overlies the Eagle Ford shales. A finely ground mixture of about 80 pounds of the shale and 575 pounds of the limestone gives approximately the proper proportions for a raw mixture to be burned to cement. Plants located below the bluff have a gravity haul of the raw materials and oil fuel is available from near by pipe lines.

In 1900 a group of capitalists, mainly from Galveston, organized and incorporated the Texas Portland Cement and Lime Company. This was the first large scale cement plant in Texas. Passing through various stages of reorganization, at one time being known as the Iola Cement Company, the present organization of the company dates from 1914. This company uses the wet process in grinding and mixing.

The Trinity Portland Cement Company was incorporated in 1907. This company uses the dry process in grinding and mixing.

Lime Industry

Dallas County has one firm, Michel Lime Company, actively burning lime. The plant is located in Oak Cliff near the western end of the Dallas-Oak Cliff viaduct. Austin chalk, near the base of that formation, is used as raw material, and the burnt product is known as "brown lime." Continuous kiln process is used. The capacity of the plant is 300 barrels per day. White lime is also burned, but the lime rock is brought from southern Texas.

The Austin chalk has been erroneously called a magnesian limestone by some writers (R. T. Hill, 21st An. Rept. pt. VII, p. 329) but while the average composition runs low in magnesia, some layers do carry a considerable amount. The layers used at the Michel Lime Co., which lie from 30 to 40 feet above the Eagle Ford shale, give a burned product which runs from 68% to 72% lime carbonate, the remainder having the composition of a natural cement. The "brown lime" acts thus as a slow setting cement, hardening with water. Its slow setting qualities permit its use for practically all purposes for which a lime mortar could be used, and it gives a stronger, harder mortar.

Brown lime cannot be used, however, for water purification, or in the production of oxygen or hydrogen, since it hardens on the addition of water and to meet the demand for white lime a pure lime rock from near Austin or Lime City has been imported for burning.

Clay Industries

Historical

The clay resources of Dallas County very early attracted the attention of the pioneers, particularly the French, who settled the French town of Reunion west of Dallas in 1854. Prof. E.

Remond (1840-1906) of this colony was particuarly active in his investigation and experiments with the clays of the county. He made successfully brick, vitrified brick, and sewer pipe. Prof. Remond was the first to import a plastic brick machine. He was also first to use the lime and shale for making concrete and instigated the founding of the Iola cement plant. Remond made brick in South, East and West Dallas, at Dawdy's Ferry and Mountain Creek. Among others who have engaged in brick making around Dallas are Frichot, Marshall, Myers, Harry, Brown, Leftwick and Merzbacher.

Transported Clays

Three sources of brick and clay are available in Dallas County: the transported clays of the Trinity River bottoms; the Eagle Ford shales; and shales in the Taylor formation. The clays of the Trinity River bottoms were early used for brick making. One of the oldest plants worked a clay deposit near the Commerce Street viaduct. This clay made an excellent brick and the plant ran successfully until the deposit was exhausted. The clays along the Trinity are usually limited in extent and require hand picking to secure a uniform grade. No general characterization of these deposits can be made because of the wide variation in texture and in other characters. Each deposit should be given thorough investigation before starting a plant. Clays of the Trinity River bottoms have been most successfully worked by the wet process. At the present time one company, the Brown Brick Co., is working the Trinity bottom clays in South Dallas.

Eagle Ford Shale

The upper beds of the Eagle Ford shale were for many years successfully worked at Harry's brick plant about seven miles west of Dallas on the T. & P. Railroad. The section at this point is as follows:

SECTION OF EAGLE FORD SHALE, HARRY'S BRICK PLANT, WEST DALLAS

	Feet
Eagle Ford Shale	
Shale, laminated, bluish gray, occasional sandy and pyritiferous laminae	20

	Feet
Shale, with large lime concretions up to four feet in diameter with numerous fossils	2
Shale, bluish gray to gray, laminated	11
Shale and sandstone, alternating slabby layers with occasional concretions	3
Shale, gray, laminated, uniform in texture	14

The uppermost beds contain a higher percentage of lime than the lower beds. The residual clay over the shale was also utilized in making a good brick.

Other ventures in brick making with Eagle Ford shale have not been so fortunate. The chief objection to the shale is that it contains limestone concretions (known as pebbles), gypsum, pyrite concretions, and organic matter. The bituminous content, with extreme toughness, practically forces the clay worker to mold by dry process. The smoking of the bricks must be done with great care and the final burning reaches a temperature said to be about 2100° F. Yet with all these objections, by careful selection of the shale, by using dry process for molding, and by skilful management, the shale can be used, and since a large local market is at hand such an enterprise should be a paying one.

Taylor Formation

The most easily worked shale in Dallas County occurs in the Taylor Formation, stratigraphically about 100 feet above the Austin chalk, with an estimated thickness of 70 to 80 feet. The shale is worked at two localities; just north of the town of Ferris, Ellis County, to which the area in Dallas County is contributory, and one mile west of Mesquite. The shale in these two localities is quite similar in appearance and is probably near the same horizon. It consists of a blue shale which on passing upward into the zone of weathering changes into a fine-grained yellow clay, very uniform in color and texture. This uniformity, very fine texture and freedom from lime makes the clay easy to work. It burns at a comparatively low temperature, at about 1700°, shows small shrinkage, and makes a most excellent common brick. It is worked by the dry process.

As seen in the clay pits north of Ferris the shale is blue but rapidly weathers to yellow clay. The lime content is quite low and that furnished largely by the infrequent occurrence of thin, fragile, bivalve shells which rapidly disintegrate on exposure to the weather.

The Ferris brick is well known throughout Texas. Four of the brick plants are located in Dallas County with nine presses giving a daily output of 180,000 brick. The total output of plants around the town of Ferris is almost a half million brick daily. The grade of brick is "common brick," with an average weight of 4½ pounds. This is lighter than the brick made from the Eagle Ford Shale.

One mile west of Mesquite, about sixteen miles northeast of of Ferris, the Dallas Press Brick Company is working in a shale at practically the same horizon and with similar properties. The shale pit shows a fine textured blue shale which weathers to a yellow clay. The lime content is low, shrinkage value low, and the brick burns at about 1700°, according to Mr. Merzbacher, the superintendent. The product is similar in color and weight to the Ferris brick.

WATER SUPPLY

The water supply of Dallas County comes from streams and reservoirs, from springs and from shallow and artesian wells. For the water supply of the city of Dallas, in addition to many artesian wells, the waters of various tributary streams of the Trinity River have been impounded by dams and piped to the city where they are purified in settling basins for household use. A large reservoir covering about ten square miles has been formed by damming White Rock Creek to the northeast of the city.

Springs

The springs in Dallas County belong to two types, seepage springs and fissure springs. At several localities, particularly along White Rock Creek, seepage springs occur along the valley slope at the base of thick highland gravel deposits. The water derived from rainfall stored in the gravel beds is free from lime and when uncontaminated by cesspools or outhouses is good drinking water.

The second type, the fissure spring, is found along the stream beds cut into the Austin chalk. In these springs the water which collects along certain of the more porous layers of the chalk rock is permitted to come to the surface along the more or less open fissure between the fault blocks. Excellent examples of these fissure springs are found along Turtle Creek, Plate 16B, and Cedar Creek in Forest Park. When Dallas was a village these springs were important sources of water supply, but with the large increase in the population they have properly been abandoned for more sanitary sources of supply.

Dug Wells

Over the area covered by river alluvium and in many areas underlaid by chalk and shale, shallow dug wells, ten to fifty feet, have been sunk to supply farm houses with water. When properly constructed and when located on the land slope so that no drainage from outhouses or barns can seep into them, such wells have proven fairly satisfactory, though usually those dug on the uplands go dry in dry years..

The habit of locating these wells in draws or low drain-ways where they fill rapidly after each rain cannot be too severely condemned as unsanitary and dangerous.

Artesian Wells

The great reservoir of artesian water underneath the area of Dallas County is distributed in three great sheets of sand: the Woodbine, the Glen Rose and the Trinity, which lie at successively deeper intervals.

The artesian waters fill these sheets of sand and every part of the county is underlaid by them. This fact is emphasized because of the popular fallacy that the water occurs in veins. Any farmer, corporation or village can secure water by drilling sufficiently deep for it.

Then general relation of the water-bearing beds is shown in the block diagram Figure 1. Since the beds dip to the southeast at a rate of approximately 55 to 60 feet per mile, the Woodbine sands which come to the surface in the western part of the county

Plate XVIII-A. Flowing artesian well from Trinity sands, Southern Methodist University, Dallas, Texas.

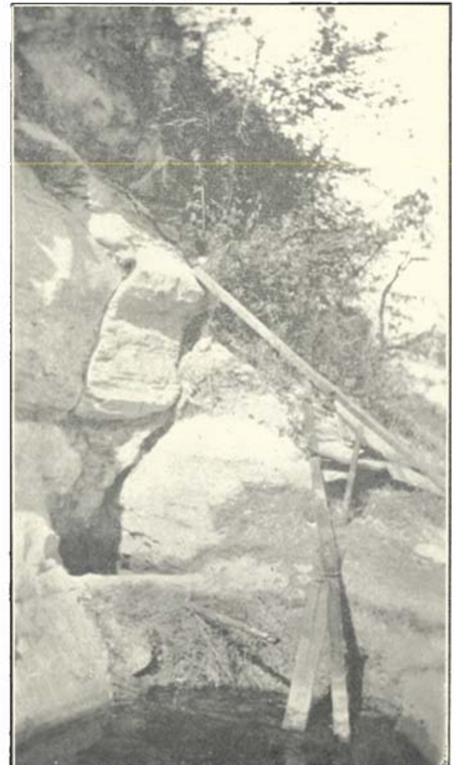


Plate XVIII-B. Fissure spring, Turtle Creek, near Southern Methodist University campus.

lie at a depth of approximately 1650 feet along the eastern side of the county. At Seagoville on the southwestern edge of the county, the Woodbine sands are struck at 1625 feet. Around Dallas the Woodbine is found at depths of 500 to 800 feet.

A full and valuable discussion of the water supply of Dallas County up to the year 1900, by R. T. Hill, is given in the 21st An. Rept. pt. VII, pp. 595-606, United States Geological Survey. Little need be added to that report concerning the water supply from the Woodbine sands.

Since 1900 a number of deep wells have been sunk in and around the City of Dallas which have tapped the much deeper reservoirs of the Glen Rose or Paluxy and the excellent water supply from the Trinity sands. In the deep well at the Union Terminal station the Glen Rose sands were struck at 2200 feet and the Trinity sands at 2500 feet. Seven wells in Dallas have been drilled to the Trinity sands: Fair Park, Union Terminal, Oak Cliff, Turtle Creek, Highland Park, Bachman's Dam, and Southern Methodist University.

A detailed log of the well at Union Terminal Station and at Southern Methodist University, with the writer's interpretation of the geological formations passed through, is given in Plate XVII.

The waters of the Trinity sands give decidedly the best and most potable of all the artesian sources of supply. A typical chemical analysis of the Trinity water is given below.

CHEMICAL ANALYSIS OF TRINITY ARTESIAN WATER
Well at Southern Methodist University

	Parts per Million	Grains per U. S. Gallon
Total solids	1245.	72.21
Loss on ignition	86.	4.99
Iron and aluminum oxides	32.8	1.91
Silica and insoluble matter	2.0	.12
Sodium chloride		12.85
Sodium sulphate		34.86
Sodium bicarbonate		31.15
Calcium bicarbonate		3.19
Magnesium bicarbonate		.90
Sodium carbonates		3.69

The most noticeable characteristic of the above analysis is the low percentage of salts carried by the water.

Glen Rose Beds

The water sands of the Glen Rose beds are for domestic purposes least desirable, though possessing therapeutic value in the treatment of certain diseases. Intermediate in character are the waters of the Woodbine sands. There is considerable variation, both vertically and laterally, as to the saltness of the water from these sands. The top sands are generally quite salty. This item is important since some wells have been abandoned when good waters could have been obtained by sinking the well deeper.

Woodbine Reservoir

The Woodbine formation has a thickness of about 325 feet in which the water sands occupy variable positions. The thicker lenses of sand are found near the base of the formation where thicknesses of 30 to 40 feet have been reported.

In the following table is shown the varying positions of the sands in the Woodbine formation, measurements being taken downward to the sands from the base of the Austin Chalk as a datum plane. In the well at St. Mary's College, for example, sand was struck 500 feet below the Austin chalk; in the well at the Busch building 480 feet below the chalk; in the well at the ice and cold storage plant, 430 feet below the chalk. All the wells shown are located within a radius of three miles. That the logs are fairly accurate is shown by the fact that the top of the first sand is reported at about 480 feet in four near-by wells. On the other hand, the variation is striking and shows that it is necessary to allow for such depths in estimating the cost of well borings.

VARYING POSITIONS AND THICKNESS OF WOODBINE SANDS

Datum Plane Base of Austin Chalk

	Depth in Feet		
	1st Sand	2nd Sand	3d Sand
1. St. Mary's College	500-501	600-612	655-690
2. Terrill School	484-525	590-600	688-695
3. Southwestern Life	505-525	......	650-835

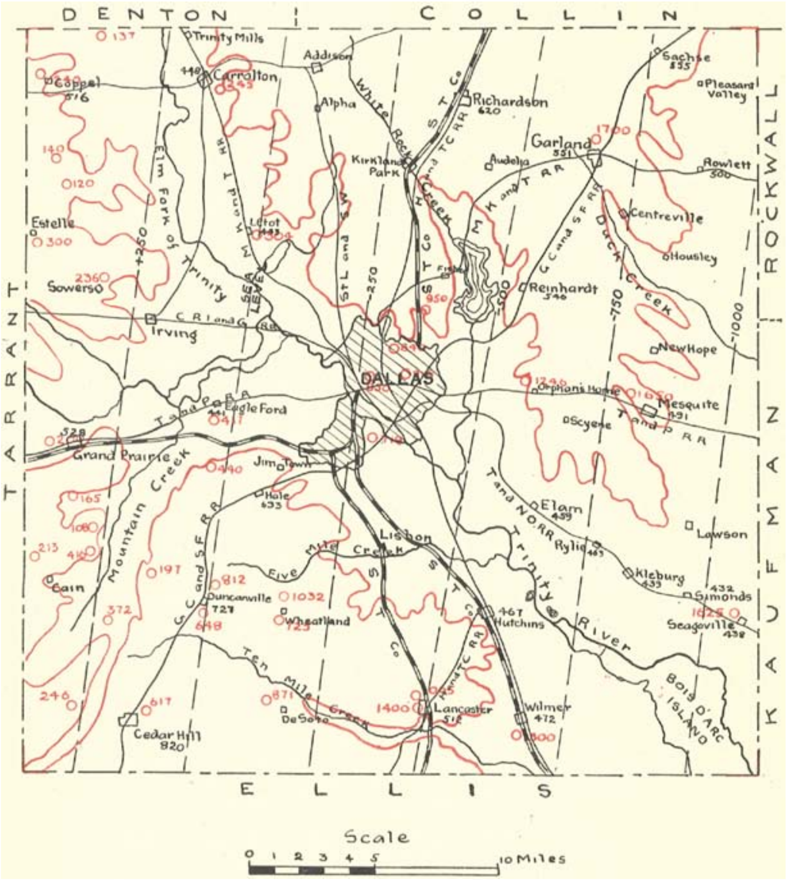


Plate XIX. Map of Dallas County showing the approximate depth of the middle of the Woodbine formation, referred to mean sea level. 500-foot surface contour, and depth of wells, surface datum, shown in red. Elevations of local points over the county shown in black.

		Depth in Feet		
4.	Green Floral Co.	500-515	590-635	......
		538-555	......	......
5.	Vickery Place	503-526	626-627	666-700
6.	Turtle Creek Pump Sta.	480-481	......	680-700
7.	McCoy Well (East of Dallas)	485-500	590-610	680-700
8.	Munger Place	......	595-625	695-715
9.	Ice and Cold Storage	430-455	510-570	......
10.	Am. Exchange Natl. Bank	480-510	625-670	750-780
11.	Busch Building	480-525	640-700	......

The following unpublished well logs are added because of their critical value in locating the Woodbine sands:

WELL LOGS SUBMITTED BY T. E. SHUTT, DALLAS, TEXAS

Well, Cedar Hill, Texas

0 to 5 ft.	5 ft.	Soil
5 to 180 ft.	180 ft.	Soft white and blue rock
180 to 589 ft.	404 ft.	Blue shale, occasional boulders
589 to 617 ft.	28 ft.	1st Woodbine water sand

Total depth.......617 ft.

Well, Florence Hill, Texas

0 to 10 ft.	10ft.	Soil and clay
10 to 192 ft.	192 ft.	Blue shale and gumbo
192 to 213 ft.	21 ft.	1st Woodbine water sand
213 to 370 ft.	157 ft.	Hard blue shale and gumbo mixed with sand and sand rocks
370 to 406 ft.	36 ft.	2nd Woodbine water sand

Total depth.......416 ft.

Well of L. S. Brotherton, Wheatland, Texas

0 to 6 ft.	6 ft.	Black soil
6 to 275 ft.	275 ft.	Soft white and blue rock
275 to 760 ft.	485 ft.	Soft blue shale
760 to 781 ft.	21 ft.	1st Woodbine sand, very hard
781 to 994 ft.	213 ft.	Sandy shale, strata of gumbo
994 to 1026 ft.	32 ft.	2nd Woodbine sands

Total depth.......1032 ft.

Well, Duncanville Gin Co., Duncanville, Texas

0 to 4 ft.	4 ft.	Soil
4 to 160 ft.	160 ft.	Soft white and blue rock
160 to 621 ft.	461 ft.	Soft blue shale
621 to 648 ft.	23 ft.	1st Woodbine sands

Total depth.......648 ft.

LOG OF 1731 FT. ARTESIAN WELL AT SEAGOVILLE, TEXAS

Kindness Mr. T. C. Andrews, Banker

Formation	Color	Hard or Soft	Feet
Sand	Red	Hard	16
Sand rock	Red	Hard	2
Shale	Black	Firm	2
Shale	Black	Firm	50
Gumbo	Black	Hard	74
Shale	Black	Firm	42
Gumbo	Black	Hard	18
Shale	Black	Hard	27
Gumbo	Black	Hard	30
Shale	Black	Hard	12
Gumbo	Black	Hard	7
Shale	Black	Soft	26
Sandy shale	Gray	Soft	6
Gumbo	Black	Soft	18
Lime rock	White	Soft	112
Weatherford lime	Blue	Hard	20
Weatherford lime	Blue	Hard	7
Lime rock	White	Soft	140
Lime rock	White	Hard	20
Lime rock	White	Hard	42
Shale	Black	Hard	115
Shell rock	Brown	Hard	2
Sand rock	Gray	Hard	2
Gumbo	Black	Hard	14
Shale	Black	Hard	112
Soapstone	Blue	Hard	12
Gumbo	Black	Hard	12
Shale	Black	Hard	109
Gumbo	Black	Hard	6
Shell rock	Gray	Hard	2
Shale	Gray	Soft	119
Gumbo	Black	Hard	26
Shell rock	Black	Hard	5
Shell rock	Gray	Hard	2
Gumbo	Black	Hard	11
Shale	Black	Hard	40
Gumbo	Black	Hard	12
Sandy shale	Gray	Hard	100
Gumbo	Yellow	Soft	80
Sand rock	Black	Hard	2
Sand	Dark	Soft	8
Gumbo	Yellow	Hard	10

Formation	Color	Hard or Soft	Feet
Soapstone	Blue	Hard	4
Gumbo	Yellow	Hard	14
Sand rock	Gray	Hard	10
Water sand	Gray	Hard	11
Water sand	Gray	Hard	8
Gunpowder shale	Black	Soft	52
Total			1731

Trinity Sands

The Trinity sands are reported as having a total thickness from 203 to 250 feet with hard sand layers at varying intervals in the sand. The top of the Trinity sands lies 1600 feet below the base of the Woodbine. The two sands probably lie in parallel sheets so that the contour map of the Woodbine sands, by adding 1600 to each contour will give a contour map of the Trinity sands. If this is correct, then the Trinity sands will be found at a depth of 1400 feet along the western part of the county and at a depth of 2600 feet below sea level in the eastern part of the county.

Prospects for Oil and Gas

Prospects for oil and gas in Dallas County are limited to two possibilities: the finding of a local flexure or pocket in the Cretaceous formations carrying sand layers, which, as an inverted basin, would catch and hold gas and oil under it while allowing an uninterrupted flow of the artesian waters; and second, the prospect of drilling a deep well into the underlying Paleozoic rocks.

Outside of numerous slight reversals of dip due to easily detected block faulting, there was only one locality in the county seen by the writer—that east of De Soto—where the reversal of the normal dip seemed to indicate a minor flexure. Even this short reversal may possibly be accounted for by block faulting.

Of the Cretaceous rocks underlying the county, only the sand formation would permit reservoirs large enough to contain oil in commercial quantities. Sands of the Trinity, Glen Rose, and

Woodbine formations have been tapped at many points in the county, but so far as the writer has been able to learn, never have these sands been oil or gas bearing. On the other hand, traces of oil have been found in several wells in the county, but in each case the show of oil came from the Eagle Ford shales which carry a large amount of bituminous and carbonaceous material. Since the shales are too compact to afford a reservoir in which the oil scattered throughout the mass might collect, the shales may be set aside as a possible prospect for oil. Shows of oil have also been found in the chalk rock, but again there is not sufficient open space for oil to collect in commercial quantities. Again, if either the Trinity, Glen Rose or Woodbine sands had in any past period of time held oil, it seems that the area underlying Dallas County, being so near the edge of the outcrop of those sands, would probably be barren of oil since it would be dissipated and forced out by the hydrostatic pressure of the artesian water. Up to the present time there have been found no structures in the Cretaceous beds as shown either by well logs or surface outcrops which would justify drilling for oil.

What the Paleozoic rocks under the Cretaceous series hold is unknown. Under the Trinity sands 50 feet of "red" shales have been reported, whether Permian or Carboniferous is undetermined. In the deep Burchill well being bored in Fort Worth, near Polytechnic Heights, at the present time, 2800 feet of blue to black shales have been reported below the Trinity sands.

Whether a parallel series would be found under Dallas County can be determined only by boring. Underneath the city of Dallas the test of the Paleozoic rocks would begin at about 2800 feet. To try out 3000 feet of Paleozoic rock would require a well practically 6000 feet deep. Aside from the depth of the well, the chance of finding oil would seem to be about the same as that of drilling in the Ranger-Brownwood oil field without any regard for structure.

Altitudes in Dallas County

The following altitudes in Dallas County are taken from various sources,—among others the Texas Almanac, 1914, published by the Galveston-Dallas News.

	Feet		Feet
Carrollton	488	Kleburg	439
Cedar Hill	820	Lancaster	512
Coppell	516	Letot	443
Dallas	466	Mesquite	491
Dallas Junction	431	Reinhardt	546
Duncanville	727	Richardson	620
Eagle Ford	441	Rowlett	500
East Dallas	465	Rylie	463
Elam	459	Sachse	555
Farmers Branch	465	Seagoville	438
Garland	551	Simonds	432
Grand Prairie	528	Thomas	504
Hale	633	Trinity Mills	559
Honey Springs	446	Wantmore Junction	433
Hutchins	467	Wilmer	472

Locations of Special Geological Interest

The following locations in Dallas County will be of special interest to students in geology and to nature lovers:

Cedar Creek, Forest Park, City of Dallas. Along the creek are to be seen splendid examples of stream erosion, outcrops of Austin chalk, fissure springs, and various other types and phenomena of block faulting.

Turtle Creek, Highland Park, City of Dallas. The permanent water supply of this stream comes from a series of fissure springs. Excellent examples of block faulting, stream erosion and outcrops of the Austin chalk are to be seen from the campus of Southern Methodist University to the mouth of the stream at the Trinity River.

West Dallas Gravel Pits. Numerous pits to be visited, showing the structure of the gravel deposits, kinds of material and method of working these pits.

East Dallas Sand Pits, east of the Fair Grounds. Lagow sand pits near the oil mill; Vilbig sand pits about 1½ miles east of the Fair Grounds. These sand pits are remarkable for their examples of cross bedding and current action and the large number of fossil elephants which have been found in them.

Cement Industries. Two large and excellently managed Portland cement plants are located on the T. & P. Railroad west of Dallas at Cement City and Eagle Ford stations. Excellent exposures of the Austin chalk and Eagle Ford shales occur at each locality.

The lime pits of the Michel Lime Co. are located in Oak Cliff near the west end of the Dallas-Oak Cliff Viaduct.

Brick plants are to be seen in West Dallas at Harry's Station and in South Dallas on the Trinity bottoms.

Along the Dallas-to-Fort Worth pike are many exposures of Austin chalk and of the Eagle Ford shales. This road crosses the top of the White Rock cuesta and the deep cut at its crest shows an excellent exposure of the contact between the Eagle Ford shales and the Austin chalk.

Views showing the general physiography of the area are to be seen along the excellent roads to Lancaster, to Garland, to Forney and to the basin of the White Rock Reservoir.

Bulletin No. 1818, Bureau of Economic Geology and Technology, University of Texas.

ARTESIAN WELLS IN DALLAS COUNTY

WELL LOG CHART

Owner. Union Terminal Co., Dallas, Texas.
Type of Rig. Rotary
Elevation. 417.14 Feet U.S.G.S.
Drillers. Dearing and Sons.
Location. Union Terminal Station, City of Dallas.

GEOLOGICAL FORMATIONS

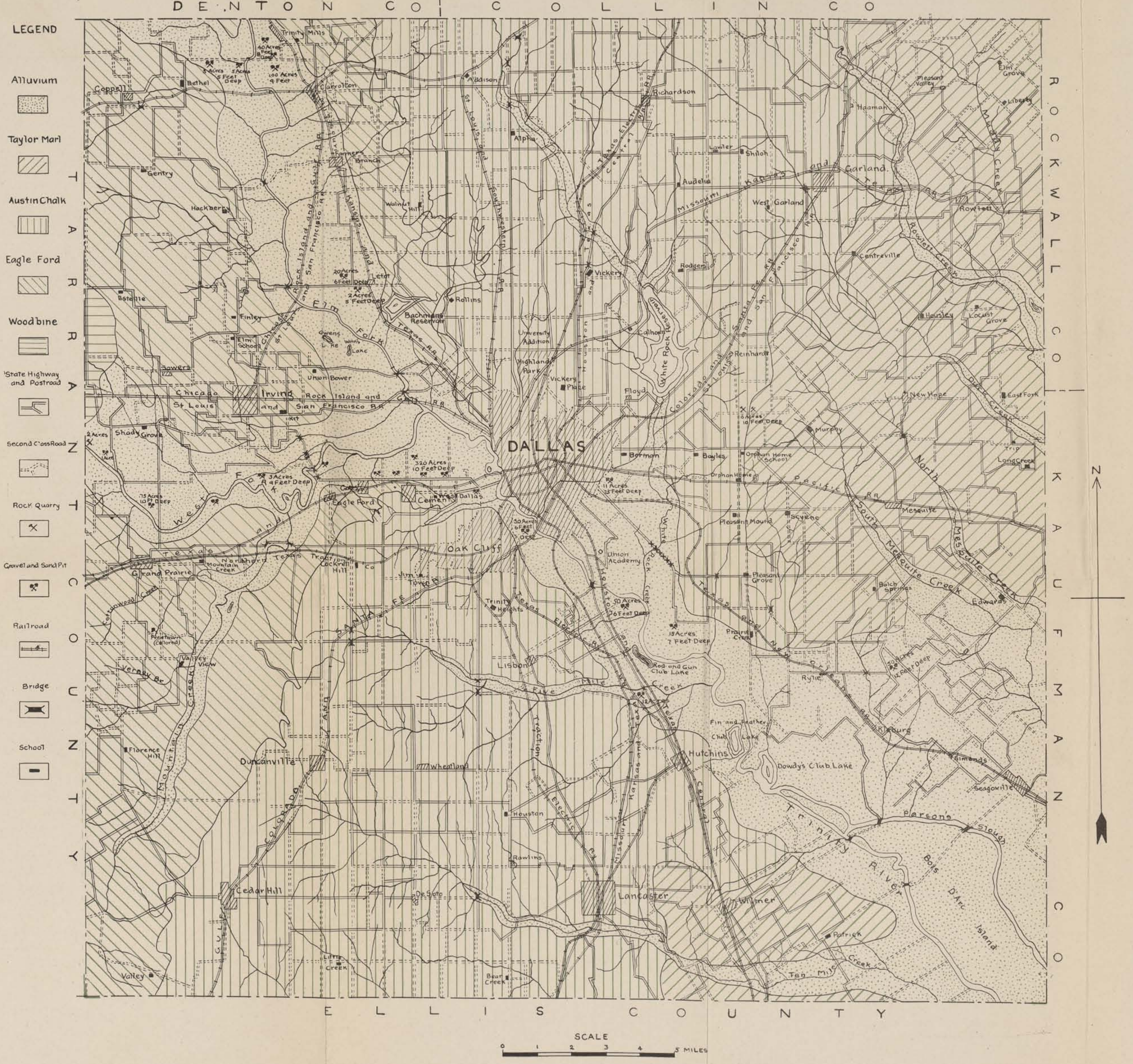
WELL LOG CHART

Owner. Southern Methodist University, Dallas.
Type of Rig. Rotary. Elevation 539.6 Feet USGS
Initial Production 500,000 gallons per 24 hours
Engineers. Myers and Noyes.
Location. Southern Methodist University, Dallas, Texas.

GEOLOGICAL MAP OF DALLAS COUNTY

BY
ELLIS W SHULER

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
J. A. UDDEN. DIRECTOR.
UNIVERSITY OF TEXAS BULLETIN NO 1818
AUSTIN. 1918.



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