University of Texas Bulletin

No. 1750: September 5, 1917

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

The Geology of Camp Bowie and Vicinity

By
ELLIS W. SHULER
Professor of Geology, Southern Methodist University

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AUSTIN, TEXAS

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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

THE GEOLOGY OF CAMP BOWIE AND VICINITY

By Ellis W. Shuler

The Landscape Around Camp Bowie

A most interesting landscape greets the eye from the soldier tents of Camp Bowie on Arlington Heights. To the north, below precipitous cliffs, lie the broad bottom lands of the West Fork of the Trinity River. On the south and east, gradual slopes lead down to the narrow flood plain of Clear Fork, which encircles the heights and joins the larger stream from the northwest. To the east, across the flood plain, on a broad rock bench of white limestone forty or fifty feet above the river, lies the city of Fort Worth; while beyond the city is seen a low tree-topped ridge which runs southward, fading into the distance. Southward and again far to the north across the stream bottoms, stretches a vast rolling prairie, covered, save in a few abrupt breaks of bare white rocks, with grass and bunches of grazing cattle. To explain and put a meaning into the landscape is the purpose of this article.

Study of the Landscape Important to the Soldier

While to the tourist a knowledge of the landscape adds to his pleasure and to his intellectual development, to the soldier a knowledge and study of the landscape is of far more vital importance; for the line of march and the field of battle is chosen, not by man, but by nature. The spectacular campaigns of Stonewall Jackson in Virginia were only possible through a most intimate knowledge of the topography of the country in which he fought. Armies reckon not only with armies but with fortifications of nature as well. The present highly specialized trench warfare along the Western Front can be conducted only in those areas where the land is covered with deep soils, soft limestones, or shales.

This bulletin is written in the hope that it will prove an incentive to an interest in the things in nature near at hand around Camp Bowie, and thus that it may relieve in part the tedious routine of camp life; but most of all it is written to put the soldier on guard, if he would fight his enemy to conquer, that nothing is trivial or to be despised which gives the soldier an insight into the landscape.

The scout, to detect the camouflage, must know what is normal in the landscape; the artilleryman must know not only the heights and slopes, but the kinds of rock and the effect of shell explosion on each; the airman must be able to interpret in terms of hill and valley every splotch of color below him; the attacking party must know whether or not it is possible to dig in; while the general who attacks or defends must marshal every form in the landscape to his defense.

It seems a singularly fortunate, or most probably a deliberate, choice in the location of Camp Bowie, that the topography around this camp is the same type of topography found along much of the Western Front, and that the underlying rocks are similar, in geologic age, in hardness and texture, and in the kind of fossil life entombed within, to those to be seen along the Marne, around Lens, Vimy, Arras, and others of the hard fought battlefields of France.

Time as a Factor in the Landscape

The earth is old; so old that the imagination fails to comprehend or grasp its age. Measured in units of the earth's revolutions around the sun, or by the lifetime of man, the estimate of fifty millions of years gives a most inadequate conception. Yet, while the earth is old, the face of the earth is ever being changed and modified under the force of land sculpture in the air and in the waters. But this flow from form to form in the landscape is not the result of caprice or blind chance. It is thus possible to understand and to interpret a landscape; to know both how it came into existence and what will be its final form. To make this interpretation, it is necessary to know the climatic conditions of the area, and the underground structures. The supreme importance of underground structure will be seen at once in the general principle that, in an area underlain by alternating hard and soft rocks which come to the surface, the outcrops of the harder rock will locate the elevations, the mountains and hills, while the soft rock will locate the depressions, or valleys and plains.

Rocks and Rock Structures Underlying Camp Bowie.

One of the chief assets of the city of Fort Worth is that it has a large supply of artesian water. To secure this supply, many deep wells have been drilled; and, by experience and mathematical calculations, the drillers know how deep they must drill and the kind of rock through which they must pass until they strike the water sands. From the data secured from the wells of the cities of Fort Worth, Arlington, Dallas, and other localities near by, and from a study of the attitude and character of the rocks which come to the surface in the surrounding areas, quite accurate knowledge has been secured both of the rocks and of the rock structures down to certain depths underneath the region around Camp Bowie.

In figure 1 is given an idealized section and birdseye view of the country from Camp Bowie eastward to Dallas. This sketch is known as a block diagram. The area is represented as a block sawn out of the crust of the earth, so that the underlying rock structure is shown in the edge of the block, while the surface topography is shown on the top of the block. It is thus possible to see at a glance the causal relation between the underlying rock structure and the configuration of the surface of the land.

One of the deepest artesian wells in the area above described was recently bored on the campus of the Southern Methodist University, at Dallas. (See United States Geological Survey Bulletin No. 629.) This well is 2,850 feet deep. From top to bottom the following rocks were encountered: chalk, 159 ft.; clay, shale and gumbo, with some lime, 507 ft.; sand and interbedded clays, 326 ft.; limestone, 377 ft.; limestone. 194 ft.; sand and clays, 207 ft.; limestone, 469 ft.; and sands, 106 ft.

Going from Dallas westward, the order of appearance of the rocks at the surface is chalk, shale, sand, limestone, limestone, sand, limestone, and sand, until the rocks in Palo Pinto County are reached, which are quite different in hardness and in general position. The fact that the series of rocks in the well-sec-

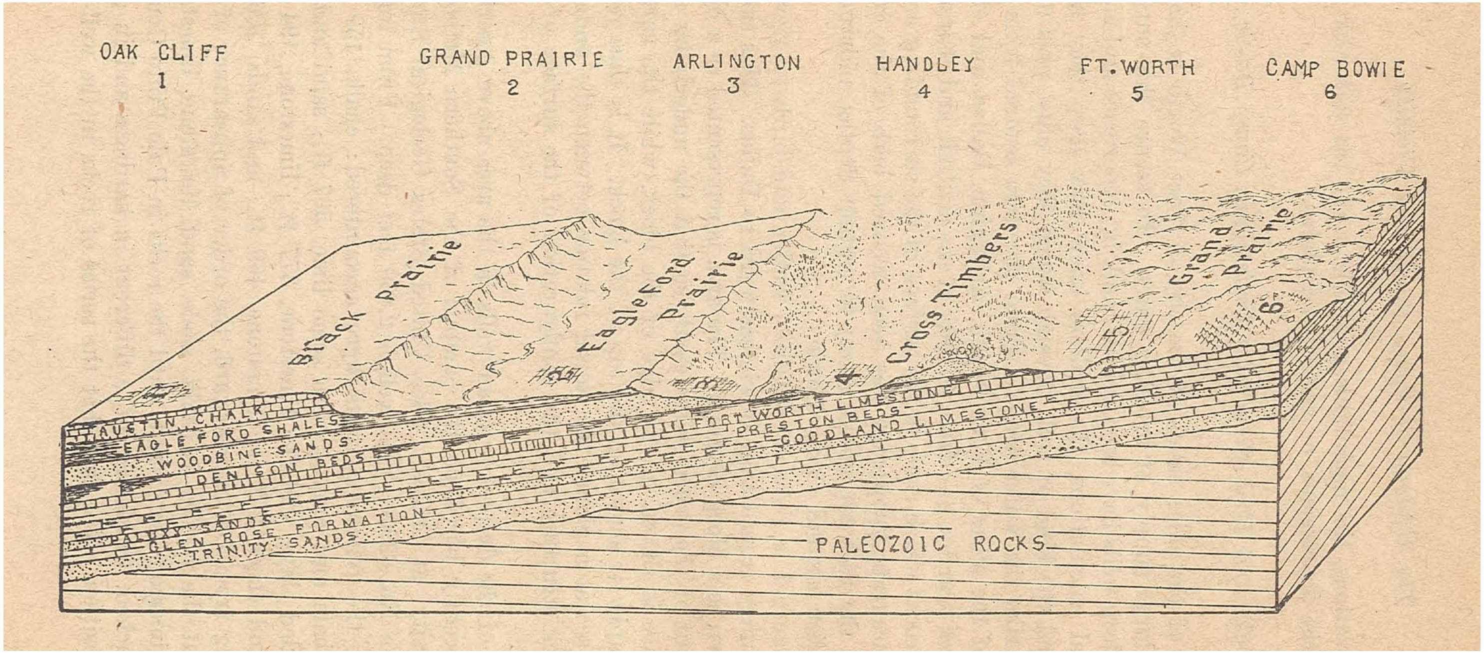

Figure 1. Block diagram showing the underground structure and surface topography, the cuestas, in the vicinity of Camp Bowie.

tion at Dallas is the same as the outcropping series, as one goes westward, gives the clue to the underground structure. It is evident that the outcropping beds, in the form of great sheets of rock, dip beneath the surface to the east, and at Dallas lie at various depths below the surface; the bed outcropping farthest to the west being buried deepest under the city of Dallas. This is shown in the block diagram in figure 1. Well-drilling is thus a mathematical problem in which is given the distance along the surface and the angle of dip of the beds under ground; required, to find the depth of any bed at a given point.

For convenience, the geologist has given names to the beds or sheets of rock, usually from the locality where the best exposures occur or where the formation is first described in print. The chalk at Dallas is part of a great sheet of chalk which was first described from its occurrence around the city of Austin. The shales below the Austin chalk are called Eagle Ford, from a little town by that name to the west of Dallas. Other formation names are given in the same manner. The formations recorded in the well above and in the successive series of rocks appearing to the west of the well, have been given the following names: Austin Chalk; Eagle Ford Shales; Woodbine Sands; Fort Worth, Preston, and Goodland Limestone; Paluxy Sands; Glen Rose Limestone, and Trinity Sands. The series of rocks above described belong to the Cretaceous Period. Underneath this series lie much older rocks belonging to the Paleozoic Period of geologic time.

The Cuestas

In a region where the beds dip at a low angle in one general direction, if there is a difference in the resistance of certain of the beds to erosion, that is, if they are harder than the others, such beds will give rise to 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, and on the other side a short steep slope. Such an unsymmetrical hill is called a cuesta.

As is seen from figure 1, between Dallas and Fort Worth there are three cuestas, two of which are important topographic features. The most striking cuesta is that developed on the Austin chalk. The cuesta developed on the Woodbine sands is equally important, but it is not so typical an example as that of the Austin chalk.

The Austin chalk cuesta stands in relief, because the chalk is more resistant than the underlying Eagle Ford shales which outcrop to the west of it. This cuesta, viewed from Dallas, shows a long gentle slope upward, which is covered by the city of Oak Cliff; viewed from the west, as at Grand Prairie, the short steep slope has the appearance of a mountain range in the distance.

The cuesta on the Woodbine sands is due to the fact that the limestones to the west are carried away in solution faster than the sands which stand up in a line of rounded hills capped with ferruginous sandstone and covered with timber. These hills, however, show the cuesta topography in that the steeper slopes face the west. The cuesta on the Woodbine sands bounds the eastern horizon from Camp Bowie across the city of Fort Worth.

Underneath the Woodbine sands lie the soft Denison beds, which make a part of the steep slope of the Woodbine cuesta. Below the soft Denison beds is found the Fort Worth limestone, a notably harder layer. This, again, underlies the long gentle rolling slope of the next cuesta to the west upon which Camp Bowie is located.

Prairies and Cross-Timbers

With the exception of the topography developed on the Woodbine sands, the prairies are located on the long gentle slopes of the cuestas. Thus, in going westward, one passes over the Black Prairie on the Austin chalk, the Eagle Ford Prairie on the Eagle Ford shales, and the Grand Prairie on the Fort Worth limestone. Prairie lands lack forests, and are usually covered with fine black residual soils. Just why the prairie lands are not timbered is a problem which has been variously explained, but that it is dependent upon the character of the soil, soil texture, and drainage rather than climate, seems quite evident, since in the belts where the Woodbine and Trinity sands come to the surface under the same conditions of climate there is a thick covering of timber.

These two belts of timber-covered sands have been called, respectively, the Eastern and Western cross-timbers. The cross-timber belts are of much less importance as farming lands than the prairies. As a source for lumber, they are of small value also, except for firewood, since the main forest growth is of stunted post oak, black jack, hackberries, and a few elms. The two belts are, however, of tremendous economic importance in that the outcrops of these sands in the cross-timbers form the catchment area for the great artesian water supply under the prairies.

Cuesta Topography in France

Particular attention is called to the cuesta topography because of the vital part this land form has played in the defense of France; for, fortunately, the heat of France, the country around Paris, is protected by encircling rims of hills, the steeper slopes of which face outward and form natural fortifications against an invading army.

This topography is due to the fact that the structure of the rock formations underlying that part of France, the so-called Paris Basin, has the form of nested bowls, individual formations coming successively to the surface in passing outward from the city of Paris. The rocks dip back toward Paris at low angles, and thus erosion has developed successive rims of cuesta hills on the harder formations, with the steeper slopes facing outward. These give commanding heights, with a maximum effectiveness for artillery positions, which can be defended with a minimum of effort from infantry attacks.

Again, the landscape in France reflects the underlying rock in the soil, the vegetation, and the farming, just as around Camp Bowie. Belts underlain by sand are forest-covered; clays and shales underlie farming lands; while smooth bare hills are found on the chalk.

Drainage

The area around Camp Bowie is drained by the Trinity River and its tributaries. The relation of the drainage to the cuesta hills is the paradox in the landscape, for the river crosses these hills at right angles. The explanation is that the Trinity River is older than the hills. The land, upon its emergence from the water, sloped gently toward the Gulf and upon this initial slope of the surface the Trinity had its birth.

As time passed, the Trinity deepened its valley, and the general surface of the land was lowered; lateral tributaries etched valleys along the outcrops of the softer beds, while the harder beds were left standing in relief. The Trinity, running in a comparatively narrow valley, has held its original course across the grain of the country, while the side tributaries, as, for example, Mountain Creek, Village Creek, and Sycamore Creek, developing later than the main stream, flow parallel to the grain of the country along the steeper front of the cuestas.

This feature, again, has military value, since in a cuesta topography these major transverse streams offer the line of greatest strategic weakness, and along such streams the invading armies must be resisted and repelled. The River Marne is thus one of the lines of easy advance into the heart of France, and its defense has been glorified by the death of many a brave Frenchman.

Rock Formations and Fossil Content Around Camp Bowie

Fort Worth Limestone

The white limestone which underlies Camp Bowie and the rolling hills of Grand Prairie has been named the Fort Worth limestone, or more properly the Fort Worth formation, because the city of Fort Worth is built upon it. Lithologically, the formation is made up of a series of alternating beds of hard and soft limestones, the hard layers spaced about eight to twelve inches apart with the soft layers between. When the rock is exposed to the weather, the softer beds are etched back, while the harder layers stand out in relief, and thus outcrops of the Fort Worth limestone show a characteristic ribbed appearance, such as is seen in figure 2. Fort Worth is the type

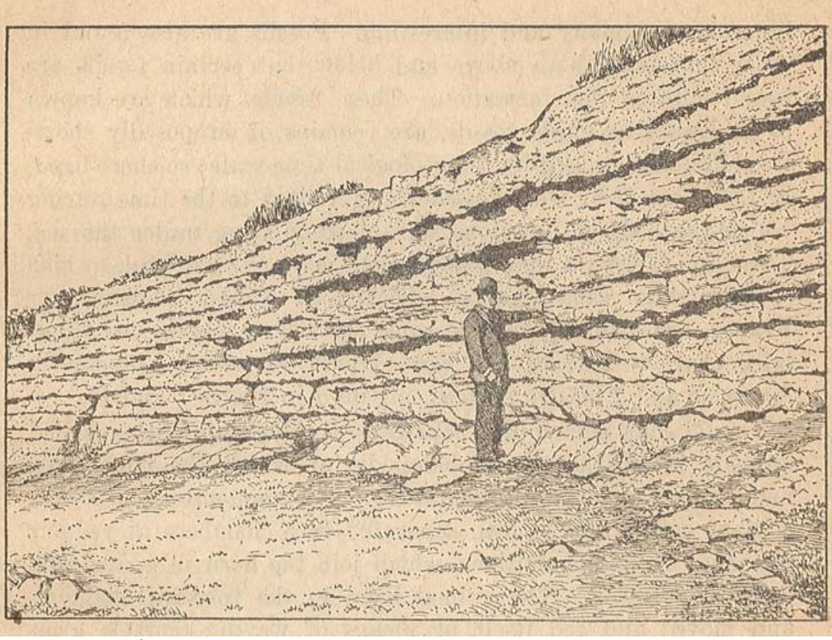

Figure 2. Fort Worth Formation, Fort Worth, Texas

locality for the formation, and many excellent exposures are to be seen about the city, as in the railway cuts near the Union Station; Trinity River bluffs, where the bridges cross to Arlington Heights, and to North Fort Worth; Forest Park; Sycamore Park, at the foot of Polytechnic Heights; and many exposures around the site of Camp Bowie and Lake Como.

The Fort Worth formation underlies the Grand Prairie, which differs from other Texas prairies in that it has a distinctly rolling topography.

The limestone, except for an ocasional bare spot where the white rock comes to the surface, is covered by a thin brown or black chocolate soil, which on account of the shallowness is left a natural pasture, and the area is generally covered with cattle ranches.

Fossils in the Fort Worth Limestone

A fossil is the imprint or remains of an animal or plant which is found in a rock. The fossil remains found in the Fort Worth limestone are many and interesting. Fossils are also found in other limestones both above and below, but certain fossils are found only in this formation. These fossils, which are known to geologists as guide fossils, are remains of supposedly short-lived animals, judged by the geological time scale; so short-lived, in fact, that their whole existence is limited to the time during which the beds of limestone were accumulating under the sea. These guide fossils thus become time markers, and rocks which contain these same fossils, whether in Texas, Alabama, or France, are evidently of the same age. Two fossils are especially characteristic of the Fort Worth limestone, *Ammonites leonensis* and *Epiaster elegans,* pictured in Plates I and II.

The "Leona ammonite" belongs to a sub-group of the shelled animals known as the cephalopods, of which the chambered nautilus is a modern representative. The ammonite shell is like a giant coiled ram's horn, separated into chambers at regular distances by cross-partitions, which join the horn in a curiously crinkled jointing. The animal lived in the forward chamber, and moved and fed itself by means of waving tentacle arms surrounding the mouth. When the animal died, the shell fell to the bottom of the ocean floor, and was buried in the lime mud. But, when the limestone was elevated again on land and exposed to weathering, these shells now fossilized and filled with lime muds were uncovered, and being more resistant to weathering than the surrounding rock, now lie on the surface. There are many sizes and shapes in the ammonite family, ranging from specimens two or three inches in diameter up to that of *Ammonites leonensis,* a veritable wagon wheel in size. This big fellow is found by the scores in outcrops around Fort Worth. Splendid examples are to be found along the roads from Camp Bowie to Lake Como, where broken fragments of the coil, like felloes from a wheel, and many whole shells, lie on the roadside.

A second fossil especially characteristic of the Fort Worth formation is *Epiaster elegans.* This "elegant biscuit urchin" belongs to the echinoids, "hedge hog" division of a great group of marine animals, of which the star fish and common biscuit urchin is a modern representative. The characteristic feature of these animals is the 5-partite division of the anatomy. The animal skeleton is made up of a series of plates which make a dome-shaped roof and a more or less flattened bottom. Many forms have a coronet shape. Practically all types were covered with knobs and spikes, which probably served for protection and, in part, locomotion. *Epiaster elegans* (Plate II, above) is usually found beautifully preserved, so that individual plates of the skeleton, knobs and bosses, and the serial rows of openings through which tube-like feet were projected, are all found in wonderful clearness and detail. Many other fossil animals are found in the limestone; such as ancient oysters, marine snails, ancient pecten shells, and other types.

If there is a plant representative among the fossils of the Fort Worth limestone, it is to be found in the characteristic but problematic fossil found on large slabs of the limestone, a network of crossing, branching, and recrossing ridges in size up to finger widths which covers the surface of the rock. These fucoid-like structures are thought by some to be the remains of sea weeds.

Fossils in Other Formations Around Camp Bowie

The formations both above and below the Fort Worth limestone are a full storehouse of fossil wealth, reflecting the varied life of the seas during the deposition of these rocks. West of Camp Bowie, underneath the Fort Worth limestone, as, for example, along the steep slope where the White Settlement road leaves Arlington Heights, are the Preston and Goodland limestone beds, full of biscuit urchins, many tiny as a thumb-nail; oysters, marine snails, ammonites, and other types of fossils.

To the east and lying above the Fort Worth limestone are the Denison beds. In going up the ravine from Sycamore Park to Polytechnic Heights, many interesting fossil forms are found. The one which will attract instant attention is a bed of tiny oysters which is about two feet thick. Still higher along the slope, twenty feet above the Fort Worth limestone, there is another characteristic oyster which has a wide distribution in Texas. It is known as *Gryphaea washitaensis*. This is shown in Plate I, lower figure.

A close relative of this oyster, but much larger, is found near the top of the Denison beds, as they outcrop in the deep cut along the T. & P. Railway near Handley. This oyster is known as *Gryphaea mucronata*. This is illustrated in Plate II. The list of good collecting grounds around Camp Bowie is a long one. In addition to the localities mentioned above, should be listed Forest Park, Sycamore Creek, White Rock, and along the road to Benbrook.

Fossils from the Sand and Gravel Pits

There is yet to be mentioned a fossil life found in the ancient sand and gravel pits around Fort Worth. These sand and gravel deposits were laid down by the Trinity River when it flowed at higher levels, during the period of Pleistocene refrigeration, when the northern parts of North America and Europe were covered with a great ice cap.

At that time, great herds of elephants, mastodons, and ancient bison roamed the Texas prairies, just as did the buffaloes within the memory of men living in Fort Worth today. Skulls and tusks, jaws, leg bones, and other fragments of these giants of ancient time are often found in the gravel and sand pits.

Geological Literature on the Area Around Camp Bowie

The above sketch of the geology of the area around Camp Bowie is but a brief and non-technical description. Further accounts are to be found in the following references, all of which will probably be found in the public library at Fort Worth:

Bulletin University of Texas, No. 44, "Review of the Geology of Texas."

United States Geological Survey, Twenty-first Annual Report, part VII.

United States Geological Survey Bulletin No. 629.

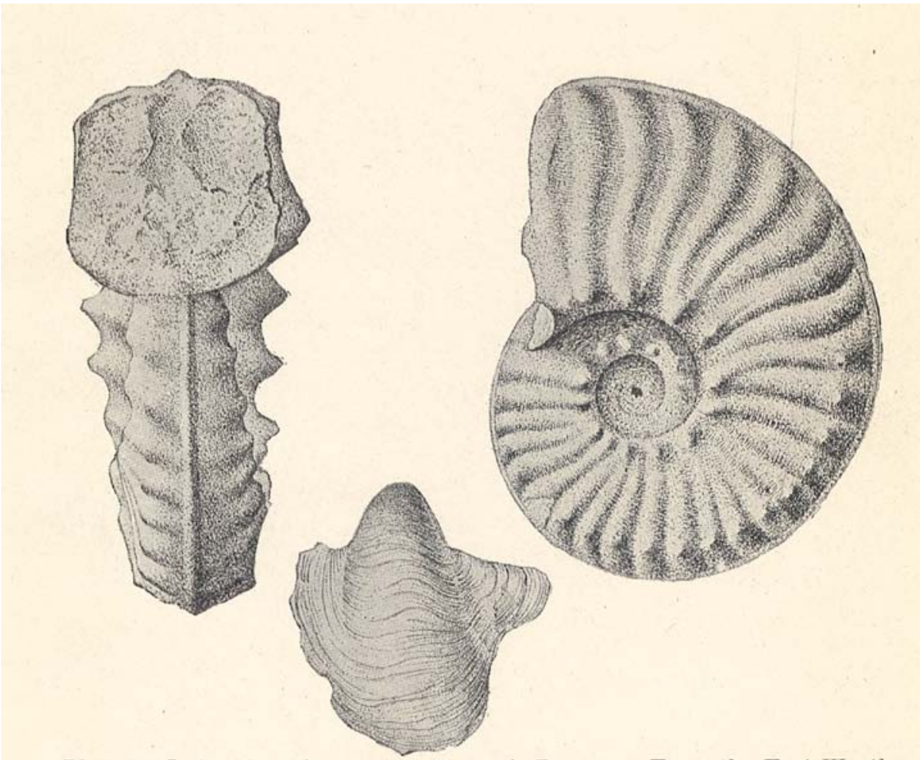

Plate I. Left side: Ammonites Conensis Roemer. From the Fort Worth Limestone.
Right side: Same; a side view.
Below: Gryphaea Washitaensis Hill. From the Dennison beds.

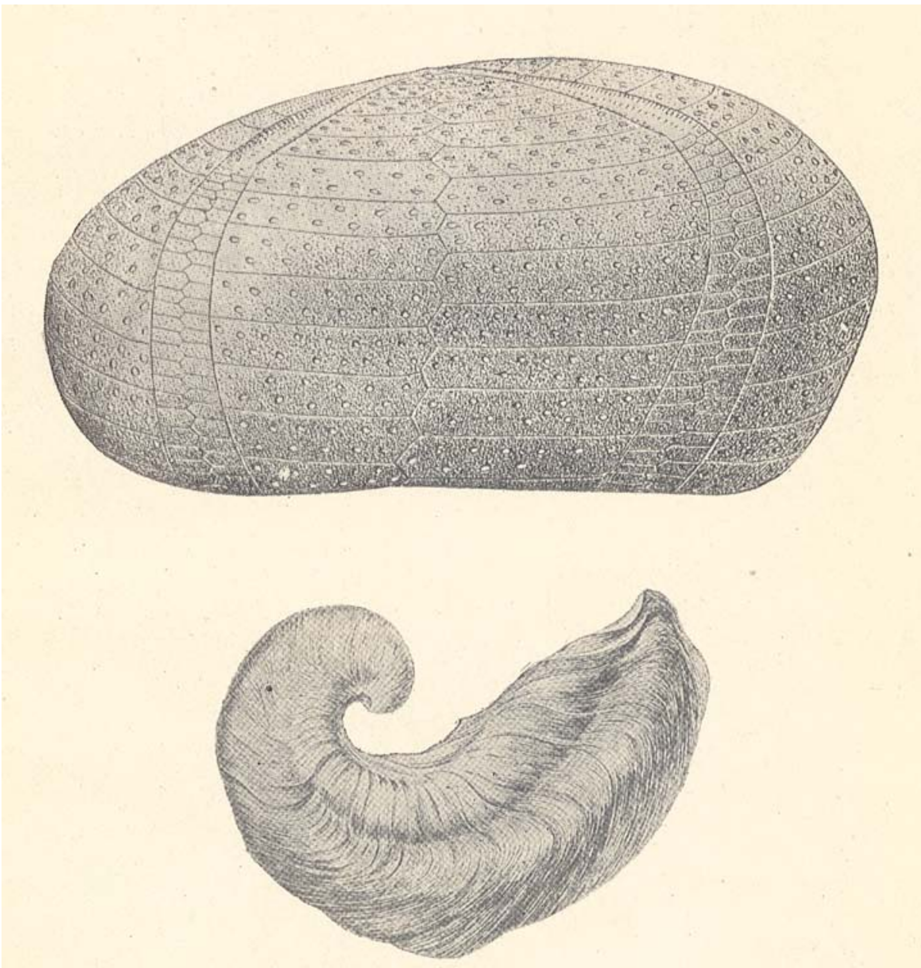

Plate II. Above: Epiaster elegans Shumard. From the Fort Worth Limestone.

Below: Gryphaea mucronata Roemer. From the Dennison beds.

PUBLICATIONS OF THE BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY

The Composition of Texas Coals and Lignites and the Use of Producer Gas in Texas. Wm. B. Phillips, S. H. Worrell, and Drury McN. Phillips. University of Texas Bulletin No. 189, July, 1911. (Out of print.)

A Reconnaissance Report on the Geology of the Oil and Gas Fields of Wichita and Clay Counties. J. A. Udden, assisted by Drury McN. Phillips. University of Texas Bulletin No. 246, September, 1912. Price, 50 cents.

The Fuels Used in Texas. Wm. B. Phillips and S. H. Worrell. University of Texas Bulletin No. 307, December 22, 1913. Price, 40 cents.

The Deep Boring at Spur. J. A. Udden. University of Texas Bulletin No. 363, October 5, 1914. (Out of print.)

The Mineral Resources of Texas. Wm. B. Phillips. University of Texas Bulletin No. 365, October 15, 1914. Price, 50 cents.

Potash in the Texas Permian. J. A. Udden. University of Texas Bulletin No. 17, March 20, 1915. Price, 10 cents.

Geology and Underground Waters of the Northern Llano Estacado. Charles Laurence Baker. University of Texas Bulletin No. 57, October 10, 1915. Few remaining copies at 75 cents each.

Road Materials of Texas. James P. Nash. University of Texas Bulletin No. 62, November 5, 1915. Price, 20 cents.

Origin of Texas Red Beds. Charles Laurence Baker. University of Texas Bulletin No. 29, May 20, 1916. Price, 5 cents.

Annual Report for the Year 1915, M. E. Stiles; Geological Maps in Texas, J. A. Udden. University of Texas Bulletin No. 35, June 20, 1916.

Review of the Geology of Texas (with map). J. A. Udden, C. L. Baker, Emil Böse. University of Texas Bulletin No. 44, 1916. Price, in paper cover, 70 cents; bound in cloth, 90 cents.

Contributions to the Knowledge of Richthofenia from the Permian of West Texas. Emil Böse. University of Texas Bulletin No. 55, October 1, 1916. Price, 15 cents.

The Thrall Oil Field. J. A. Udden, H. P. Bybee. University of Texas Bulletin No. 66, November 25, 1916. Price 40 cents.

Rustler Springs Sulphur Deposits. E. L. Porch, Jr. University of Texas Bulletin No. 1722, April 15, 1917. Price 30 cents.

Texas Granites. J. P. Nash. University of Texas Bulletin No. 1725, May 1, 1917. Price 10 cents.

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