BUREAU OF ECONOMIC GEOLOGY
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# GEOLOGIC QUADRANGLE MAPS

## Palo Alto Creek Quadrangle
## Gillespie County, Texas

By

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# GEOLOGY OF THE PALO ALTO CREEK QUADRANGLE, GILLESPIE COUNTY, TEXAS

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## GENERAL SETTING

Palo Alto Creek quadrangle is south of the Llano region and is in the marginal portion of the Edwards Plateau where much of the plateau surface has been destroyed by erosion. Along the northern edge of the quadrangle a portion of a finger of the plateau trends eastward, and in the west-central part another finger of the plateau frays out into a number of isolated outliers. The rest of the quadrangle is a portion of the gently undulating broad Pedernales River basin.

The geology of the Palo Alto Creek quadrangle is shown on a planimetric map, and the only topographic map available is the reconnaissance 30-minute Fredericksburg quadrangle. Elevations ranging between 1,556 and 1,975 feet were determined during traversing for control, but neither the highest nor the lowest elevation was reached. However, it is estimated that the relief within the quadrangle is about 550 feet, ranging between about 1,525 and 2,075 feet in elevation.

The quadrangle is entirely within the Pedernales River drainage basin and is mostly drained by Palo Alto Creek and its tributaries. Barons Creek drains the southwestern corner of the quadrangle, and Willow Creek and the tributaries of North Grape Creek drain a small area in the northeastern corner.

The Palo Alto Creek quadrangle is high on the southern side of the Llano uplift, and rocks from pre-Cambrian to Ordovician in age outcrop as inliers surrounded by Cretaceous rocks. The faulting accompanying the Ouachita orogeny (Barnes, 1948) is not exposed, but dips in Paleozoic rocks up to 9° are present. The Cretaceous rocks are essentially horizontal, dipping eastward about 8 feet per mile.

Broader discussions of the stratigraphic, structural, economic, and geophysical problems of the region cannot be given in the space available. References cited below deal with some of these problems. This publication on the Palo Alto Creek quadrangle is one of a series of similar publications, an index to which is shown on the opposite page. The reader is referred to this index map to locate other quadrangles mentioned in the present text.

## GEOLOGIC FORMATIONS

### PRE-CAMBRIAN ROCKS

#### OATMAN CREEK GRANITE

The only outcropping pre-Cambrian rock within the quadrangle is granite, covering about 82 acres, situated 3.5 miles airline north-northeast of Fredericksburg along the eastern side of the upper Crabapple road. The outcrop is 4,000 feet long in a north-south direction, is 1,200 feet wide, and forms a hill standing approximately 200 feet above the surrounding Hensell sand. The hill is known as Bear Mountain which is locally famous for the balanced rock near its summit. Hand-leveling at a distance of about 1 mile indicates that the top of Bear Mountain reaches to within 5 feet of the base of the Edwards limestone. The whole surface of the granite is rough and boulder-strewn; the boulders are mostly in place and are brought into relief by weathering.

The granite has been described by Barnes, Dawson, and Parkinson (1947, pp. 58–60) and analyzed by Goldich (1941, p. 700). The chemical analysis reveals that the granite is highly silicic; it is similar in composition to an aplite and is therefore an aplogranite. Its composition and cataclastic character identify it as Oatman Creek granite.

### PALEOZOIC ROCKS

#### CAMBRIAN SYSTEM (UPPER CAMBRIAN)

##### Riley Formation

*Cap Mountain limestone member.*—An outcrop of Cap Mountain limestone 2,800 feet long in an east-west direction and about 1,700 feet wide forms a low hill just southeast of the Llano highway 5 miles northeast of Fredericksburg. The rock is well exposed in Marshalls Creek for a distance of about 1,800 feet where it is composed of brown calcareous sandstone beds and highly sandy limestone beds. To the east and stratigraphically higher the rock is more calcareous. The Cap Mountain limestone dips about 9° to the east along Marshalls Creek but appears to flatten eastward. A test pit or small quarry is situated near the center of the outcrop.

Another small outcrop of Cap Mountain limestone is situated 600 feet downstream from the falls on Palo Alto Creek. About 4 feet of section is exposed. The lower 3 feet questionably classified as limestone is glauconitic, yellowish orange, much burrowed, highly silty, and perhaps argillaceous. It contains linguloids. The top foot is grayish-red sandstone, and the one trilobite seen is possibly *Coosella*.

##### Wilberns Formation

*Pedernales dolomite member.* — A poorly exposed outcrop thought to be Pedernales dolomite is situated just south of the Burnet road about 6 miles east-northeast of Fredericksburg. The dolomite is cherty, fine grained, dirty gray, and a few poorly preserved trilobites found in the chert are thought by Dr. W. C. Bell to be Cambrian species.

#### ORDOVICIAN SYSTEM (LOWER ORDOVICIAN-ELLENBURGER GROUP)

##### Tanyard Formation

*Staendebach member.*—Cherty fine-grained dolomite of the Staendebach member crops out in several places along Palo Alto Creek in the southeastern part of the quadrangle, and one outcrop centers on the southeast corner of the quadrangle. No fossils were noted in the cherts, but from the lithologic characteristics of the dolomite and chert and the presence of superposed rocks of Gorman age a short distance to the south in the Cain City quadrangle, the outcrops are fairly definitely identified as Staendebach in age.

## MESOZOIC ROCKS

#### CRETACEOUS SYSTEM (LOWER CRETACEOUS)

##### Shingle Hills Formation

*Hensell sand member (Barnes, 1948).*—The Hensell sand is about 345 feet thick in outcrop within the quadrangle, and additional beds are present in the subsurface.

The Hensell sand varies widely in color and composition throughout the quadrangle and is influenced to some extent by the type of rock being transgressed. At the surface the Hensell sand rests upon granite of pre-Cambrian age, sandy limestone of Cambrian age, and dolomite of Cambrian and Ordovician age. In the subsurface it is likely that other units of the pre-Cambrian, Cambrian, and Ordovician are overlapped, and only a short distance to the north of the quadrangle the Hensell overlaps essentially all units of the pre-Cambrian exposed in the Llano uplift.

The upper boundary of the Hensell sand is gradational and becomes stratigraphically higher northward as the limestones of the Glen Rose are replaced laterally by clastic sediments. In the northern part of the quadrangle the Hensell sand extends up to the base of the Walnut clay and at the extreme edge of the quadrangle, where the Walnut can no longer be identified, it extends up to the Comanche Peak limestone. The Hensell sand is composed of two color facies, the lower one predominantly red and the upper one predominantly gray. The dividing line between these facies roughly parallels the base of the Glen Rose limestone and therefore rises stratigraphically northward, being controlled in part by the proximity of the shore at the time the sediments were deposited.

The Hensell sand is in general very poorly sorted and ranges from conglomerate and granules through the various sand sizes to silt and clay. The conglomerate exposed in the Palo Alto quadrangle is limited to a few small outcrops, one of which is mapped on the east side of Bear Mountain; another is mapped along Palo Alto Creek near the southern boundary of the quadrangle. Angular quartz granules and solution-sculptured microcline are common in the lower part of the Hensell sand in the southern part of the quadrangle where numerous exposures can be seen along drains and in road ditches. The upper portion of the Hensell sand is finer grained, contains abundant silt and clay, and in the vicinity of the base of the Glen Rose some of the beds are calcareous.

The Hensell is so little indurated that it readily breaks down and forms gentle slopes except immediately beneath the Glen Rose limestone. The topography of the Hensell in the southern part of the quadrangle, where it is coarse and highly siliceous, is very gently rolling, and here the Hensell supports a growth of broad-leaf oak which forms a black featureless expanse of woodland on aerial photographs. The soil from the Hensell is much more extensively cultivated than soils from any other formation; consequently the Hensell supports a much higher density of population than any other formation in the quadrangle.

Since the Hensell sand is so little indurated, sections more than 10 feet thick are rare, especially in the lower part of the member. However, a 75-foot section of the Hensell sand is present along Barons Creek near the southern border of the quadrangle.

Another section of Hensell sand 27 feet thick was measured between a Cap Mountain limestone outcrop in the bed of Palo Alto Creek and the lip of the falls in Palo Alto Creek. The rock is mostly fine-grained sand, which is argillaceous, contains much caliche, and is of a wide variety of colors near grayish pink, yellowish brown, and yellowish orange. An additional thickness of 162 feet is estimated for the beds intervening between the top of the section and the base of the Walnut clay. The rocks are mostly poorly exposed, but from the soil and a few good exposures it is judged that much of the lower portion of the interval is reddish fine-grained material. A few coarse-grained beds containing pebbles are exposed. A calcareous bed sufficiently indurated to produce a bench is near the top of the interval, and the rocks from the base of the bed to the base of the Walnut clay are mapped as Glen Rose limestone.

*Glen Rose limestone member.* — Within the Palo Alto Creek quadrangle the Glen Rose limestone member may attain a thickness of as much as 150 feet in its southeasternmost outcrop. It is 55 feet thick at Cross Mountain as measured in a section described below and 40 feet thick 2.5 miles northeast of Fredericksburg. Northward it thins rapidly, being absent along the northern border of the quadrangle. The thinning is caused by lateral gradation, the carbonate beds in the Glen Rose grading to clay, silt, and sand northward toward the Llano uplift. The base of the Glen Rose limestone is arbitrarily placed at the base of the lowest bench-forming bed, be it limestone, dolomite, or a calcareous sandstone.

The Glen Rose limestone consists of alternating beds of limestone, dolomite, clay, and sand or, more correctly stated, beds having various proportions of these materials. The Glen Rose limestone is not very fossiliferous within the Palo Alto Creek quadrangle. One rather poor collection (locality 8-3A) was secured from about 6¼ miles northeast of Fredericksburg from an outlier 2,000 feet east of the highway to Llano. Dr. Ralph Imlay identified *Actaeonella* sp. and *Exogyra* sp. from this locality.

The Glen Rose limestone, consisting of beds having varying resistance to erosion, produces a terraced topography. In the Palo Alto Creek quadrangle these terraces show very nicely on aerial photographs. In general the Glen Rose limestone is the most sterile of the various units within the quadrangle and the least vegetated. Bands of white where there is insufficient vegetation to cover the underlying rock alternate with bands supporting vegetation. It contrasts with the upper portion of the Hensell sand, having about the same amount of vegetation but evenly distributed.

##### Fredericksburg Group

The Fredericksburg group in the Palo Alto Creek quadrangle consists of about 150 feet of Edwards limestone, 28 feet of Comanche Peak limestone, and up to about 5.5 feet of Walnut clay. The boundaries between the units are gradational, and so far as this quadrangle is concerned, Thompson's (1935) observation that these units should have about the rank of members seems logical. However, instead of introducing a new name, it seems that Fredericksburg could easily be dropped from group to formational rank, especially since the U. S. Geological Survey excludes the Kiamichi clay from the Fredericksburg group (Wilmarth, 1938, p. 776).

*Walnut clay.*—The Walnut clay is about 5.5 feet thick north of Fredericksburg in the vicinity of Cross Mountain and thins northward, disappearing before the north edge of the quadrangle is reached. In most of the quadrangle the Walnut clay rests on beds of Glen Rose limestone which vary in composition from place to place, but in the northern part of the quadrangle it rests directly on Hensell sand. The Walnut clay grades upward into the Comanche Peak limestone, and any boundary between the two that may be chosen is purely arbitrary, especially in areas where exposures are poor. Within the quadrangle the width of the Walnut clay outcrop is too narrow to map, and it has been represented on the map by a solid color line. Northward the line is discontinued largely on the basis of the disappearance of *Exogyra* as float. Fresh outcrops are rare, and undoubtedly the Walnut has been mapped beyond the point where it is predominantly clay, since *Exogyra* is quite abundant in the basal few feet of rocks mapped as Comanche Peak limestone where it is fully developed.

The Walnut clay is composed of calcareous clay grading upward into impure nodular limestone. The clay is highly calcareous, silty, fossiliferous, somewhat sandy, and is yellowish gray mottled by yellowish orange. It is too thin to influence noticeably the vegetation or culture of the area. Most of the fossil collections made from the Walnut clay also contain fossils from the basal portion of the overlying Comanche Peak limestone, since the fossils from both units weather free and intermingle. Fossils from locality 8–12A, about 2.8 miles airline northeast of Fredericksburg, have been identified by Dr. Ralph Imlay as follows:

Exogyra texana Roemer
Enallaster cf. bravoensis Böse
Holectypus planatus Roemer

*Metengonoceras* cf. *inscriptum* Hyatt has been identified by Dr. Imlay from locality 8–24C, which is about 2 miles airline north of Fredericksburg.

*Comanche Peak limestone.* — The Comanche Peak limestone averages about 25 feet in thickness in the Palo Alto Creek quadrangle, being slightly thinner in the northern part of the quadrangle and 25.5 feet thick near Cross Mountain. It grades downward into the Walnut clay where present and in the northern part of the quadrangle rests directly on the Hensell sand. Upward the Comanche Peak limestone grades into the Edwards limestone, and the boundary is arbitrarily placed at the base of a thin-bedded, very fine-grained limestone, which in some outcrops contains thin chert plates.

The Comanche Peak limestone contains considerable argillaceous material, especially in its basal part, which is also the most highly fossiliferous portion. The lower part tends to be nodular, and much of the Comanche Peak has been extensively burrowed. These burrows are very well exposed in a road cut along the upper Crabapple road 1¾ miles north of Fredericksburg. The top few feet of the Comanche Peak, unlike the lower portion, is well bedded with from one to three beds having about the proper thickness to be used as building stone. Stray, mostly polished quartz and chert pebbles up to 2 inches in size are present in the Comanche Peak limestone. Some of these may have been carried to their present position by kelp, and others may be gastroliths.

The Comanche Peak limestone is softer than the overlying Edwards limestone and has eroded into a steep slope which is characteristic of its outcrop throughout the quadrangle. On north slopes it has a distinctive vegetation shown on aerial photographs by vegetational banding. The outcrop of the Edwards has an average density of vegetation greater than that of the Glen Rose limestone, and in addition the vegetation shows better segregation into bands. Above the abrupt slope of the Comanche Peak limestone the Edwards limestone flattens out into gently sloping surfaces.

The Edwards surface is mostly rocky and above some beds is chert-strewn. Some of the chert in the Edwards is of a quality suitable for the manufacture of artifacts, and because it was used extensively by the aborigines is mostly referred to as flint. The Edwards limestone within the Palo Alto Creek quadrangle is for the most part so gently sloping and the outcrops are so inadequate that it is difficult to measure a complete section. However, in the section given below, 35 feet of Edwards is described.

No fossil collections were made.

## QUATERNARY DEPOSITS

*High gravel.*—Many of the deposits mapped as high gravel are essentially deposits of colluvium which have moved down slope from the Comanche Peak scarp. These deposits are derived largely from the Edwards limestone and at one time may have practically masked the Hensell sand within the Palo Alto Creek quadrangle. Many of the remaining remnants are in divide areas where erosive forces can attack them only slowly.

The high gravel is composed chiefly of pebbles, cobbles, and finer materials, some of which have been calichified. Much of the material is limestone, chert, and dolomite from the Edwards and limestone from the Comanche Peak. Quartz pebbles present are reworked from the Hensell sand, and an occasional pebble may be one of the erratics from the Comanche Peak limestone.

The high gravel deposits mapped along the major streams in part contain less caliche and may be largely reworked material from colluvial deposits. No line of demarcation exists in border-line cases between deposits that are truly colluvial and those that are deposited by stream action. For this reason the deposits are mapped under one designation. The high gravel supports a clumpy vegetation, live oak mottes being common. Because of their distinctive photographic pattern, several small outcrops of high gravel were found in the densely wooded portion of the Hensell outcrop area.

*Alluvium.*—Deposits of alluvium are situated mostly along Barons and Palo Alto Creeks including north branches of Palo Alto Creek such as Marshalls Creek. Narrow belts and patches of alluvium follow many of the lesser drainages in the area but are insignificant and have not been mapped. East of Fredericksburg and south of the Burnet road the alluvial pattern indicates that Palo Alto Creek formerly flowed farther north in a somewhat circuitous route. The new channel is so recent that significant alluvial deposits have not had time to accumulate along the creek.

The alluvium is composed of sand and silt at the surface and of coarser materials beneath. Alluvial cones have formed where short drains debouch onto alluvial flats. Most of the areas of alluvium are cultivated, but some areas which are not cleared support a dense vegetation including trees, vines, and undergrowth which on aerial photographs is even denser and darker than the pattern on the lower part of the Hensell sand. The more open areas of alluvium, especially along the banks of streams, are populated by tall pecan trees.

## SUBSURFACE GEOLOGY

Within the Palo Alto Creek quadrangle there is very little information from wells about the subsurface geology. The sporadic outcrops of Paleozoic and pre-Cambrian rocks within the quadrangle suggest that these rocks form the surface upon which the Cretaceous rests. The youngest Paleozoic rock seen at the surface is Staendebach in age, but Gorman rocks crop out a short distance to the south and may very well extend into the southern part of the quadrangle. In the Llano uplift the outcropping pre-Cretaceous rocks are faulted, and their pattern beneath the Cretaceous within the quadrangle may be as complicated as it is elsewhere in the Llano uplift.

The information about the pre-Cambrian rocks upon which the Cretaceous and Paleozoic rocks lie is very meager, being confined to one exposure, one well, and some gravity data. The exposure is Bear Mountain, an Oatman Creek granite, a type of granite which usually occurs in small masses about the size of Bear Mountain and often near the margin of Town Mountain granite masses. The gravity data indicate that Bear Mountain is about marginal to a gravity low. Romberg and Barnes (1944 and subsequent unpublished data) find that in areas of outcropping pre-Cambrian rocks in the Llano uplift, large gravity lows are associated with Town Mountain granite masses. A well drilled in the Live Oak Creek quadrangle penetrated Town Mountain granite along the margin of the gravity low and on about the same isogam as Bear Mountain is located. From interpretation of the gravity data it is postulated that a Town Mountain granite mass which centers in the Hilltop quadrangle underlies the northwestern corner of the Palo Alto Creek quadrangle. Much of the Palo Alto Creek quadrangle appears to be an area of low gravity values, indicating the presence of light-weight rocks such as granite or acidic gneiss. Another Town Mountain granite mass probably trends into the northeastern corner of the quadrangle from the vicinity of Willow City where Town Mountain granite crops out.

A sharply defined gravity high trending eastward from the Live Oak Creek quadrangle penetrates the Palo Alto Creek quadrangle for about 1 mile. The rock responsible or at least partly responsible for the high is diorite and was penetrated by a well drilled by the City of Fredericksburg.

The City of Fredericksburg well No. 5, in the vicinity of Barons Creek not far from the Ranch Motel, is located near the point where the San Antonio highway (U. S. No. 87) turns south. About 30 samples from this well were submitted to the Bureau by Alfred Neffendorff. All of the material except the bottom 23 feet consists of various proportions of sand and limestone, the limestone having the appearance of caliche. Since the well was drilled in relatively loose material much caving is to be expected, and the caliche fragments may be from near the surface. The caliche grades from microgranular limestone, to highly sandy limestone, to calcareous sandstone. The sand is composed of quartz and microcline, is poorly sorted, red stained, and medium grained to coarse grained in the top sample, 0 to 17 feet, and mostly coarse grained to very coarse grained from 17 to 200 feet. Almost perfectly rounded quartz grains are present in the top sample, and occasional round grains were noted in other samples. These grains are probably derived from some of the Cambrian sandstones. Most of the quartz grains are angular, rough, and show little rounding. The microcline is in angular, blocky, solution-pitted grains, many of which are large. A few samples are almost 50 percent microcline. From about 170 to 200 feet the sand is smeared by brown clay, and from 200 to 216 feet the samples are composed preponderantly of a highly weathered dark-colored igneous rock (diorite). From 216 to 223 feet, which is the total depth of the well, the diorite is fresh, nearly black, and is composed of hornblende having an index of refraction in excess of 1.65, andesine feldspar, and a very small amount of biotite.

## MINERAL RESOURCES

The mineral resources of the quadrangle are limited to nonmetallic substances and water. Outside of the soils, the most productive of which are from the Hensell sand and the alluvium, the most important nonmetallic resources are construction materials.

### CONSTRUCTION MATERIALS

*Building stone.*—Granite has been produced from Bear Mountain for many years to supply a local and regional demand. The granite is much jointed, resulting in considerable waste during quarrying, but is of exceptional quality and handsome appearance. The granite has been used locally in the attractive county courthouse and for many tombstones and other monuments.

Many of the older buildings in Fredericksburg and the surrounding country are of rock quarried from the top of the Comanche Peak limestone in the Palo Alto Creek and Live Oak Creek quadrangles. From one to three beds of stone of suitable thickness are present and have been quarried along the top of many of the Comanche Peak scarps and outliers in the vicinity of Fredericksburg. The stone is soft and easily worked and has satisfactory weathering characteristics for the Fredericksburg climate. However, the stone is drab and no new stone of this type has been quarried in recent years. Some of the beds of the Edwards limestone are of the proper thickness for ledgestone for building and are light colored, somewhat harder, and in general more pleasing in appearance than the limestone from the Comanche Peak.

*Road material.*—Road materials from several of the geologic units within the quadrangle have been used. Four of the pits mapped are near the top of the Hensell sand, three in the Glen Rose limestone, one in the Edwards limestone, and seven in the Quaternary high gravel. The material has been used for both highway base-course material and for surfacing secondary roads.

Base-course materials used in some of the present highways cause freeze damage, and as these highways are replaced better materials should be used. Much of the material used so far has come from the Comanche Peak and other soft easily worked geologic units. It might be better to use harder rocks for base-course material such as are found in some portions of the Edwards limestone. The Cap Mountain limestone along State highway No. 16 might also furnish desirable base-course material. Some of the outcrops of dolomite in the Staendebach member are sufficiently above stream level so that they could be quarried for granules for highway surfacing. However, at present they are not near a highway.

*Sand and gravel.*—The sand in the Hensell is mostly too impure to be used as a building sand, but in some areas wind has drifted and sorted enough of it for local use. The alluvial deposits as well as the high gravel deposits are too impure to be used as a source of gravel if better materials are available. Better deposits are situated along Pedernales River only a short distance to the south. Some portions of the Edwards limestone, the Cap Mountain limestone, and the Staendebach member are good for the production of crushed stone.

*Gypsum.*—The approximate trace of the Kirschberg evaporite embraces some small areas at the northern edge of the quadrangle. It is unlikely that much gypsum remains within the quadrangle because of solution.

## WATER

A ground-water survey of Gillespie County was made by Shield (1937). Most of the wells inventoried in the Palo Alto Creek quadrangle are in the Hensell sand and range in depth from 23 to 236 feet. The depth to the surface of the water ranges between 5 and 122 feet. The total solids in the 35 water samples analyzed range from 219 to 2,576 parts per million, and only 6 samples contained more than 1,000 parts per million. The main easily available source of ground water in the area is the Hensell sand. In the vicinity of Fredericksburg wells encounter pre-Cambrian rock at a depth of about 200 feet, and north of Fredericksburg granite crops out. In the eastern part of the quadrangle, however, outcrops of Cap Mountain limestone, Pedernales dolomite, and dolomite of the Staendebach member of the Tanyard formation indicate that the Hickory sandstone could be present beneath about half of the quadrangle. The Hickory sandstone should be a good aquifer, but it will be difficult to predict its presence and its depth because of complicated structure.

The Welge sandstone and Lion Mountain sandstone should be present in the southeastern part of the quadrangle but in a smaller area than the Hickory. These sandstones are much thinner than the Hickory sandstone, and their qualities as an aquifer are little known; however, the Welge at least should carry some water.

An aquifer is also present near the base of the Edwards limestone. Two springs are mapped in this position, and others are probably present. Marshall Spring, mapped along the west side of the Llano highway, has a measured flow of 4 gallons a minute (Shield, 1937). A well near by on the divide has a water level recorded at about the same elevation as the spring.

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## STRATIGRAPHIC SECTION

### Cross Mountain Section

| Description | Thickness in feet: Interval | Thickness in feet: Cumulative | Feet above base |
|---|---|---|---|
| *Fredericksburg group: 66 feet measured* | | | |
| *Edwards limestone: 35 feet measured* | | | |
| 1. Limestone and dolomite—microgranular to sublithographic, white to yellowish gray and containing an occasional yellowish orange mottle. The dolomite is so fine grained that it was not distinguished in the field. From microscopic examination of samples, dolomite appears to dominate from 93 to 103 feet and be approximately equal to the limestone between 113 and 123 feet. The limestone from 90 to 92 feet is massive and in lower part of interval contains semi-chalcedonic to opaque, dark yellowish brown chert nodules which weather light brown, and at top of interval a similar pale yellowish brown chert is in oval to elongate nodules; 92 to 93.5 feet, thin bedded; 93.5 to 95 feet, massive and containing gray chert nodules in base; 95 to 98 feet, thin bedded and apparently argillaceous since it is thrown into sharp folds; 98 to 100.5 feet, massive to nodular at top; 100.5 to 104 feet, pulverulent to calichified weathered limestone; 104 to 107 feet, hard and honeycombed; 107 to 109 feet, hard, well-bedded, and beds 6 inches thick; 109 to 111 feet, mostly covered but having some thin beds showing as fragments in the soil; 111 to 112 feet, white and beds 4 to 6 inches thick; 112 to 118 feet, poorly exposed but apparently massive and burrowed since rock has a tendency to be honeycombed; 118 to 122 feet, hard, honeycombed in lower part, becoming smoother above; and from 122 to 123 feet, well bedded and beds up to 4 inches thick. | 33 | 33 | 90 –123 |
| 2. Limestone—very fine grained, between yellowish gray and white, harder than the Comanche Peak limestone beneath, very thin bedded, and most of the beds between one-quarter and 1 inch in thickness. No chert was noted, but on the opposite side of the ridge toward Bear Mountain, flat chert plates are common in this interval. | 2 | 35 | 88 – 90 |
| *Comanche Peak limestone: 25.5 feet thick* | | | |
| 3. Limestone—very fine grained, highly dolomitic, argillaceous, grayish yellow, and some beds slightly speckled by yellowish orange. The limestone is well bedded and beds mostly from 4 to 20 inches in thickness, except for some argillaceous thin bedded zones. The commonly used building stone beds are in the upper part of the interval. | 8 | 43 | 80 – 88 |
| 4. Limestone and dolomite—very fine grained except for considerable coarse grained ground up shell material, argillaceous, slightly sandy, highly burrowed and burrows weather in relief. The burrows are dolomite and the matrix is limestone. The burrows are mostly half an inch to 1 inch in diameter, but some are larger and others are smaller. The rock is grayish yellow containing some yellowish orange stain, and there is very little color contrast between the burrows and the matrix; the burrows may be slightly darker. The rock in this interval forms one massive bed. A thin section was made across the boundary of a burrow at 76 feet. The matrix is extremely fine grained calcite containing a few very widely spaced small dolomite rhombs and sand grains, an abundance of fossil fragments, and several microfossils. The burrow is chiefly microgranular dolomite and contains fragments of the matrix averaging perhaps a millimeter in size. The boundary between the two is irregular but sharp, and elements in the matrix next to the dolomite are aligned parallel to the boundary, indicating that the matrix in the walls was deformed. | 9 | 52 | 71 – 80 |
| 5. Limestone—fine grained, argillaceous, somewhat sandy, from very fine to coarse, a few microgranular dolomite rhombs, yellowish gray mottled by pale yellowish orange, and massive but nodular. The top foot is somewhat more argillaceous and tends to be flaky bedded and recessive. The interval is highly fossiliferous upward. The fossils are similar to those in the Walnut clay, except that *Exogyra* is much less abundant. The contact between the Walnut clay and Comanche Peak limestone is at the point where the clay content becomes enough less so that the Comanche Peak limestone in vertical cuts remains standing and the Walnut clay beneath becomes recessive. This is a gradational contact which is somewhat irregular and placed at different points depending on the degree of weathering. | 8.5 | 60.5 | 62.5– 71 |
| *Walnut clay: 5.5 feet thick* | | | |
| 6. Clay and limestone—the clay is highly calcareous, contains considerable very fine to fine sand, an occasional coarse grain, and is highly fossiliferous. Both the clay and limestone are yellowish gray mottled by yellowish orange, the yellowish orange being less pronounced upward. The fossils noted are *Exogyra* abundant; *Gryphaea* and pelecypod casts common; and gastropod casts and echinoids present. The bottom contact of the Walnut is poorly exposed but can be uncovered by digging. Little is seen to indicate a disconformity other than an intensifying of color in the clay at the top of the Glen Rose limestone. | 5.5 | 66 | 57 – 62.5 |
| *Shingle Hills formation: 57 feet measured* | | | |
| *Glen Rose limestone member: 55 feet thick* | | | |
| 7. Clay—calcareous, contains much very fine sand, and is yellowish orange except for the top surface which is dark yellowish orange. The basal portion of the clay is poorly exposed. *SHIFT* eastward across fence into pasture. | 4 | 70 | 53 – 57 |
| 8. Clay—calcareous, sandy, silty, and light greenish gray mottled by yellowish orange in the lower part, and light greenish gray in the upper part. At 37.5 feet there is about 6 inches of yellow, indurated silt, having light greenish gray bleached streaks along joints. A 3-inch bed of coarse, poorly sorted, yellowish gray quartz sand is at 39 feet. The interval from 41 to 42 feet is somewhat indurated, being rather highly calcareous. | 14 | 84 | 39 – 53 |
| 9. Limestone—white, hard, and contains considerable medium to coarse grained sand. | 1 | 85 | 38 – 39 |
| 10. Clay—poorly exposed, calcareous, and has a high content of poorly sorted, well rounded, fine sand and silt. | 2 | 87 | 36 – 38 |
| 11. Limestone—highly silty, sandy, and appears to be gradational from the interval below. | 3 | 90 | 33 – 36 |
| 12. Clay—silty, grayish yellow to yellow, poorly exposed, calcareous, and contains considerable caliche as irregular to platy forms. *SHIFT* across fence to road cut on east side of road. | 3 | 93 | 30 – 33 |
| 13. Dolomite—microgranular, silty, mottled grayish yellow and grayish pink, and with basal 6 inches sandy. | 3 | 96 | 27 – 30 |
| 14. Clay—highly silty, calcareous, and alternately streaked grayish yellow and pale greenish yellow. | 1.5 | 97.5 | 25.5– 27 |
| 15. Limestone—coarse grained, highly argillaceous, pale greenish yellow, and has a flaky parting parallel to the bedding. The limestone is composed of oyster shell fragments. | 0.5 | 98 | 25 – 25.5 |
| 16. Dolomite—microgranular, highly silty, grayish pink, and yellowish gray. | 1 | 99 | 24 – 25 |
| 17. Clay—silty, calcareous, and variegated, being mostly yellowish gray and grayish pink. *SHIFT* across fence into pasture. | 1 | 100 | 23 – 24 |
| 18. Covered—the soil is pink. | 2 | 102 | 21 – 23 |
| 19. Dolomite—microgranular, grayish pink, outcrops widely and contains fine grained, poorly sorted, fairly well rounded sand. A thin section reveals that the dolomite is extremely fine grained and that high magnification is needed to resolve the rhombs. Formless carbonate between the rhombs may be calcite. The abundant sand is mostly angular and composed chiefly of quartz, considerable microcline, and some chert. One grain of glauconite (?) and a few poorly preserved microfossils are present. | 2 | 104 | 19 – 21 |
| 20. Covered—except for top few inches which is silty, calcareous, and sandy, pale olive clay. Reddish soil midway in the interval suggests that red clay may be present. | 6 | 110 | 13 – 19 |
| 21. Dolomite—microgranular, sandy in lower portion, silty and argillaceous throughout, soft, somewhat porous, and mostly grayish pink containing some yellowish gray mottles. The top foot of the interval is resistant to weathering, outcrops widely, and forms a bench. A thin section reveals that the rock is predominantly microgranular dolomite, and that there are a few large, zoned, dolomite rhombs. The sand is mostly quartz and there is a small amount of feldspar. A few poorly preserved microfossils are present. | 4 | 114 | 9 – 13 |
| 22. Clay—calcareous, slightly sandy, between yellowish gray and pale olive, and contains some grayish pink mottles. | 1 | 115 | 8 – 9 |
| 23. Covered—but probably the same as interval 22. | 3 | 118 | 5 – 8 |
| 24. Dolomite—microgranular, sandy, silty, and grayish yellow in lower part, and yellowish gray and contains many poorly preserved shell casts in upper part. | 3 | 121 | 2 – 5 |
| *Hensell sand member: 2 feet measured* | | | |
| 25. Clay—the calcareous top portion of the interval is slightly silty and pale yellowish green, and the lower portion is somewhat silty, moderate red, and contains caliche nodules. | 2 | 123 | 0 – 2 |

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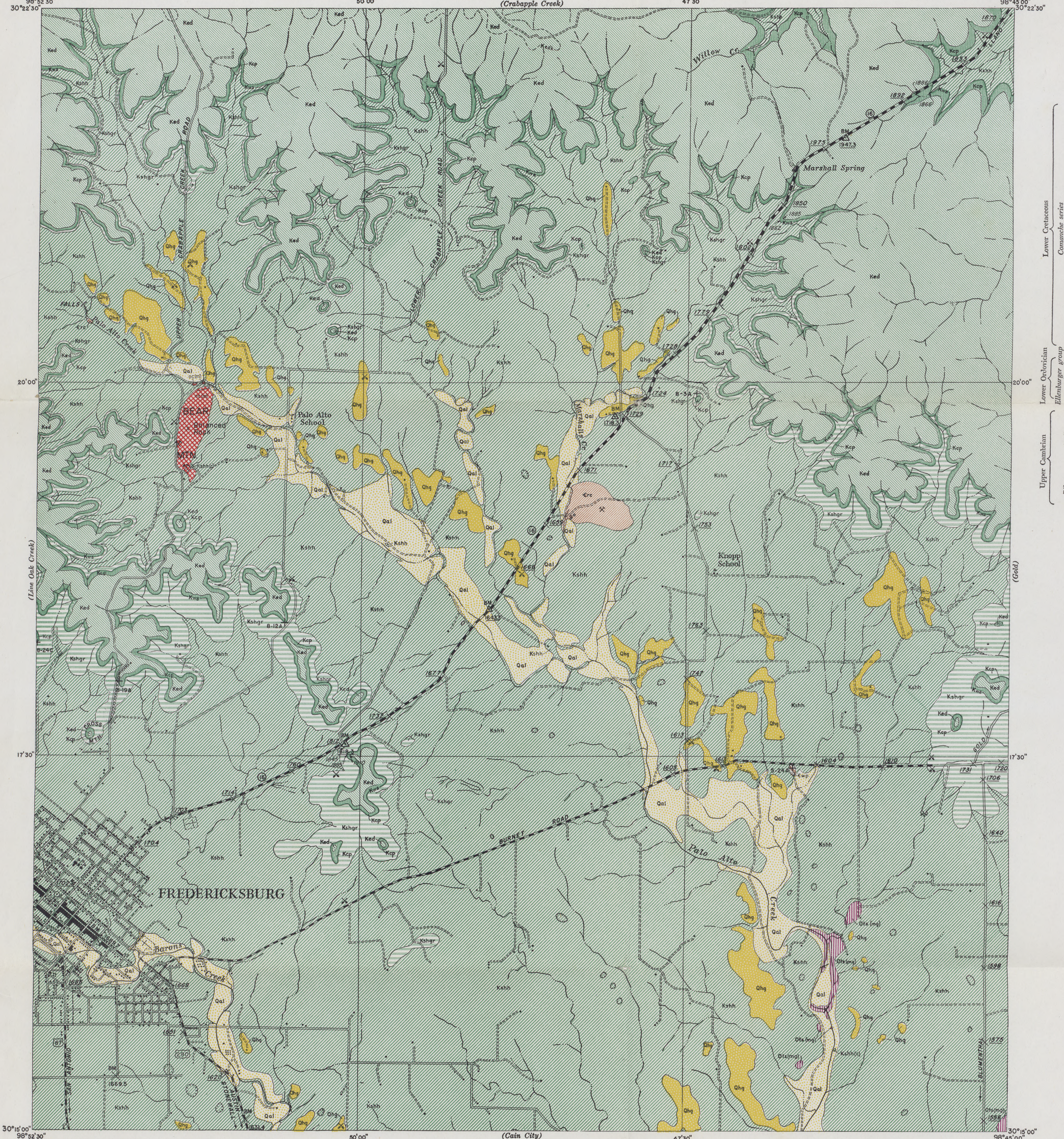
TEXAS
PALO ALTO CREEK QUADRANGLE




## EXPLANATION

### SEDIMENTARY ROCKS

**QUATERNARY**

Qal — **Alluvium**
*(gravel, sand, and silt, along stream bottoms)*

Qhg — **High gravel**
*(gravel and sand in terraces along streams and as colluvial deposits in part changed to caliche on slopes)*

*UNCONFORMITY*

**CRETACEOUS**

Lower Cretaceous — Comanche series

Ked / Kedk — **Edwards limestone**
*(showing approximate trace of the Kirschberg evaporite horizon, Kedk. Well bedded, in part cherty, in part magnesian; varies widely in composition, hardness, and thickness of beds)*

Kcp — **Comanche Peak limestone**
*(marl and marly limestone ranging from nodular at base to well bedded at top)*

Kwa — **Walnut clay**
*(calcareous clay, grading upward into the marl of the overlying member; contains a profusion of Exogyra texana)*

Shingle Hills formation

Kshgr — **Glen Rose limestone member**
*(alternating beds of limestone, marl, and clay, some of which are highly arenaceous)*

Kshh / Kshh(c) — **Hensell sand member**
*(sand, silt, and clay, predominantly red and gray, with conglomerate, Kshh(c), at base)*

*UNCONFORMITY*

**ORDOVICIAN**

Lower Ordovician — Ellenburger group — Tanyard formation

Ots (mg) — **Staendebach member**
*(dolomitic facies, thickly to thinly bedded, cherty, fine to medium grained)*

*DISCONFORMITY*

**CAMBRIAN**

Upper Cambrian — Wilberns formation

Cwp — **Pedernales dolomite member**
*(thickly to thinly bedded, sparingly to abundantly cherty, predominantly fine to very fine grained)*

*DISCONFORMITY*

Riley formation

Erc — **Cap Mountain limestone member**
*(granular, glauconitic, gray to brown; grades to calcareous sandstone at base)*

*UNCONFORMITY*

### IGNEOUS ROCKS

**PRE-CAMBRIAN**

Oatman Creek granite
*(aplogranite of red color and medium grain)*

Observed and inferred contact

Strike and dip of beds

+ 8-24C — Locality of fossil collection

Tank
*(earth-dammed pond for water storage)*

× 1728 — Alidade elevation of gravity station

1910 — Alidade elevation

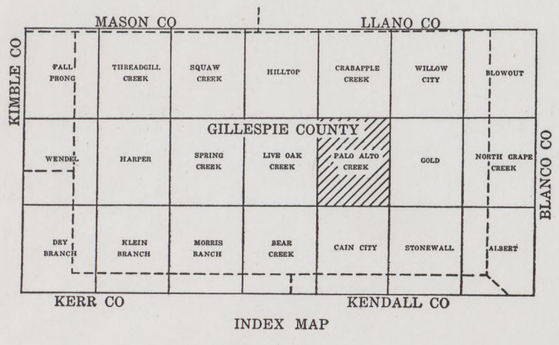
>>>> — Line of described section

Base from U. S. Department of Agriculture, Agricultural Adjustment Administration, aerial photographs flown by Kargl Aerial Surveys, Ltd., 1938.

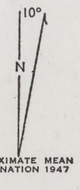
Scale 1 / 31,680

1 — ½ — 0 — 1 Mile
5000 — 2500 — 0 — 5000 Feet
1 — ½ — 0 — 1 Kilometer

*Datum is mean sea level*




INDEX MAP




APPROXIMATE MEAN DECLINATION 1947

Geology by Virgil E. Barnes 1939–1948
Assisted by Louis Dixon and L. E. Warren
Cartography by Ann Connor and J. W. Macon

# GEOLOGIC MAP OF THE PALO ALTO CREEK QUADRANGLE, GILLESPIE COUNTY, TEXAS