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Geology of the Type Area, Canyon Group, North-Central Texas¹

BY ROBERT LEE LAURY²

ABSTRACT

The strata of Pennsylvanian age in north-central Texas dip gently and uniformly to the northwest. They are divided, in ascending order, into the Strawn, Canyon, and Cisco Groups. A cover of Lower Cretaceous rocks on the Callahan Divide separates the two major Pennsylvanian outcrop areas in the Colorado and Brazos River valleys. The type area of the Canyon Group is in the Brazos region.

The Canyon Group is distinguished by its thick bioclastic limestones and intervening shales, thin limestones, and lenticular sandstones. Deposition of the Canyon sediments took place under cyclic, alternating shallow marine to nonmarine conditions, and was continuous with only minor local discontinuities. The Canyon strata are conformable with those of the underlying Strawn and overlying Cisco Groups.

The Canyon Group was studied in the outcrop in its type area, located in the region of the common corner of Palo Pinto, Stephens, and Eastland Counties, Texas. Twenty-four mappable members of eight formations (in ascending order, Palo Pinto Limestone, Posideon Formation, Wolf Mountain Shale, Winchell Limestone, Placid Shale, Ranger Limestone, Colony Creek Shale, and Home Creek Limestone) have been mapped and are described. Of the members, three have been named (Fambro Sandstone and Wiles Limestone Members of the Posideon Formation, and the Staff Limestone Members of the Wolf Mountain Shale) and the remainder are informally designated by a rock type and geologic symbol.

Five members of the Keechi Creek Shale of the Strawn Group, a small area of the Finis Shale of the Cisco Group, and numerous outliers of conglomerate of the Trinity Group (Cretaceous) have also been mapped and are described in the report.

The Canyon is considered to be a group (rock unit) that includes all strata from the base of the Palo Pinto Limestone to the top of the Home Creek Limestone.

INTRODUCTION

General Geologic Setting

The rocks of Pennsylvanian age in north-central Texas dip gently and consistently to the northwest and are divided, in ascending order, into the Strawn, Canyon, and Cisco Groups. The strata have a regional dip of approximately 50 feet per mile and have been sub-

¹ A thesis submitted in partial fulfillment for the degree Master of Science in Geology, Southern Methodist University.

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jected to little if any structural disturbance. A cover of Lower Cretaceous rocks (Callahan Divide) separates the two major Pennsylvania outcrop areas of the Colorado and Brazos River valleys. This type of the Canyon Group is in the Brazos region (Figure 1).

In contrast to the predominance of terrigenous clastics in the Strawn and Cisco Groups, the Canyon Group is distinguished by its thick bioclastic limestones and intervening shales, thin limestones, and lenticular sandstones. Deposition of the Canyon sediments took place under cyclic, alternating shallow marine to nonmarine conditions, and was continuous with only minor local disconformities. The Canyon strata are conformable with those of the Strawn and Cisco Groups.

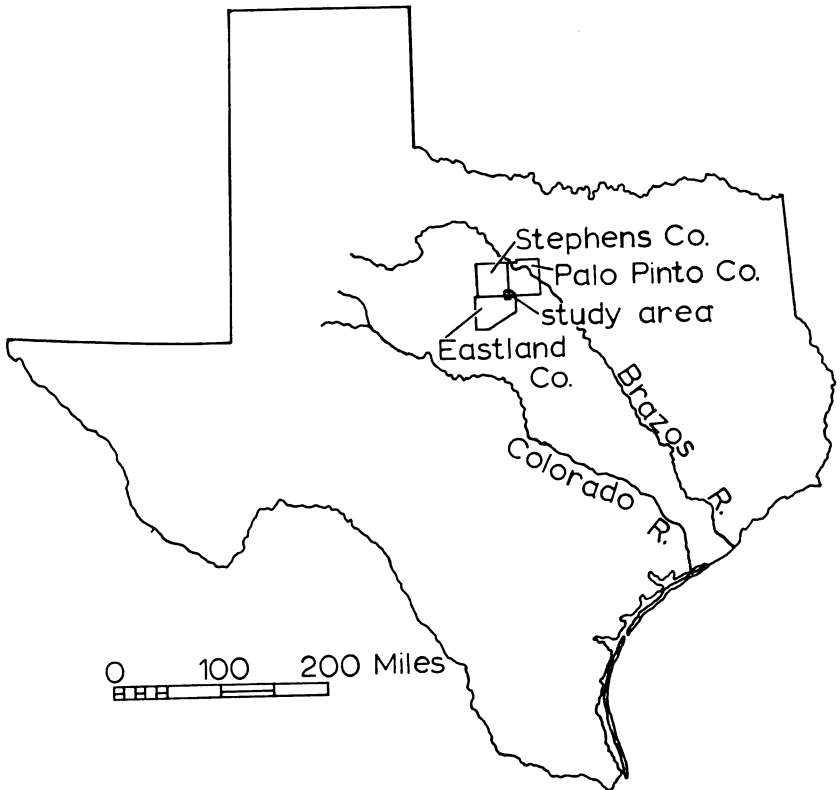


Fig. 1. Location of study area.

Purpose of Study

Lateral and vertical changes in facies are common in the Pennsylvanian strata of north-central Texas. Workers, nevertheless, have attempted to correlate between widely separated outcrop areas with insufficient data concerning the intervening strata. The result has been the proposal of classifications based on miscorrelated beds. These classifications have been debated and gradually revised as the number of detailed stratigraphic studies has increased. The type area of the Canyon Group is one of the several critical areas that has never been carefully studied. This report provides a detailed geologic map of the Canyon Group type area and descriptions of 24 members of 8 formations of the Canyon Group. The map and text are supplemented by a comparative nomenclature chart, 28 measured stratigraphic sections, 43 locality descriptions, 4 cross sections and an areal distribution map of the Fambro Sandstone Member. The purpose of the investigation was to determine the nature and extent of the units of the Canyon Group in its type area; to critically study and, if necessary, revise them; and finally to provide the systematic stratigraphy necessary to future studies of both a detailed and regional nature.

Of the various rock types found in the Canyon Group the limestones are the most mappable and thus the most important regional stratigraphic markers. This study has shown, however, that most of the limestones are variable in lithology, thickness, and in stratigraphic distribution, and therefore require detailed field tracing if they are to be accurately correlated. Only the physical stratigraphy was studied. The occurrence of fossils and the similarities of certain faunas, however, is noted. The type area of the Canyon Group should serve as a key reference area for future regional studies of the Canyon strata in the Brazos River valley.

*Location**Present Study*

The area of investigation is located around the common corner of Palo Pinto, Stephens, and Eastland Counties between the towns of Strawn and Ranger and includes the type area of the Canyon Group (Cummins 1891). The town of Canyon, Palo Pinto County, for which the strata were named, no longer exists. The townsite was located on the Texas and Pacific Railway four miles west of Strawn.

The study area is bounded on the north by Farm-to-Market Road 207, on the south by U. S. Highway 80, on the west by Farm-to-Market Road 717, and on the east by State Highway 16. Farm-to-Market Road 2372 traverses part of the area from Strawn west to Russell Reservoir. No other paved roads are present in the area.

Methods employed

Reconnaissance of the Canyon strata of the Brazos River valley was conducted in the fall of 1960 and the spring of 1961. Field work in the type area of the Canyon Group was done during two and a half months in the summer and fall of 1961.

Geologic contacts were plotted on 1:20,000 stereographic aerial photographs which were flown in 1951 and 1954 by the U. S. Department of Agriculture. The contacts were enlarged by using a ratio projector and traced onto a base from the photographs at the enlarged scale of 1:12,000. Controlled photo mosaics of the same scale were used to maintain accuracy in constructing the base map. Geologic contacts were mapped at the base and top of all members except where indicated. Where a member is thin or its top is not exposed on a bench or dip slope, or where two members are exposed in a vertical face, a single contact is used to represent the base and top of the lower unit and the base of the upper member.

Grain size of clastic rocks is described according to the Wentworth (1922) grade scale, while the thickness of bedding is classified after McKee and Weir (1953) as modified by Ingram (1954).

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STRATIGRAPHIC NOMENCLATURE

Early Investigations

Perhaps the most important contributions to Pennsylvanian stratigraphy of north-central Texas have been incidental to investigations

of coal fields in the Brazos and Colorado River valleys (Tarr, 1890; Cummins, 1891; Drake, 1893). Cummins first identified the coal-bearing strata as belonging to the Pennsylvanian System. For the larger sequence of which these "beds" are a part, he proposed the names: Bend, Millsap, Strawn, Canyon, Cisco, and Albany, in ascending order. Cummins' work was conducted primarily in the Brazos River valley. There his Canyon division included the alternating limestone and shale which overlie the shale, sandstone, and conglomerate of the Strawn, and that underlie the predominately clastic sequence of the Cisco. On the basis of difference in bulk lithology, Cummins placed the Canyon-Strawn boundary at the base of the lowermost prominent limestone, and the Canyon-Cisco contact at the top of the highest prominent limestone of the Brazos River valley. These limestones are the Palo Pinto and Home Creek Limestones, respectively, of Plummer and Moore (1921).

Drake, mapping in the Colorado River valley, adopted Cummins' classification of the Canyon division and subdivided it into twelve beds, to which he gave local names. On the basis of studies in the Brazos River drainage area, Plummer (1919) presented a preliminary classification (Table 1) which included formations defined in that region. A more comprehensive classification was later proposed by Plummer and Moore (1921) in which the Canyon "group" replaced the previously used Canyon "division." They proposed new formation names, based on localities in the Brazos area, and relegated Drake's beds to member status. Studies of individual areas in the Brazos River valley have been conducted by Dobbin (1922), Reeves (1922), Plummer and Hornberger (1935), and Bradish (1937).

Correlation and Classification

The correlation of Pennsylvanian stratigraphic units between the Colorado and Brazos River valleys is difficult. Several factors are directly responsible for this difficulty. The Canyon strata thicken to the north and northeast from less than 750 feet in Brown County, Colorado River valley, to over 2,000 feet in Montague County, Brazos River valley (Turner, 1957, p. 70). Abrupt vertical and lateral changes in lithology are common in the Canyon. Correlation of Canyon rocks is further complicated by a cover of Lower Cretaceous rocks on the divide between the Colorado and Brazos

River valleys. As a result, the correlations of Pennsylvanian age strata in the Colorado River area with those of the Brazos River area are questionable and have been frequently revised.

Early workers were concerned only with rock-unit classifications. A major departure from this procedure came in 1940 when M. G. Cheney proposed a time-rock classification for Pennsylvania strata of north-central Texas. He transferred the term "Canyon" from group to series rank, and on the basis of its contained faunal zones correlated it with the Missourian Series of the northern Mid-Continent region. A drastic redefinition of the Canyon followed whereby the group and formation boundaries were readjusted in an attempt to make them coincide with faunally defined time lines (Table 1). Many of the resulting "formations" were not mappable. Since 1940, investigators using faunal evidence in an attempt to locate the boundary between the Strawn and Canyon "Series" in the Brazos River area have moved the boundary through a stratigraphic interval of nearly 400 feet.

The writer believes that the correlation of the Pennsylvanian strata of north-central Texas with those of the northern Mid-Continent can be achieved more accurately by comparing faunal criteria and extending the better established time-rock nomenclature of the Mid-Continent area into Texas. The revision of "rock" units to coincide with time lines contradicts accepted practice. Moreover, the units are no longer readily mappable and thus, in many cases, fail to meet the criteria set by the American Commission of Stratigraphic Nomenclature (1961) for the definition of rock units.

The rock-defined Canyon Group of the present study is a modification of the older, field-oriented classifications (Table 1). The studies of the Canyon Group in north-central Texas have revealed a number of basic mappable units. These include several widespread limestones, some sandstones, and the intervening shale sequences. The author feels that many of the members of the older classifications are worthy of formation rank. Thus, from the earlier classifications only the Palo Pinto Limestone is retained as a formation. The Graford, Brad, and Caddo Creek Formations of earlier workers have been supplanted in the present study by the Posideon Formation, Wolf Mountain Shale, Winchell Limestone, Placid Shale, Ranger Limestone, Colony Creek Shale, and the Home Creek Limestone

(Table 1). Formal member rank is proposed for the Fambro Sandstone and Wiles Limestone Members of the Posideon Formation, and the Staff Limestone Member of the Wolf Mountain Shale. The several informal members, represented only by symbols, are shown in Table 1 (Laury, 1962).

Plummer and Moore (1921) placed the base of the Canyon Group at the base of the Palo Pinto Limestone and the upper boundary at the top of the Home Creek Limestone. These boundaries are in keeping with the rock-stratigraphic classifications and are followed in the present study. The base of the Home Creek Limestone is generally a more recognizable contact than the top of the unit. However, the writer feels that placing the Home Creek Limestone in the overlying Cisco Group would not conform to the natural unity of these two distinctive rock sequences. Cummins (1891) and later workers described the Canyon sediments as reflecting an environment of predominant carbonate deposition, in contrast to the primarily terrigenous clastic sequences of the Strawn and Cisco. The Home Creek Limestone is clearly related to the Canyon carbonate deposition and should therefore be retained in the Canyon Group.

STRATIGRAPHY

Strawn Group

Two thin limestones in the upper part of the Strawn Group were mapped in this investigation. Reynolds (1953, unpublished master's thesis, University of Texas), who studied the South Palo Pinto Creek Area, Eastland County, carried the two units into the southeastern portion of the type Canyon area. The beds were designated, in descending order, the "Dog Bend" and "Capps" Limestones. In this report they are recognized as informal limestone members Pkc₄ and Pkc₂, respectively, of the Keechi Creek Shale—the upper formation of the Strawn Group. Pkc₁, Pkc₃, and Pkc₅ are the shale members of the Keechi Creek but are not here discussed except where mentioned in relation to the two limestone members.

Keechi Creek Shale (Pkc)

The Keechi Creek "sandstone and shale" was named by Plummer and Moore (1921, p. 78) as the upper member of the Mineral Wells Formation of the Strawn group. In its type area along Keechi Creek west of Mineral Wells, Palo Pinto County, it was defined as con-

sisting of about 100 to 150 feet of “. . . light gray, cross-bedded, calcareous sandstones and light gray sandy shales . . .” underlying the Palo Pinto Limestone and overlying the Turkey Creek Sandstone. In the vicinity of Strawn and further to the south, Plummer and Moore found the Turkey Creek Sandstone to be absent (1921, p. 78).

In the area of the present study an acceptable base for the Keechi Creek Shale was not found. For this reason the two limestones are arbitrarily included as informal members of the Keechi Creek Shale.

Limestone Member Pkc₂

This limestone was mapped by Reynolds (1953, unpublished master's thesis, University of Texas) as the “Capps” Limestone. The Capps Limestone of Plummer and Moore (1921) has its type locality in the Colorado River valley in Brown County. There it is a four-foot thick limestone of highly variable lithology (*idem*, p. 96-97). Since it has not been traced north of the Callahan Divide into the Brazos River valley, its recognition there is subject to question. Because its continuity with the Capps of the type area has not been demonstrated, the “Capps” Limestone of Reynolds is here referred to as Limestone Member Pkc₂ of the Keechi Creek Shale.

General Character.—Limestone Member Pkc₂ is present in the southeastern portion of the type area of the Canyon where it forms a small escarpment approximately 30 feet high. The limestone is gray, highly fossiliferous, and irregularly thin-bedded to nodular. The thickness of the unit is estimated to be 5 to 6 feet (Locality 39). A 50-foot interval of shale and siltstone, largely covered, separates Member Pkc₂ and the overlying Limestone Member Pkc₄.

Within a mile to the north of Locality 39, Limestone Member Pkc₂ loses identity and grades into a series of well indurated, brown to gray, calcareous sandstone beds, the total thickness of which varies from one to three feet. This sandstone extends northward as far as Strawn where it caps a thick shale sequence and forms an escarpment on which most of the town of Strawn is built (Locality 42). No attempt was made however, to map the member beyond the point where it loses its limestone character.

Limestone Member Pkc₄

General Character.—Member Pkc₄, or the “Dog Bend Limestone” of Reynolds (1953, unpublished master's thesis, University of Texas),

was traced from the southern boundary of the Canyon type area (Locality 38) northward to Palo Pinto Creek (Locality 40). The unit occurs from 165 to 145 feet below the base of the Palo Pinto Limestone (Sections 27 and 10, respectively). In the southern part of the area (Locality 38) the member is a gray, hard, well indurated, highly calcareous sandstone. It is medium- to thin-bedded, frequently displays cross-bedding and ripple marks, and has a maximum thickness of 2.5 feet. To the north the unit grades to a sandy limestone, develops medium to very thick bedding, and reaches a thickness of 3.5 feet. The limestone weathers brown but is gray on a fresh surface. Where the member is thick-bedded, it commonly forms a small bench. North of Palo Pinto Creek the massive sandy limestone parts into a series of thin sandstones which grade laterally into shale. On Farm-to-Market Road 207 a limestone and claystone pebble conglomerate crops out at approximately the same horizon as Member Pkc₄ (Locality 41). The conglomerate, however, is very localized and could not with certainty be correlated with Member Pkc₄.

Dog Bend Limestone.—The type section of the Dog Bend Limestone of Plummer (1929) is in Palo Pinto County at the Dog Bend of the Brazos River between Mineral Wells and Palo Pinto. Descriptions of the unit as well as of the exact location of its type section are vague. Plummer and Hornberger (1935, p. 31) state that the Dog Bend Limestone is “. . . a thin stratum of impure sandy limestone.” They could not trace the Dog Bend any farther to the southwest than the Village Bend of the Brazos River. This is almost 18 miles northwest of the point where Member Pkc₄ of this report disappears. Therefore, Member Pkc₄ is equivalent to Bed Sa₁ of Plummer and Hornberger (1935, Pl. 2). Bed Sa₁, a thin limestone, is stratigraphically much higher than the Dog Bend Limestone and probably correlates with the conglomerate of Locality 41.

Canyon Group

As discussed by Plummer and Moore (1921, p. 87), “The Canyon group of beds represents an epoch following the deposition of sandstones, conglomerates, and coal beds of the Strawn group during which time the bordering land to the east (Ouachita front) had been worn down and furnished mainly fine calcareous sediments, so that the conditions were favorable for the formation of a series

of thick limestones and fine calcareous clays, with only a few lenses of sandstone." Feray (personal communication) further believes that this group represents a period of continuous deposition interrupted only by minor, local disconformities.

Cummins (1891, p. 374), working in northern Palo Pinto and southern Young and Jack Counties, was the first to delimit the strata now assigned to the Canyon Group. To these rocks he assigned the name Canyon "division" for the former town of Canyon. The townsite was four miles west of Strawn on the right-of-way of the Texas and Pacific Railroad. The Canyon Group of Plummer and Moore (1921) includes all of the strata of Cummins' Canyon division (from the base of the Palo Pinto Limestone to the top of the Home Creek Limestone). Using these stratigraphic limits, the author found the total thickness of the strata of the Canyon Group in its type area to be approximately 725 feet.

Palo Pinto Limestone (Ppp)

The Palo Pinto Limestone is the basal unit of the Canyon Group in the Brazos River valley. In this study, as in most earlier ones, the Palo Pinto Limestone has been given the rank of formation. Dobbin (1922) preferred to include the Palo Pinto as a member of the Graford Formation, but still retained the Palo Pinto Limestone as the lowest member of the Canyon Group (Table 1). As discussed above, Cheney in 1940 extended the boundaries of the Canyon Group to coincide with the faunal boundaries of the Missourian Series of the northern Mid-Continent. In so doing, he raised the Canyon to series status and its formations to group rank (Table 1). Since the Missourian Series is recognized by the presence of the fusulinid genus *Triticites*, Cheney placed the base of the Canyon "Series" below the first occurrence of *Triticites*. In the Brazos River valley the boundary is drawn at the base of the Lake Pinto Sandstone, a unit approximately 400 feet below the Palo Pinto Limestone. The Palo Pinto Formation was revised and, with the underlying Keechi Creek and Salesville Formations, was included in the newly proposed "Whitt Group" (Table 1). Cheney's "Palo Pinto Formation" included the Wynn Limestone (Palo Pinto Limestone of previous investigators) with the overlying Posideon Shale and Wiles Limestone, and an underlying sandstone. The present writer feels that Cheney's revision of the Palo Pinto Formation does not improve the

original classification. Numerous sandstones, for instance, occur below the Palo Pinto Limestone. Most of these are poorly exposed and difficult to map. Their interrelationships are correspondingly questionable. Thus this classification is rejected in this report in favor of the nomenclature based on the older field-oriented classifications.

The Palo Pinto Limestone was named and given formation rank by Plummer and Moore (1921, p. 92). At its type locality along old Highway No. 1 west of Palo Pinto, Palo Pinto County, the formation was defined to include only the massive limestone ledges overlying the Strawn Group and underlying the thick marl bed in the base of the Graford Formation. The Palo Pinto Limestone is described by Plummer and Moore (*idem*) as “. . . a thick, crystalline, dark-gray limestone weathering white or grayish yellow.” The lower portion is thinner bedded than the upper portion. Plummer and Hornberger (1935, p. 44) describe the Palo Pinto beds as consisting of “. . . thick, irregularly bedded limestone, a few thin marls or very calcareous clay beds, and a little chert.” The Palo Pinto Limestone thins toward the southwest after reaching a thickness of nearly 100 feet in the northeastern part of Palo Pinto County. The limestone has not been recognized in the Colorado River valley.

General character

In the type area of the Canyon Group the Palo Pinto Limestone varies in thickness from 16 (Section 1) to 24.5 feet (Section 27). Two units are generally distinguishable in the Palo Pinto Limestone. The lower forms a single, thick block of irregularly thin-bedded, finely crystalline, highly bioclastic gray limestone. The limestone is generally fossiliferous with an abundance of brachiopods and crinoid columnals. The upper part of this block commonly contains several zones of fusulinids, often sufficiently abundant to be termed a coquina. The colonial coral *Syringopora* is sometimes found in association with, or immediately above the fusuline horizon. The lower unit of the Palo Pinto has an average thickness of 12 feet, but where the upper unit is not developed, the former increases to nearly 16 feet.

The lower portion of the Palo Pinto Limestone caps the prominent escarpment above the less resistant Strawn beds. The lower unit is strongly jointed and breaks off in large rectangular blocks. The upper unit of the Palo Pinto Limestone is nonresistant and often recedes leaving a broad bench at the top of the lower limestone block. The

upper unit is an extremely bioclastic, nodular to marly, fine to coarsely crystalline gray limestone. It reaches a maximum thickness at Section 23 of 12.5 feet. The upper portion of the Palo Pinto Limestone is frequently obscured by debris from overlying beds. Even when covered, however, its presence is indicated by the rubbly, nodular erosion surface it leaves on the slope above the lower Palo Pinto bench. No pronounced changes in thickness or lithologic character were noted in the Palo Pinto Limestone. The above-described units within the Palo Pinto Limestone were not mapped.

Posideon Formation (Pp)

The Posideon "shale" was described by Plummer and Hornberger (1935, p. 48-50) as the basal member of the Graford Formation in Palo Pinto County. It was defined as underlying the Wiles Limestone Member and overlying the Palo Pinto Limestone, and as consisting of about 50 feet of ". . . dark gray, soft, sandy to calcareous fossiliferous shale containing thin layers of limestone," (1935, p. 48). It was named for exposures above the Palo Pinto Limestone in the vicinity of Posideon, Palo Pinto County.

Bradish (1937), in place of using the term "Posideon Shale" for the correlative interval in Stephens County, preferred to use the Colorado River term, "Brownwood shale." Cheney (1940) included the Posideon Shale as a member in his Palo Pinto Formation.

In this report the Posideon is given formation status and is considered to include all the beds from the top of the Palo Pinto Limestone to the top of the Wiles Limestone Member. In the northern part of the Canyon type area the Wiles as well as the next lower limestone member (Pp₄) have pinched out and are absent. The base of the overlying formation, the Wolf Mountain Shale, is therefore lowered to the next clear stratigraphic datum, Limestone Member Pp₂. The stratigraphic interval of the Posideon Formation is reduced accordingly (Table 1). Two formal members, the Fambro Sandstone and the Wiles Limestone, and five informal members were mapped and are described in this report. The informal members include two limestones, Pp₂ and Pp₄, and three shales, Pp₁, Pp₃, and Pp₅. The three shale members of the Posideon Formation are generally poorly exposed. They will be discussed, where pertinent, under the section on the sandstone or limestone member with which they are most closely associated.

Fambro Sandstone Member (Ppf)

Type locality and description.—In a portion of the Canyon area and in the region to the south, a thick, massive, cross-bedded, reddish brown ferruginous sandstone overlies the Palo Pinto Limestone. The sandstone and the thin, 5- to 10-foot shale which often separates it from the underlying limestone were named by Reynolds (1953, unpublished master's thesis, University of Texas, p. 83-94) the Fambro Sandstone Member of the Brownwood Formation (Colorado Valley term). The type locality of the member is on the T. C. Fambro Ranch in northeast Eastland County, $\frac{1}{2}$ mile south of U. S. Highway 80 and $\frac{3}{4}$ mile west of State Highway 16. The Fambro Sandstone Member in its type section is described by Reynolds (*idem*, p. 84) as 48.5 feet thick, reddish brown to yellowish orange, coarse grained to conglomeratic, massively cross-bedded, and containing wood fragments in the upper part.

General character.—In this report the Fambro is included as a member of the Posideon Formation. The lithology of the member is remarkably constant throughout its outcrop extent. The sandstone is fine to medium grained, ferruginous, yellowish to reddish brown, massive, cross-bedded, and weathers into rounded boulders up to 10 feet in diameter. The grains are primarily quartz and are rounded to subrounded. The rock is weakly and variably cemented with iron oxide or quartz. In strongly cross-bedded zones the sand grains are usually much larger and are often found in association with pebbles of chert and claystone. On weathered surfaces the clay often deteriorates leaving the surface of the sandstone pitted. Except for the occasional occurrence of plant fragments and wood, the Fambro is devoid of fossils.

No sandstone other than the Fambro was mapped in the area of this study. Its reddish brown color, massive and cross-bedded character, and stratigraphic position immediately above the Palo Pinto Limestone scarp make it very distinctive. In viewing the unit in three dimensions, the Fambro forms a linear north-south trending body the maximum thickness of which is about 45 feet. The width of the body averages about $1\frac{1}{4}$ to $1\frac{1}{2}$ miles (Pl. 2). Its linear extent is about 6 miles. It does, however, extend to the north and south beyond the map area. Future studies in these two areas should prove interesting. The lateral diminution of the Fambro is relatively

abrupt and is shown on the map (Pl. 1) by zig-zag lines. In Section 26 a 50-foot sequence of gray shale with thin, one-inch lentils of fossiliferous calcareous sandstone is present above the Palo Pinto Limestone. Only 200-300 feet to the north a complete sequence of the Fambro Member is present in the same stratigraphic position. Where the Fambro is absent in the Canyon type area, the interval above the Palo Pinto Limestone is strikingly similar both in lithology and fauna to that described above (Sections 15, 23, 27; Localities 6, 12). The fauna, containing abundant pelecypods, gastropods, crinoids, brachiopods, bryozoans, and occasional trilobites, plus the associated rocks suggest a shallow, possibly turbid or muddy water environment of deposition. The Fambro Sandstone, with its linear distribution pattern, and its massively cross-bedded, occasional conglomeratic, nonfossiliferous character suggests a deltaic stream or offshore bar type of deposit.

A 5- to 7-foot thick shale often separates the Fambro Sandstone from the underlying Palo Pinto Limestone and is probably gradational into the upper marls of the latter. The shale is generally covered by boulders slumped from the overlying sandstone. The shale unit is too thin to appear on the map (Pl. 1), and there it is included in the Fambro Sandstone. Where the Fambro thins and disappears, the underlying shale is included with the adjacent shale into which the Fambro grades and is designated informally as Shale Member Pp_1 .

Limestone Member Pp_2

This unit forms one of the most prominent stratigraphic datum surfaces in the type area of the Canyon Group. It occurs from 75-80 feet above the top of the prominent, lower ledge-forming unit of the Palo Pinto Limestone and maintains a thickness of 30 inches throughout the area. Dobbin (1922, p. 60) also recognizes the significance of this bed as ". . . a valuable horizon marker and datum plane." The limestone is dense, sublithographic to finely crystalline, bioclastic, gray with a tan weathering surface, and sparingly fossiliferous. The most striking characteristic of Member Pp_2 , other than its uniform thickness and lateral persistence, is its pronounced jointing. The limestone occurs as a single massive bed though commonly it develops a bedding plane in the middle. Weathering causes either the upper portion or the whole bed to separate along the joint planes allowing large rectangular blocks to slump over the underlying units.

The upper several inches of the limestone is sometimes argillaceous and typically develops splintery, shaly parting. When this occurs, the upper surface of the bed is very irregular and is minutely jointed.

Limestone Member Pp₂ is often underlain by a 5- to 10-foot thin-bedded, fine grained, reddish brown ferruginous sandstone. When present this generally forms a bench in front of the limestone. The sandstone appears to have no genetic relationship to the Fambro Sandstone, and where the two occur together, are separated by a thin shale interval (Locality 14).

Member Pp₂ has been assigned no formal name in previous literature. Plummer and Hornberger (1935, Pl. 2) appear to have carried this unit as the "Wiles limestone (Yk₂)." This is a miscorrelation and will be discussed later under the heading "Wiles Limestone Member." No formal name is proposed for Limestone Member Pp₂.

Limestone Member Pp₄

Limestone Member Pp₄ is a generally poorly exposed but persistent unit throughout most of the Canyon Group type area. It has received no formal name and none is proposed here. The member is typically developed in the vicinity of the type section of the Wiles Limestone Member (Section 14, unit 10) and Section 26 (unit 9). It occurs as a 3- to 5-foot nodular to conglomeratic or brecciated, gray fossiliferous limestone, the base of which is approximately 15 feet above Limestone Member Pp₂. Where distinctly brecciated or conglomeratic, pebbles of gray sublithographic limestone are cemented together by a calcareous, ferruginous clay imparting an overall pink color to the unit. In places both nodular and conglomeratic beds can be differentiated (e.g. Localities 1, 4). A maximum thickness of nearly 20 feet was measured at Section 23, but the average thickness is about 5 to 8 feet. Member Pp₄ forms a low, rounded, grass covered bench above Limestone Member Pp₂. The surface of the bench is littered with grayish white pebbles of limestone and numerous large specimens of the rugose coral *Campophyllum*. This coral was not found at any other stratigraphic position in area.

On Farm-to-Market Road 207, north of the northernmost exposure of Limestone Pp₄, a thick sandstone caps a 45-foot high hill above Limestone Member Pp₂ (Locality 15). Member Pp₄ is absent here, either by removal by local erosion which preceded the deposition of the sandstone, or by pinch-out before reaching this locality.

Wiles Limestone Member (Ppwi)

Type locality and description.—As originally defined by Dobbin (1922, p. 60), "The Wiles limestone, which is also a member of the Graford formation (Table 1), occurs about 136 feet above the Palo Pinto limestone and is so named because of its exposure near the town of Wiles (Stephens County). . . . The limestone is massive, dark gray, and not very fossiliferous." Plummer and Hornberger (1935, p. 48) also included the Wiles Limestone as a member of the Graford Formation (Table 1) and described the limestone as gray (blue when freshly broken), hard, from 3 to 8 feet thick, and lying about 50 feet above the Palo Pinto Limestone in the vicinity of Posideon, Palo Pinto County.

In the present report the Wiles is regarded as the upper member of the Posideon Formation. The writer feels the Wiles Limestone is more naturally related to the units of the Posideon Formation than to those of the overlying Wolf Mountain Shale.

Section 14 in the central part of the Canyon area was measured at the type locality of the Wiles (Pl. 1). The town of Wiles no longer exists; however, the locality is distinguished by the remains of an old oil well, believed to be the Palo Pinto Oil and Gas Co.'s Swenson No. 1 as mentioned by Dobbin (1922, p. 60), which were found on top of a small escarpment formed by the Wiles. A portion of the section is reproduced below and is herein designated as the type locality of the Wiles Limestone Member of the Posideon Formation.

Posideon Formation—	Thickness, Feet
Wiles Limestone Member—	
12. Limestone, gray, sublithographic, irregularly thin- to medium-bedded, fossiliferous, some algal material. Weathers rounded and readily slumps. Best exposed at north end of offset. Caps small scarp and forms bench of variable width	4.0
Shale Member Pp ₅ —	
11. Shale, generally covered with slump blocks of Wiles Limestone. Measurement made at south end of offset	21.5-
Limestone Member Pp ₄ —	
10. Limestone, base covered, medium gray with tan veins, weathers medium to dark gray, sublithographic to	

finely crystalline, fossiliferous (brachiopods, some corals), irregularly thin-bedded to nodular. Nodular weathering. Makes bench	2.5+
Shale Member Pp ₃ —	
9. Covered, shale (?); much nodular material in float, presumably from unit 10, but could contain another unit of Member Pp ₄	18.0-
Limestone Member Pp ₂ —	
8. Limestone, medium gray, tan weathering, massive, dense, sublithographic to very finely crystalline, sparingly fossiliferous, crinoid fragments common. Prominently jointed, weathers into large, rounded blocks. Forms prominent bench	2.5
Shale Member Pp ₁ —	
7. Covered, shale	4.0
6. Sandstone, base covered, light gray, brown to yellow weathering, calcareous, fine to very fine grained, evenly thin-bedded, worm trails	0.5
5. Covered, shale	17.0
4. Limestone, brown, sandy, fine grained; highly irregular pitted surface with fucoids, ripple marks, etc., on bottom. Fossiliferous (brachiopods, bryozoa)	0.3
3. Shale, gray, calcareous	1.0
2. Limestone, grayish green, brown weathering, sandy; highly fossiliferous with well preserved brachiopods, bryozoa, corals, pelecypods	0.3
1. Covered, shale	4.0
Total	75.6

The stratigraphic positions here described are fairly representative for these beds elsewhere in the study area.

General character.—In the Canyon Group type area the Wiles Limestone Member reaches its maximum thickness of 12 to 14 feet in the vicinity of Sections 1, 27, and 15 (southeast corner of the area). Here it caps a prominent, easterly facing escarpment, and develops to the northwest the longest dip slope of any unit in the type area of the Canyon Group. The lithology of the Wiles Limestone Member is extremely variable. The limestone is irregularly

medium- to thick-bedded; bioclastic and commonly algal; gray to gray mottled, but weathers tan and brown; and dense, generally sublithographic, but in some places coarsely crystalline. To the northwest the member gradually decreases in thickness (Pl. 2, B-B') and completely pinches out before reaching Farm-to-Market Road 207 (Cf. Sections 23, 26, 14 and 16).

The Wiles Limestone Member was not found north of Section 16, where it consists of 6 inches of dark gray argillaceous limestone. The unit near the town of Posideon, Palo Pinto County, designated by Plummer and Hornberger (1935, p. 48) as the "Wiles limestone" is in all probability not correlative with the Wiles of the Canyon type area. It is, however, entirely possible that the "Wiles limestone (Yk₂)" of Plummer and Hornberger (1935, Pl. 2) is a continuation of limestone member Pp₂ of this report. This would account for the stratigraphic interval of "about 50 feet (idem, p. 48)" between the "Wiles limestone" of Plummer and Hornberger and the Palo Pinto Limestone, as opposed to approximately 135-foot interval between the Palo Pinto Limestone and the Wiles Limestone Member in the type area of the Canyon Group. If the Wiles proves to be absent near the town of Posideon, then the Posideon "shale" of Plummer and Hornberger (idem) will have to be redefined, as the original upper boundary was drawn at the bottom of the Wiles.

Wolfe Mountain Shale (Pwm)

Plummer and Hornberger (1935, p. 48) describe the Wolf Mountain Shale as, ". . . a bluish-gray, soft fossiliferous shale containing numerous hard, brown, limonitic concretions and a few lentils or layers of sandstone. This shale is typically exposed below the capping Merriman limestone (Winchell Limestone of this report) in the slopes of Wolf Mountain, 4 miles west-northwest of Palo Pinto (Palo Pinto County)." Plummer and Hornberger (idem) included the Wolf Mountain Shale together with the overlying Merriman Limestone and underlying Wiles Limestone and Posideon Shale as members of the Graford Formation (Table 1).

A complete section of Wolf Mountain Shale at the type locality was not described in the report of Plummer and Hornberger. However, a short distance to the north they measured a complete section showing 301 feet of Wolf Mountain Shale (1935, p. 48-49).

The Colorado River term "Brownwood shale" was applied by

Plummer and Moore (1921) to the strata in the Brazos River valley (Table 1). This term, though, has been dropped by most workers in the Brazos area because its exact relationship to the units in the Brazos River valley is uncertain.

In this report the Wolf Mountain Shale is considered to be a formation in the Canyon Group. Its upper boundary is placed at the base of the Winchell Limestone and the lower boundary at the top of the uppermost limestone member of the Posideon Formation (Table 1). Where the Wiles Limestone Member is present, the top of this unit represents the base of the Wolf Mountain Shale. North of Section 16, where the Wiles and the underlying Limestone Member Pp_4 are absent, the base of the Wolf Mountain Shale is placed at the top of the next lower limestone member (Pp_2) of the Posideon Formation, and the thickness of the latter is accordingly reduced.

In this report the Staff Limestone Member is the only formal member of the Wolfe Mountain Shale. Shales Pwm_1 and Pwm_3 are informal members. Where the Staff (Pwm_2) loses its identity (Locality 29), the strata from the top of the Wiles Limestone Member of the Posideon Formation to the base of the Winchell Limestone are represented by the symbol "Pwm." The Wolf Mountain Shale ranges from 230 to 263 feet thick where the underlying Wiles Limestone Member is present to approximately 275 feet thick where the latter is absent. No formal names are proposed for shale members Pwm_1 and Pwm_3 .

Shale Member Pwm_1

The interval (Pwm_1) below the Staff Limestone Member of the Wolf Mountain Shale and above the Wiles Limestone Member of the Posideon Shale is primarily gray shale. This shale, as is common of other shales of the Canyon Group, contains many thin layers of brown clay-ironstone concretions. Thin lentils of sandstone and siltstone, locally highly calcareous and fossiliferous, are common in the upper part of the member. In the lower portion several thick prominently cross-bedded sandstones are present (Section 23, Locality 8, 9, 10, 18, 28). They are usually separated from the underlying Posideon by a shale interval. At Localities 8 and 9 erosion prior to deposition of the sandstone has completely removed the underlying Wiles Limestone Member of the Posideon and in some places scoured into the upper surface of Limestone Member Pp_4 . Blocks of massive

ferruginous sandstone up to 20 feet across litter the slopes of the two small hills. No attempt was made to establish relationships between the various sandstones.

Staff Limestone Member (Pwm₂)

Type locality and description.—Reeves (1922, p. 120) proposed the name "Staff limestone" for a limestone 10 feet thick outcropping 160 feet below the base of the Adams Branch Limestone (Winchell Limestone of this report) near the town of Staff, Eastland County. He describes the upper half of the Staff as weathering into gray fragments, whereas ". . . the lower part is massive, hard, and yellow," (idem). Reeves included the Staff as a member of the Graford Formation (Table 1).

In this report the unit is regarded as a member of the Wolf Mountain Shale.

General character.—In the area of investigation the Staff Limestone Member is best exposed in a roadcut approximately 2½ miles east of Ranger along U. S. Highway 80 (Section 2). This outcrop is about 9½ miles north-northeast of the type locality of the Staff. The Staff lies 95 feet above the Wiles Member of the Posideon, 129 feet below the Winchell Limestone, and consists of 6 feet of dense, generally sublithographic, brown weathering gray limestone. It is evenly medium- to thin-bedded with thin layers of calcareous brown shale separating the limestone layers. A coquina of fossil fragments occurs at the base of the bed. To the northeast the Staff becomes progressively more difficult to measure and describe, because shale beds between the limestone layers increase in number, thereby reducing the overall resistance of the unit (Locality 28). Moreover, to the northeast the limestone beds themselves become progressively sandier and less resistant. Fusulines occur in several of the upper layers of the Staff (Localities 20, 26, 27). The Staff Limestone Member could not be traced any farther northward than Locality 29, where it is very sandy and nonresistant (Pl. 2, B-B'). Several thin-bedded, sandy, fossiliferous fusulinid limestones and calcareous sandstones were found in the upper Wolf Mountain Shale to the north of Locality 29 (Localities 17, 19; Sections 14—unit 14, 16—unit 11) but could not definitely be correlated with the northernmost exposure of the Staff Limestone Member.

Shale Member Pwm₃

The interval between the Staff Limestone Member and the base of the Winchell Limestone contains several beds and thick lenses of sandstone. Most of these sandstones are profusely cross-bedded, some displaying pronounced channelling. They generally form a series of narrow benches along the slope of the steep escarpment below the capping Winchell limestone. The sandstones are predominantly medium grained, tan to brown, ferruginous, friable with occasional secondary calcite cement, and are well sorted with subangular to subrounded quartz grains being the dominant constituent. Numerous minute localizations of limonite produce the brown speckled appearance typical of these sandstones.

The thickest sandstones found in the Wolf Mountain Shale form a prominent bench below the Winchell Limestone and are separated from it by a slope, presumably shale, covered by slump blocks of Winchell. These sandstones attain thicknesses of 40 to 50 feet (Sections 14, 16, 9).

Several thin lentils of limestone are also found in the upper Wolf Mountain Shale. Most are very impure, fossiliferous, bioclastic, and have only limited distribution. None were named or mapped. Shale and, to a lesser extent, siltstone, though usually poorly exposed, are the dominant lithologic types in the lower and upper Wolf Mountain Shale.

Winchell Limestone (Pw)

The strata in the Brazos River valley now called the Winchell Limestone have undergone several revisions in classification. Plummer (1919, p. 136, 142) first named these rocks the "Graford limestone" and assigned them to his Graford Formation (Table 1). He believed the Graford Limestone to be approximately equivalent to the Adams Branch Limestone of the Colorado River valley. Plummer and Moore (1921, p. 101-102), on the basis of lithologic similarities and relationships to an underlying fusulinid bed, confirmed the equivalence of the Adams Branch and Graford Limestones and applied the name Adams Branch Limestone to the strata formerly called the Graford Limestone in the Brazos River area. They described the Adams Branch Limestone in Palo Pinto County as ". . . in most places made up of two layers separated by 10 or 15 feet of yellow

clay. The upper layer is from four to five feet thick and the lower from 15 to 60 feet and in places 100 feet thick" (*idem*).

On the basis of correlation of fusulinid beds between the Brazos and Colorado River valleys, Cheney (1929, p. 19) reported the "Adams Branch limestone" of Plummer and Moore (1921) in the Brazos region to be a unit stratigraphically higher than the type Adams Branch of the Colorado River area. He further stated that the Brazos River unit is ". . . the same as Drake's Clear Creek limestone of the Colorado River section, and also the same as Reeves' Merriman limestone member (Reeves, 1922, p. 120) in the Ranger district (Brazos River section)." Cheney in turn correlated the Adams Branch Limestone of the Colorado section with the Staff Limestone of Reeves (1922) in the Brazos area. Sellards, *et al.* (1932, p. 111) abandoned the term "Adams Branch" in the Brazos drainage area on account of this apparent confusion. "Clear Creek," because the name was preoccupied, was also abandoned by them and the term "Merriman limestone" was expanded to include the strata in question. The Merriman Limestone as described by Reeves (1922, p. 120) at the type locality south of Ranger, however, is a single bed of limestone 4 feet thick which is separated by about 70 to 80 feet of shale from the underlying Adams Branch Limestone of Plummer and Moore (Table 1). The Merriman Limestone as redefined by Sellards, *et al.*, therefore included not only Reeves' type Merriman, but also the so-called Adams Branch Limestone as well. Neither Plummer or Hornberger (1935, p. 47) were cognizant of Reeves' description of the type Merriman Limestone when they described the latter as the 25- to 75-foot thick limestone ". . . mapped previously by Plummer and Moore as the Adams Branch limestone."

This confusion prompted a further revision of the nomenclature in 1938 by C. O. Nickell (p. 96-107). He applied the name "Winchell member of the Graford formation" to ". . . the group of limestones separated by thick shale beds and thin sandstones in the Winchell area, in Brown County (Colorado River valley). . . . This group of limestones includes the Clear Creek limestone of Drake and of Plummer and Moore (Table 1), plus some higher beds heretofore included in the Placid shale member of Plummer and Moore." Nickell (p. 106-107) measured 72 feet of Winchell at its type locality.

Although Nickell's revisions were directed primarily toward units

in the Colorado River valley, he mentions the similar deposits in ". . . the upper member of the Graford formation of the Brazos Valley . . ." which include ". . . a group of limestone beds that thicken and thin, with shale beds of varying thickness between them," (p. 97). Nickell made no formal proposal to recognize the Winchell as a member of the Graford Formation in the Brazos valley, but strongly suggested this move.

Cheney (1940, p. 88-90), in a discussion of the geology of north-central Texas, followed Nickell's recommendation and applied the name Winchell to ". . . the several limestone members which were originally called 'Clear Creek' by Drake and 'Merriman' by later writers" (p. 89). In the Brazos River valley the Winchell therefore included all the strata from the base of the "Adams Branch Limestone" of Plummer and Moore to the top of Reeves' Merriman Limestone. The Winchell of Cheney was the upper formation of the "Graford Group."

In the present report the Winchell Limestone is designated as a formation of the Canyon Group (Table 1). It is here considered to lie above the Wolf Mountain Shale and below the Placid Shale, and includes a lower thick limestone, a shale, and an upper thin limestone. These three units, informally designated Members Pw_1 , Pw_2 , and Pw_3 , respectively, have been mapped and are described. The boundaries of the Winchell Limestone used in this study coincide with those used by Cheney (1940) for the Winchell "Formation." Where members of the Winchell lose their identity, the formation is represented on the map (Pl. 1) by the symbol, "Pw."

The thickness of the Winchell Limestone in the type Canyon area is relatively constant, ranging between 37 and 43 feet and averaging 41 feet. The only trend noted in the Winchell was the lateral change to the northeast of the shale of Member Pw_2 into thin-bedded limestone. Beyond this point of change no members of the Winchell Limestone were mapped.

Limestone Member Pw_1

This limestone unit, believed to be the incorrectly named "Adams Branch limestone" of Plummer and Moore (1921), is not here recognized by a formal name.

Plummer and Moore (*idem*, p. 101) measured a section $1\frac{1}{4}$ miles northwest of Staff and $4\frac{1}{2}$ miles south-southwest of Merriman

church, in Eastland County, in which the "Adams Branch Limestone" is recorded as being 17 feet thick. The limestone is ". . . brownish-buff at the base, white at the top; massive, in places cherty." Reeves (1922, p. 120) also calls this unit the Adams Branch Limestone. In his stratigraphic section for the Ranger oil field (idem, p. 115), Reeves shows a thin, unnamed limestone lying between the "Adams Branch limestone member" and the overlying "Merriman limestone member." This unnamed limestone unit is possibly correlative with either the upper part of Limestone Member Pw_1 or Limestone Member Pw_3 of the present study. If the latter is true, then the Merriman Limestone of Reeves is not present in the type area of the Canyon Group, since no limestone was found between Member Pw_3 and the overlying Ranger Limestone in the south part of the area. Reeves, however, did not discuss nor attempt to map this unnamed limestone. Its relationship with the limestones in the Canyon type area is unknown and should be studied in detail since it has an important bearing on the correlation of the over-and underlying units.

General character.—The thickest section of Limestone Member Pw_1 was measured at Section 24 in an abandoned quarry northeast of Ranger. Member Pw_1 is 26 feet thick and is separated from the overlying Limestone Member Pw_3 by a gently sloping 13-foot thick covered interval, presumably shale (Member Pw_2). Member Pw_1 is separable into two units. The limestone of the lower unit (Section 24, unit 1) is dark gray, fine grained to coarsely bioclastic, fossiliferous, irregularly medium-bedded, and contains black chert nodules bearing white fossil fragments. Gray, calcareous, fossiliferous shale is commonly found along the bedding planes and occurs in a 4 to 5-inch thick bed at the top of this 10-foot unit. Crinoid fragments, fusulines, brachiopods, bryozoans, and corals are abundant in the shale. The upper unit of Limestone Member Pw_1 (Section 24, units 2, 3) is lithologically similar to the lower portion but is devoid of chert. It becomes algal, is irregularly thin-bedded to nodular in the upper 5 feet, and recedes back in a slope from the top of the quarry face. A similar sequence was observed about 3 miles to the north (Section 17) where 23 feet of Limestone Member Pw_1 were measured. At this section, the top of Member Pw_1 becomes very thin-bedded and grades into the overlying shale of Member Pw_2 .

Limestone Member Pw_1 averages about 20 to 25 feet in thickness

throughout its exposure in the area. All the chert of the Winchell Limestone and most of the fusulines appear to be confined to this unit, or within the same stratigraphic interval where the overlying shale unit is missing (Section 8, units 4a-d). Bedding is extremely variable with single beds up to 3 feet thick (Section 14, units 24a,b). North of Locality 30 the Winchell consists of a single sequence of limestone and is undifferentiated ("Pw" on Pl. 1).

Shale Member Pw₂

Member Pw₂ has no prior name, and a formal name is not here proposed. If this unit is equivalent to the 70- to 80-foot shale interval between the Merriman and "Adams Branch Limestone" of Reeves (1922, p. 120) at the Merriman type locality, then shale Member Pw₂ has thinned by about 60 feet before reaching Section 24, over a distance of approximately 8 miles. Changes in lithology such as this are not uncommon in the Pennsylvanian of north-central Texas. Nevertheless, the uncertainty of correlation of units to the south with those of the Canyon type area emphasize the need for further study in these critical areas.

General character.—Shale Member Pw₂ has a maximum thickness of approximately 15 feet in the study area, and is overlain by the upper member of the Winchell Limestone, Pw₃. In the southern part of the area member Pw₂ is a gray shale, but to the north it becomes marly. At Section 14 (type Wiles) it has decreased to 6 feet in thickness and contains four thin limestone beds (unit 25). The limestones are interesting in that they all are perforated by small worm (?) borings. The beds are gray and lithographic, averaging 3 to 5 inches in thickness, and are not persistent. From Locality 30 northward Shale Member Pw₂ is absent, its stratigraphic position being occupied by limestone (Section 8).

Limestone Member Pw₃

Limestone Member Pw₃ of the Winchell overlies Shale Member Pw₂ and underlies the Placid Shale. As with the other Winchell units, Member Pw₃ is not mapped north of Locality 30, where the members merge into a sequence of limestone and are no longer mappable. Where Shale Member Pw₂ is present, the overlying limestone member (Pw₃) commonly recedes a considerable distance from the escarpment formed by the lower massive unit (Member Pw₁).

Member Pw_3 is tentatively correlated with Reeves' Merriman Limestone. In the map of the Ranger oil field, Eastland County, Reeves (1922, Pl. 17) traced the top of the Merriman Limestone to the north but terminated the contact just south of the town of Ranger. Reeves does not discuss the character of the Merriman at this locality. In the present study the contact at the top of Limestone Member Pw_3 was carried to the southwest into the town of Ranger, approximately $1\frac{1}{8}$ miles northeast of the termination point of Reeves' Merriman Limestone. However, from the position of these two contacts it appears that the limestones may correlate. Further detailed study in this area is needed to accurately determine the relationship of these units.

Reeves (*idem*, p. 120) described the Merriman at its type locality near Merriman church, south of Ranger, Eastland County, as ". . . a persistent bed of fine-textured yellow limestone about 4 feet thick, which is very hard and usually weathers into large rectangular blocks." It occurs about 84 feet below the base of the Ranger Limestone.

General character.—In Section 24 in the south part of the study area Limestone Member Pw_3 is approximately 4 feet thick, containing brown algal structures which stand in relief on the gray weathering limestone. It is medium- to thick-bedded, gray, sublithographic to finely crystalline, and contains very few fossils or fossil fragments. Member Pw_3 occurs about 13 feet above Limestone Member Pw_1 and about 150 feet below the base of the Ranger Limestone. Farther to the north (Sections 17, 14) Member Pw_3 becomes progressively thinner bedded and increases to about 9 feet in thickness, evidently at the expense of Shale Member Pw_2 which decreases accordingly. Unit 4h of Section 8, on the northern boundary of the Canyon type area, is probably the equivalent of Member Pw_3 . It is the upper unit in the continuous limestone sequence of the Winchell in this part of the area. It is medium to dark gray, finely to coarsely crystalline, algal, and is irregularly thin-bedded at the base, becoming medium-bedded toward the top.

Placid Shale (Ppl)

Plummer and Moore (1921, p. 109-114) first applied the name "Placid shale member" (of the Brad Formation) to the 30- to 50-foot interval between the Ranger Limestone and the Clear Creek

limestone in the Colorado River valley (Table 1). At the same time, they proposed the name "Seaman Ranch beds" for the interval in the Brazos River valley between the Ranger Limestone and the "Adams Branch limestone." The Seaman Ranch Beds were defined as being ". . . equivalent to the Placid shale, the Clear Creek limestone, and Cedar-ton beds of the Colorado River Valley . . ." (idem, p. 111). As has been discussed earlier, the Brazos area equivalent of the type "Adams Branch Limestone" of Drake is stratigraphically much lower than the "Adams Branch" of Plummer and Moore in that area. The latter was correlated by Cheney (1929) with the Clear Creek Limestone (Merriman of later workers) of the Colorado River valley. The term "Adams Branch" has been abandoned in the Brazos valley because of its dual meaning there. The Seaman Ranch Beds were later redefined by Plummer and Hornberger (1935, p. 55) as overlying the Merriman Limestone of Reeves, and therefore to be equivalent to the Placid Shale of the Colorado River area. Most of the work since 1935 has been conducted in the Colorado River valley. Hence the use of Placid Shale for the interval between the Ranger Limestone and the Winchell Limestone (see previous discussion of this unit) has become entrenched in the literature.

In this report Placid Shale is used in preference to the term "Seaman Ranch beds." The former term has been less subject to confusion and hence is to be preferred. The Placid Shale is here designated a formation in the Canyon Group. The formation lies above the Winchell Limestone and below the Ranger Limestone. Two shale members, Ppl₁ and Ppl₃, and an intervening limestone member, Ppl₂, are recognized but not given formal names. These appear in exposures of the Placid Shale in the northern half of the study area.

General character

The Placid Shale has a thickness of 150 feet near Ranger (Locality 34), increases in thickness northward to 158 feet at Section 17, and then gradually thins until it is only 126 feet thick on the northern boundary of the study area (Section 22). Excluding Limestone Member Ppl₂, the Placid consists of black, gray, and olive shale; stringers and lenticular bodies of tan to brown, ferruginous, fine grained sandstone, locally up to 40 feet thick and cross-bedded; siltstone; and a few thin but persistent, 4- to 8-inch thick, highly fossiliferous, gray calcareous sandstones and sandy limestones.

Shale Member Ppl₁

Member Ppl₁ has had no formal name nor is one proposed here. It overlies the Winchell Limestone and underlies Limestone Member Ppl₂.

Shale Member Ppl₁ is present from Locality 32 northward. It is approximately 110 feet thick at Locality 32 (cf. Section 17) but steadily thins northward and is only 49 feet thick at Farm-to-Market Road 207 (Section 22). The member consists of variegated shale with occasional thin sandstone stringers, marl beds, and a single thin but persistent, highly fossiliferous limestone and calcareous sandstone. The fossiliferous bed, only locally well exposed (Localities 32, 33, 34; Sections 17, 18, 20, 22), occurs approximately 100 feet below the base of the Ranger Limestone. It contains an assemblage of well preserved pelecypods, gastropods, brachiopods, straight nautiloids, bryozoans, cup corals, the crinoid fragments. All elements of the fauna are forms that are normally small, rather than being dwarfed. This fauna strongly resembles that found in Shale Member Pp₁ of the Posideon Formation (see discussion of "Fambro Sandstone Member"; and Sections 15, 23, 27; Localities 6, 12).

Limestone Member Ppl₂

Member Ppl₂ occurs in the shale interval between the Winchell Limestone, below, and the Ranger Limestone, above. It was studied in some detail by Dobbin (1922, p. 61-62), but was not named. He stated that the limestone thins and is lost to the southwest. He also recognized along its outcrop "... a remarkable southwesterly diminution in the interval between this bed and the base of the Ranger limestone," (p. 62).

The author studied the Placid Shale independently of Dobbin's report and made essentially the same observations concerning limestone member Ppl₂. This unit makes its first appearance at Locality 32, approximately 3¾ miles north of the town of Ranger. At this location the member occurs about 45 feet below the base of the Ranger Limestone as a massive 1- to 1.5-foot bed of brown, sandy, highly bioclastic limestone. To the south, only siltstone and shale are present at this stratigraphic position. Within 1¼ miles to the north of Locality 32, however, member Ppl₂ reaches a thickness of 7 feet but remains 45 feet below the Ranger Limestone (Section 18). At Locality 36 member Ppl₂ consists of 5 feet of dark, massive,

argillaceous, bioclastic limestone. At Section 18 it is light gray, sublithographic to finely crystalline, irregularly thick- to medium-bedded, and bioclastic. The unit maintains the same lithology and thickness of 7 feet from Section 18 to Section 22, but the interval between it and the base of the Ranger increases to 70 feet at the latter section (Pl. 2, C-C'). The member also forms a distinctive topographic bench between the Winchell and Ranger Limestones.

Accompanying the thickening of Shale Member Ppl₃ to the north is the diminution in thickness of Shale Member Ppl₁ above the Winchell Limestone (see preceding discussion of "Shale Member Ppl₁"). If Limestone Ppl₂ continues to "drop" in the Placid Shale to the north, it may actually merge with the underlying Winchell Limestone. If this proves to be the case, then Limestone Member Ppl₂ in the Canyon type area may well be more correctly described as another member of the Winchell Limestone. This relationship, however, remains to be demonstrated. Further investigation in the area to the north of the present study is needed to clarify these relationships. For this reason the author does not propose a formal name for Limestone Member Ppl₂.

Bradish (1937, map) called Member Ppl₂ the "Merriman limestone." A stratigraphic section measured along Farm-to-Market Road 207 (north boundary of the study area) does bear some resemblance to the section described by Reeves (1922, p. 120) at the type locality of the Merriman Limestone. However, in light of the evidence previously discussed concerning the nature of Limestone Member Ppl₂, this member cannot be correlated with the type Merriman Limestone unless it is accurately demonstrated that the two merge in the subsurface.

Shale Member Ppl₃

No formal name is proposed for Shale Member Ppl₃; it has not previously been named.

The distribution of Shale Member Ppl₃ has been discussed under the previous section. The member is predominantly shale, often sandy, silty, and micaceous, with a few thin sandstone beds. Lithologies which vary from this general description when present are usually found immediately beneath the Ranger Limestone. In Section 20 a ferruginous, cross-bedded sandstone has a thickness of 22 feet and actually grades into the overlying Ranger Limestone. Elsewhere fos-

siliferous marls and thin, impure limestone lentils often alternate with thin-bedded calcareous sandstones.

In the vicinity of Locality 32 a very prominent topographic bench is present in the upper part of Shale Member Ppls. This bench was formed by slump and landslide from the heavily jointed Ranger Limestone. The uniform surface of this bench prompted early workers to suggest faulting for its origin. However, the thick blocks of Ranger Limestone contained therein assume all attitudes of dip and strike, thus precluding any possibility of faulting.

Ranger Limestone (Pr)

Plummer (1919, p. 142) proposed the name "Ranger limestone" for the limestone forming the scarp west of Ranger, Eastland County. He distinguished the Ranger Limestone from other members of his Canyon "division" by "The abundance of chert nodules and brown iron stained layers . . ." (*idem*). Ross (1921, p. 306) studies the Lacasa area on the western boundary of the type area of the Canyon Group and described the Ranger Limestone as consisting of three members. These are in ascending order, (1) light-gray massive limestone, 50 feet thick; (2) shale, 12 feet thick; and (3) thin-bedded buff limestone, 4 feet thick. Plummer and Moore (1921, p. 111) defined the Ranger Limestone as ". . . made up in most places of two layers, an upper thin limestone separated by 5 to 10 feet of yellow shale from a lower thick and massive limestone." In a section near Brad, Palo Pinto County, they report that the lower massive unit has a thickness of 30 to 40 feet.

In most previous reports the Ranger Limestone is shown as the upper member of the Brad Formation (Table 1). In the present report, however the Ranger Limestone is given formation status. In the present study the Ranger Limestone in the northern portion of its outcrop belt is divided into three mappable units: a thick basal limestone (Pr_1), a thin shale (Pr_2), and a thin upper limestone (Pr_3). These are the same divisions as recognized by Ross (1921) and Plummer and Moore (1921).

General character

In the Canyon area the Ranger was found to range in thickness from 57 feet (Section 19) to 38 feet (Section 7). From an east-west line located approximately one mile north of the Eastland-Stephens County boundary, south through the town of Ranger, Limestone

Member Pr₃ could not be mapped. A thick cover of Cretaceous conglomerate (Kt) is present over large areas of the west and southwest type area of the Canyon Group. The conglomerate cover together with the receding nature of the thin upper member make it virtually impossible to trace the latter in this part of the area. At a location approximately $\frac{3}{4}$ mile west of Section 17, Shale Member Pr₂ was actually found to be missing (Pl. 1). It is also believed that the shale member is absent further south along the eastward-facing scarp which is capped by the Ranger Limestone. Nevertheless, it is possible that the shale and overlying limestone, Pr₂ and Pr₃, respectively, receded down-dip prior to Cretaceous deposition and are covered by the subsequent thick Cretaceous conglomerate. That this is the case is strengthened by the appearance of all three members at Sections 4 and 4a. Further south, however, a complete sequence of Ranger Limestone was not found (cf. Sections 3, 28). On the map (Pl. 1) the symbol "Pr" is used where the members of the Ranger Limestone cannot be distinguished.

The amount of chert in the Ranger Limestone is considerably less than that found in the Winchell. This is somewhat contrary to descriptions of earlier workers who usually referred to the Ranger as the "cherty limestone." The type of chert varies in these two formations. The chert of the Ranger is characteristically brown, in contrast to the gray to black chert found in the Winchell. The chert of both formations contains numerous white fossil fragments.

The Ranger and Winchell Limestones are remarkably similar in their physical characteristics. Both have an upper thin limestone member separated by a thin shale from an underlying thick limestone member. In both formations the lower members are often separable into two distinct units of essentially equal thickness. Both formations develop prominent jointing.

Limestone Member Pr₁

Member Pr₁ has no previous formal name, and none is proposed. The most outstanding character of Limestone Member Pr₁ is its extreme variability in thickness, bedding character, and lithology (cf. Sections 4, 7, 18, 19; Locality 35). Member Pr₁ varies from 26 feet (Section 7) to 45 feet (Section 19) in thickness. The average thickness is about 33 feet. Member Pr₁ is irregularly bedded, locally marly, and is nodular in places to thick-bedded in others. Beds one to two

feet thick are common. The limestone is generally dense, sublithographic to finely crystalline, and bioclastic. Algal structures are common also. The limestone varies on fresh fracture from yellowish brown, pinkish brown, pinkish gray, to gray. Brown chert with white fossil fragments is common in the middle or lower half of Limestone Member Pr₁. The more nodular and marly intervals are usually found in the upper portion of Member Pr₁. These are highly fossiliferous and are usually dominated by brachiopods.

In the southern half of the Ranger outcrop belt a prominent change in lithology, commonly accompanied by a change in the bedding, often occurs about 15 to 20 feet above the base of Limestone Member Pr₁ and separates the member into two distinct units. The chert referred to above is usually found below, or is concentrated at the break between the two units (cf. Sections 4, 17, 19, 28). A bench is generally developed at the top of the lower unit of Member Pr₁, often just above the prominent chert layer. In contrast, the chert is absent at Section 18, and a nodular limestone and marl layer separates Limestone Member Pr₁ into the two distinct units. This marl layer was actually traced a short distance on the map (Pl. 1). Other than the concentration of chert in the unit below the break, no other trends in lithology were noted.

Jointing is very pronounced in the Ranger, and especially so in Member Pr₁. Where the top of Limestone Member Pr₁ is exposed by recession of members Pr₂ and Pr₃, the joint pattern of Limestone Member Pr₁ can be observed on the aerial photographs. The two directions of jointing generally parallel the northeast strike and northwest dip of the beds. Jointing causes massive blocks of Limestone Member Pr₁ to break away from the escarpment. Open chasms 20 to 30 feet deep are common along the edge of the escarpment. Jointing of Member Pr₁ and subsequent slumping on the underlying soft shale caused the prominent bench previously described under "Shale Member Ppl₃."

Shale Member Pr₂

Shale Member Pr₂ varies from 0 to 11 feet thick and, where exposed, ranges in lithology from a variegated purple and pale green shale (Section 4a), through a yellowish brown mottled marl (Section 5), to a brown marl and nodular limestone (Section 18). It is usually covered and forms a broad, low, grass-covered slope on top

of Limestone Member Pr₁. Member Pr₂ appears to pinch out approximately $\frac{3}{4}$ mile west of Section 17. This has been discussed under "General character" of the Ranger Limestone. The member gradually thickens to the north.

Limestone Member Pr₃

Limestone Member Pr₃ overlies Shale Member Pr₂ and underlies the Colony Creek Shale. Member Pr₃ has no formal name and none is suggested. It averages 5 feet in thickness and is characteristically yellowish brown to brownish pink, gray weathering, sublithographic to very finely crystalline, dense, bioclastic, irregularly medium-bedded, and often algal. Large masses and nodules of brown chert up to several feet across are often found in Limestone Member Pr₃. On a weathered surface the chert appears orange to black with an irregular texture and stands in high relief on the smooth, gray-weathering limestone surface. This description also is applicable to the upper beds of the Ranger Limestone where Shale Member Pr₂ is absent. Limestone Member Pr₃ forms a low bench generally a considerable distance back from the escarpment formed by Limestone Member Pr₁.

Colony Creek Shale (Pcc)

In the Brazos River valley the shale interval between the Ranger Limestone and the overlying Home Creek Limestone was called by Plummer and Moore (1921, p. 117-118) the "Hog Creek shale," following Drake's usage in the Colorado River valley. This name has been in general use by geologists since then (Table 1). However, later work by Nickell (1938, p. 116-118) in the Colorado River area revealed miscorrelations of the Home Creek Limestone Member and misapplication of the term "Hog Creek" in that area (see discussion by Eargle, 1960, p. 67-68). Because of this confusion in the Colorado River valley and its direct bearing upon the nomenclature of the Brazos area, Cheney (1948, p. 20) ". . . proposed (1) that the name Hog Creek shale, misapplied by Drake and others, be dropped; (2) that the name *Colony Creek* shale be given to beds between the Ranger and Home Creek limestones; the type area to be on the branching headwaters of Colony Creek in the vicinity of Colony School, 4 miles west of Ranger in northeastern Eastland County, Texas." The name "Colony Creek Shale" is used in this report and is included as a formation in the Canyon Group. No formal mem-

bers have been named for the Colony Creek Shale and none have been proposed.

Type description

The Colony Creek Shale, by modern standards, was inadequately described by Cheney at its type locality (*idem*). Neither a measured stratigraphic section or an adequate designation of the type locality accompanied the original description. Inasmuch as the Colony Creek Shale has proved to be a useful mappable unit, a detailed study of the type locality is essential to future work in this area.

General character

The Colony Creek Shale underlies the Home Creek Limestone and overlies the Ranger Limestone. At its southernmost exposure in the type area of the Canyon Group (Section 5), the Colony Creek Shale is 66 feet thick. Within three miles to the northeast the Colony Creek Shale has thinned to a thickness of 35 feet (Section 21). A thick, cross-bedded, fine grained sandstone is present in the upper part of the formation. The sandstone is highly lenticular, and increases in thickness to almost 40 feet between Section 5 and Locality 37. It then thins rapidly to the north before reaching Section 21 (Pl. 2, D-D'). Only one thin sandstone bed, occurring about 15 feet below the base of the Home Creek Limestone, was found in the Colony Creek Shale between Section 21 and Section 6. In general, the sandstones vary from grayish white to brown and are calcareous or ferruginous. They usually form prominent, rounded benches in front of the lower member of the Home Creek Limestone (Phc_1). Gray shale with small brown clay-ironstone concretions; yellowish brown calcareous shale; purple shale; and tan siltstone and silty shale make up the remainder of the Colony Creek Shale.

Home Creek Limestone (Phc)

Drake (1893, p. 395-400) proposed the name "Home Creek" for a limestone outcropping along Home Creek in southeastern Coleman County. He later worked to the north in northern Brown County and applied the name "Home Creek" to a lithologically similar limestone in that area. Plummer and Moore (1921, p. 117-119) correlated units in the Brazos drainage basin with those of Drake in northern Brown County and named them accordingly. For many years thereafter geologists used this terminology. In 1938, Nickell

(p. 116-118) demonstrated that the Home Creek Limestone of Drake at the type locality was not equivalent to the unit of the same name in northern Brown County but was actually the limestone that Plummer and Moore had subsequently named the "Ranger." As a solution to the problem, Nickell proposed to continue usage of the established classification of Plummer and Moore (Drake's classification in northern Brown County) and to move the type locality of the Home Creek Limestone to northern Brown County. This action is now accepted by most geologists. When Cheney altered the boundaries of the Canyon Group ("series") to coincide with the boundaries of the Missourian Series of the northern Mid-Continent, he had to revise the definition of the Home Creek Limestone (1940, p. 88-90). The latter was ". . . redefined to include the shales found locally above the highest limestone member of the Home Creek formation and below the disconformity at the base of the Cisco." Cheney's "Home Creek limestone" is vague in its definition and was not specifically discussed or mapped. The writer doubts that this unit of Cheney meets the prescribed standards of the Code of Stratigraphic Nomenclature (American Commission of Stratigraphic Nomenclature, 1961). Therefore the term Home Creek is not used in the sense of Cheney's usage.

The definition of the Home Creek Limestone of Plummer and Moore (1921) is used in this report. They describe the Home Creek Limestone near Caddo, Stephens County, approximately 8 miles north of the Canyon type area, as ". . . composed of two layers which are separated by 5 to 10 feet of calcareous shale. The upper layer is a dark, blue, fossiliferous, hard limestone and weathers to a yellow-brown color. The lower layer is an impure, clayey, light gray, poorly bedded limestone 10 to 40 feet in thickness . . ." (1921, p. 118). The Home Creek Limestone overlies the Colony Creek Shale and underlies the Finis Shale of the Cisco Group. In the type area of the Canyon Group two limestone members, Phc₁ and Phc₃, and an intervening marl member, Phc₂, are recognized (Table 1). These units have no formal status.

The minimum thickness of the Home Creek Limestone recorded in the area of study is 23 feet (Section 5a). This gradually increases to 34 feet at Section 21, accompanied by a diminution of the underlying Colony Creek Shale.

Limestone Member Phc₁

Member Phc₁ caps a small escarpment above the shale and sandstone of the Colony Creek Shale, and forms a prominent bench in front of the upper limestone member of the Home Creek. Limestone Member Phc₁ maintains a thickness of 7 to 10 feet but varies greatly in lithology and bedding character. The limestone is sublithographic to coarsely crystalline; pinkish brown, dark gray, or mottled gray; bioclastic, commonly algal and fossiliferous; and generally unevenly medium-bedded. In places the lower bed of Limestone Member Phc₁ increases to 4 or 5 feet thick and weathers with a heavily pitted surface (Section 21). This particular layer of limestone can be traced for some distance. In the north it retains its overall thickness but splits into two thinner limestones and an intervening shale (Section 6). The other beds of member Phc₁ are less easily traced due to their receding nature and tendency to be covered by debris from overlying units.

Marl Member Phc₂

The interval between members Phc₁ and Phc₃ is termed Marl Member Phc₂. At Section 5a this unit consists of 6.5 feet of tan marl, in which is included a thin, 10-inch fusulinid coquina. Member Phc₂ thickens to the north and locally contains massive, cross-bedded sandstone lentils which are deposited in channels, some of which cut completely through underlying Limestone Member Phc₁ and into the subjacent Colony Creek Shale (Locality 37). Farther north at Section 21, Member Phc₂ is approximately 19 feet thick and is made up of marl and nodular, chalky limestone. Slump blocks from Limestone Member Phc₃ usually cover the upper slopes formed by the underlying marl. No other lithologic types were found in Member Phc₂.

Limestone Member Phc₃

Limestone Member Phc₃ is the uppermost unit of the Canyon Group in its type area. The Finis Shale of the Cisco Group overlies Limestone Member Phc₃. The latter has a thickness of 5 to 9 feet along its northeast strike and is typically sublithographic, unevenly to irregularly medium-bedded, brown with gray streaks or mottling, and bioclastic. About 1½ miles northwest (downdip) from Section 21, a small quarry in the member exposes a 16-foot sequence of gray, sublithographic, nodular to highly irregularly bedded, bio-

clastic, fossiliferous limestone (Section 25). The above thickness is not complete, as the base of the limestone is not exposed in the quarry. The author believes this limestone sequence represents a downward thickening of Limestone Member Phc₃ at the expense of Marl Member Phc₂. Study of numerous logs of wells in this vicinity strengthens this theory.

Limestone Member Phc₃ forms a broad, uneven dip slope in the northwest corner of the Canyon Group type area. Prominent north-east-northwest jointing is characteristic of Member Phc₃. Patches of Cretaceous conglomerate are present along the edge of the escarpment capped by Limestone Member Phc₃.

Cisco Group

The sole representative of the Cisco Group in the area covered by this study is a small patch of gray shale overlying Limestone Member Phc₃ of the Home Creek Limestone west of Section 25. No attempt was made to study in detail the rocks of the Cisco Group. The name "Finis Shale" of Plummer and Moore (1921, p. 127-128) is used *pro tempore* for the Cisco strata of this small outcrop. Plummer and Moore applied this name to the shale immediately overlying the upper unit of the Home Creek Limestone in the Brazos River valley.

Cretaceous System

Rocks of Cretaceous age are represented in the type area of the Canyon Group by a ferruginous, cross-bedded, poorly sorted, quartz and chert-pebble conglomerate. The conglomerate is completely indurated and is largely siliceous in composition. No comparable Pennsylvanian units were found in the area under investigation. The presence or former presence of Cretaceous rocks in this area is always indicated by a rust-red rock or soil coloration. Outliers of Cretaceous strata are scattered throughout the Canyon type area and are indicated by the symbol "Kt," for the Trinity Group of which they are a part (Sellards, *et al.*, 1933, Pl 11).

Quaternary System

The Quaternary strata in the type area of the Canyon Group consist of alluvium along drainage and of terrace deposits. The alluvium, indicated "Qal" (Pl. 1), consists of thick conglomeratic sequences forming low-level terraces in the major drainage valleys and canyons. These deposits are readily distinguishable from the Cretaceous

strata by their high calcareous content in the form of pebbles, cobbles, and boulders of limestone; by their lack of complete consolidation; and by their lack of red coloration. The alluvium has in many places been incised by present streams to bedrock and locally displays thicknesses in excess of 20 feet (Locality 22).

The terrace deposits are situated considerably above the alluvium and are less distinct. The lithology and texture of the terrace deposits is comparable to that of the alluvium. Terrace deposits were not mapped in this report.

SUMMARY AND CONCLUSIONS

1. The Pennsylvanian Canyon Group has its type area in the vicinity of the common corner of Palo Pinto, Stephens, and Eastland Counties, Texas. In this area the Canyon Group consists of alternating thick limestone and shale, with occasional sandstones and thin limestones. The strata have a total thickness of about 725 feet and are divided into 8 formations and 24 members. The formations are, in ascending order: the Palo Pinto Limestone (no members); Posideon Formation (Fambro Sandstone, Shale Pp₁, Limestone Pp₂, Shale Pp₃, Limestone Pp₄, Shale Pp₅, and Wiles Limestone Members); Wolf Mountain Shale (Shale Pwm₁, Staff Limestone or Pwm₂, and Shale Pwm₃ Members); Placid Shale (Shale Ppl₁, Limestone Ppl₂, and Shale Ppl₃ Members); Ranger Limestone (Limestone Pr₁, Shale Pr₂, and Limestone Pr₃ Members). Members indicated solely by rock type and symbol are informal. No new, formal names are proposed in this report. Detailed studies of the Canyon strata should be completed on a regional basis before proposing new names. Moreover, the existing nomenclature is quite workable.

2. The distinctive, easily mappable units in the type area of Canyon Group are, with one exception, the limestones. Particularly prominent throughout the area are the Palo Pinto, Winchell, Ranger, and Home Creek Limestones. Smaller useful rock units are the Pp₂, Pp₄, Wiles, Staff, and Ppl₂ Limestone Members. Of these, however, only Limestone Member Pp₂ is persistent throughout the entire Canyon area. The lithologic exception to the above key beds is the Fambro Sandstone (Reynolds, 1953, unpublished master's thesis, University of Texas). This unit, the only sandstone mapped, is very distinctive. Shale sequences are mapped between the more easily discernible sandstones and limestones and are only as clearly

delineated as their bounding units. Shales generally are poorly exposed and are not distinctive.

3. The nomenclature used in this report is derived from a variety of sources. All units named or given symbols are defined solely on their lithologic character and are readily mappable on a 1:20,000 scale. Most of the formations used are the "members" of older reports. These units are widespread, distinctive, generally divisible into several smaller mappable units (members of this report), and are worthy of formation status.

4. The stratigraphic limits of the Canyon Group as originally defined by Plummer and Moore (1921) are accepted. By using these limits the lithologic significance of the Canyon Group is also retained, a factor important in discussing the Pennsylvanian depositional history of north-central Texas. The stratigraphic limits of the Canyon Group are not recognized as equivalent to those of the Missourian Series of the northern Mid-Continent.

5. In contrast to the predominance of terrigenous clastic sediments (shale, clay, sandstone, conglomerate) in the Strawn and Cisco Groups, the Canyon Group is distinguished by its thick bioclastic limestones and intervening shale, thin limestones, and lenticular sandstones. A detailed study of the origin and depositional environment of the Canyon sediments is not within the scope of this report. The author has certain impressions, however, which may serve to stimulate further investigation in this area of study. Prior to the deposition of the Canyon Group, the ancestral Ouachita Mountains to the southeast were elevated and continuously eroded. This was the principal source of the terrigenous clastics of the Strawn Group. A decrease in the vigor of erosional activity in the source area is indicated by the relatively small volume of coarse clastics and by the deposition of the alternating thick bioclastic limestones and shales of the Canyon Group. The shallow marine transgressions of the Canyon were often interrupted by minor regression and the formation of sandstone beds and channel deposits of possible deltaic or terrestrial origin, as evidenced by the lack of marine life and by the presence of wood and plant fragments. The limestones and thin calcareous beds are generally fossiliferous. Faunas recurring in stratigraphically higher positions suggest a repetition of environmental conditions. After the deposition of the Home Creek Limestone, persistent uplift

recurred in the Ouachita source area. As a result, deposition of clastics was renewed, and these mark the beginning of deposition of Cisco strata. Disconformities of short duration, produced primarily by sandstone channelling, are numerous throughout the Pennsylvanian sequence but are only local in extent.

6. The general stratigraphy of the Canyon Group in its type area is as follows:

- a) The Palo Pinto Limestone is a single, thick persistent bed of relatively uniform lithology throughout the area. The overall thickness of the unit varies depending upon the degree of development of the upper nodular and marly portion of the limestone. The Palo Pinto Limestone is generally very fossiliferous. Brachiopods are especially abundant; a fusulinid layer is generally present at the top of the lower ledge-forming unit.
- b) The Posideon Formation is of variable lithology and is divided into seven members. These are, in ascending order, the Fambro Sandstone, Shale Pp₁, Limestone Pp₂, Shale Pp₃, Limestone Pp₄, Shale Pp₅, and the Wiles Limestone. The Fambro has a definite linear pattern of distribution and probably represents a deltaic stream channel deposit. Several other smaller sandstone bodies are present, some of which show definite channelling. The shale and limestone members are all relatively thin. The limestones are individually distinctive and uniform in lithology, but with the exception of Member Pp₂ are not persistent to the north.
- c) The Wolf Mountain Shale is not uniform in thickness but is, however, the thickest formation in the Canyon Group. Two shale members, Pwm₁ and Pwm₃, and an intervening member, the Staff Limestone (Pwm₂), are recognized. The Staff Limestone becomes very sandy to the north and disappears. It is a thin, generally poorly exposed limestone and commonly contains abundant fusulines. Thick lenticular sandstones are present throughout the formation but are especially well developed in the upper part of Shale Member Pwm₃. Several very thin, impure limestones and fossiliferous calcareous sandstones with abundant fusulines are also found in the Wolf Mountain Shale.
- d) The Winchell Limestone is a very prominent, mappable formation in the area. It consists of three members: a thick, cherty basal limestone (Pw₁), a thin shale (Pw₂), and a thin lime-

stone at the top (Pw_3). Shale Member Pw_2 undergoes a facies change to the north into limestone. Beyond this the Winchell is a continuous, thick sequence of limestone in which no members are differentiated. The overall thickness and lithology (disregarding the change in Member Pw_2) of the respective Winchell members is relatively uniform throughout the area. The chert of the Winchell is dark gray to black. Fusulines and brachiopods are abundant in Member Pw_1 .

- e) The Placid Shale thins to the north and there is divided into a basal shale member (Ppl_1), a thin limestone (Ppl_2), and a shale member (Ppl_3) at the top. To the south the limestone rises in the section, thins, and pinches out. From this point southward no members are mapped in the Placid Shale. Sandstone is locally well developed, some even grading into the overlying Ranger Limestone. Gray shale, some marl, and a thin, highly fossiliferous calcareous sandstone make up the rest of the Placid.
- f) The Ranger Limestone, like the Winchell Limestone, has a thick lower limestone member (Pr_1), a thin shale member (Pr_2), and a thin upper limestone member (Pr_3). The shale member is not recognized in much of the southern part of the area, but is prominent and gradually thickens to the north. Brown chert is common in both limestone members. The members of the Ranger Limestone, particularly Limestone Member Pr_1 , are variable in lithology and thickness. The limestones are commonly algal and fossiliferous.
- g) The Colony Creek Shale thins markedly to the north and contains several lenticular sandstones in the upper part. Gray shale, often silty, makes up most of the unit. No members are distinguished.
- h) The Home Creek Limestone thickens to the north and contains two limestone members (Phc_1 , Phc_3) and an intervening marl member (Phc_2). All members are variable in thickness and lithology. The upper limestone member, Phc_3 , appears to thicken to the northwest (downdip) at the expense of Marl Member Phc_2 . Marl Phc_2 locally develops a channel sandstone which scours through Limestone Member Phc_1 . Both limestone members are fossiliferous.

7. This report provides detailed stratigraphic information in the type area of the Canyon Group, and is intended to supply a needed base for further local or regional studies in the Canyon strata of north-central Texas.

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A P P E N D I X

Measured Sections

Section 1 (M-4, 5)*

Measured from lowest shale exposure in ditch by abandoned road, westward along road to top of Wiles Limestone.

Thickness
Feet

Posideon Formation—

Wiles Limestone Member—

17. Limestone, base covered, dense, yellowish brown; weathers gray to tan. Sublithographic, bioclastic and algal. Irregularly thin- to thick-bedded, thicker beds at top. Caps prominent scarp and has long dip slope..... 13.0+

Shale Member Pp₅—

16. Shale, mostly covered, light brown to purple; sandy, occasional thin sandstone stringers..... 22.0+

Limestone Member Pp₄—

15. Limestone, poorly exposed, chalky, nodular to marly; light gray, weathers white. Fossiliferous, abundant large solitary corals (*Campophyllum*). Forms small, rounded bench; hard nodules and corals litter surface..... 8.5

Shale Member Pp₃—

14. Sandstone, brown, fine to medium grained, thin-bedded. Thin (1') shale in middle..... 4.0

13. Covered, shale..... 12.5

Limestone Member Pp₂—

12. Limestone, dense, sublithographic, weathers light brown; fossiliferous. Lower 1.0' is light gray; upper 1.4' is darker gray. Massive; sometimes has single parting in middle. Well jointed, breaks off in large blocks. Forms low bench..... 2.4

Shale Member Pp₁—

11. Shale, mostly covered, sandy, light brown..... 15.5

10. Sandstone, brown to gray; fine to medium grained; thin-bedded. Very thin shale layers intercalated..... 2.3

9. Shale, mostly covered, brown, sandy. Thin (2") sandstone stringer 4' from base..... 11.0

Fambro Sandstone Member—

8. Sandstone, light brown to light gray; weathers reddish brown to dark gray; massive, thick- to very thick-bedded in places, heavily cross-bedded. Ferruginous. Fine to medium grained, well sorted, subrounded, friable. Very little matrix. Clear quartz chief constituent, some dark chert. Coarse grained sand and claystone pebbles common in some cross-bedded zones; clay weathers out leaving pitted surface. Thin, cross-bedded, conglomeratic layer at base. Weathers rounded in massive boulders.... 44.5+

Shale Member Pp₁ (included with Ppf on Plate 1)—

7. Shale, gray, fissile; carboniferous; selenite crystals, plant fragments. Sandy at top. Generally covered by slump from Fambro.... 8.5+

* (Coordinates, Pl. 1)

Palo Pinto Limestone (no members recognized)—

6. Limestone.....	16.0
6b. Limestone, 2.0', gray, nodular to marly. Fusulines abundant to coquind in lower part. <i>Syringopora</i> colonies locally present above fusuline horizon. Marl at top.	
6a. Limestone, 14.0', medium gray, weathers dark gray; fine grained, bioclastic. Irregularly thin-bedded. Fossiliferous, fusulines abundant in top layer. Single 2-foot bed at base. Bench at top.	

Keechi Creek Shale (of Strawn Group)—

Shale Member Pkc₅—

5. Shale, covered to poorly exposed.....	7.0
4. Sandstone, base covered, brown; massive to thin-bedded. Calcareous, developing thin, bioclastic limestone lentils with fusulines. Fine to very fine grained.....	3.0+
3. Shale, covered to poorly exposed.....	25.0+
2. Sandstone, gray, brown weathering, massive to thin-bedded, cross-bedded. Fine to very fine grained.....	3.9
1. Shale, gray, dark gray to brown weathering; blocky with interbedded brown clay-ironstone nodules. Upper 38.5' poorly exposed.....	55.0+
Total.....	254.1+

Section 2 (G, H-2, 3)

Measured from top of Wiles Limestone Member in bed of Russell Creek, west to base of Staff Limestone, offset southwest to roadcut, continued southwest along north side of road (short interval of depression), then north to top of Winchell Limestone outlier.

Winchell Limestone—

Limestone Member Pw₁ (lower part)—

16. Limestone, dense, gray to yellowish brown, weathers gray to brown; sublithographic, bioclastic. Large (1'+) dark gray to black chert masses and nodules in upper 5'. Irregularly medium-bedded.....	8.0+
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Wolf Mountain Shale—

Shale Member Pwm₃—

15. Shale and lenticular sandstone; sandstone lentil in middle, thickens to northwest. Mostly covered.....	26.5
14. Sandstone, yellowish-brown to gray; medium grained; thin-bedded, profusely cross-bedded. Calcareous cement.....	6.5
13. Limestone, dense, brown, weathers gray to brown; sub-lithographic, algal; massive.....	1.5
12. Clay shale, blue-gray, calcareous.....	7.0+
11. Sandstone, brown to gray, medium grained, calcareous, cross-bedded. Intercalated calcareous shale. Top of unit appears to be uneven, but is mostly covered and indistinct.....	8.8+
10. Limestone, brown, massive, argillaceous. Has variable thickness. Thin shale (4") above unit. Weathers brown with irregular surface.....	1.0+

9. Clay, blue-gray, calcareous.....	6.5
8. Sandstone, yellow to reddish brown; medium to fine grained; irregularly very thick-bedded to massive; cross-bedded, with much channelling. Thickens to 30' by removal of part of underlying shale (unit 7). Ferruginous.....	19.0+
7. Shale, partially covered; bluish gray for the most part, olive drab and sandy in upper 2'; locally removed by sandstone (unit 8) and is reduced to 3.5'.....	14.8—
6. Sandstone, brown to yellowish white; ferruginous in part, friable where not ferruginous; medium to fine grained. Irregularly thin-bedded, cross-bedded. Shale along bedding planes.....	4.0
5. Covered, shale.....	31.0
Staff Limestone Member (Pwm ₂)—	
4. Limestone, medium gray, brownish gray weathering; bioclastic, coquina of fragments at base. Base shaly, grading to sublithographic and lense upward. Evenly thin- to medium-bedded alternates with thin layers of brown calcareous shale. Forms prominent bench.....	6.0
Shale Member Pwm ₁ —	
3. Shale, yellowish brown to grayish white, calcareous. Contains carboniferous matter; lentils of brown, bioclastic limestone; and a layer of sandstone pods (pinch and swell).....	3.8
2. Sandstone and sandy shale, alternating; calcareous, carboniferous matter; gray, yellow-brown weathering; sandstone regularly very thin- to medium-bedded. Ripple marks, fucoids, worm trails. Base covered.....	4.7+
1. Shale, mostly covered, yellow-brown to gray, clayey, carboniferous. Fairly well exposed in roadcut (upper part only). Forms long slope.....	86.5+
Total.....	235.6+

Section 3 (C-4)

Measured from abandoned shale quarry pit, northwest to top of Ranger Limestone escarpment.

Ranger Limestone (no members recognized)—

2. Limestone, yellow-brown to pink, brown to gray weathering; dense, algal, sublithographic; medium- to thick-bedded and uneven. Forms wide bench and caps prominent escarpment around Ranger. Believed to correlate with unit 8a of Section 4.....	16.0
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Placid Shale (no members recognized)—

1. Shale and marl, exposed where quarried, mostly covered elsewhere. Base concealed.....	61.7
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1e. Marl, 2.0', brown; highly fossiliferous with well preserved brachiopods, crinoids, gastropods, some fish teeth. Similar occurrence in upper part of unit 7, Section 4.

1d. Covered, 20.0', shale, calcareous. Many slump blocks from Ranger Limestone.

1c. Shale, 6.2', clayey, gray to purple, weathers blocky. Few fossil fragments. (Thin (2-6") sandstone stringers, brown.

1b. Shale, 4.0', sandy, micaceous; gray-green, weathering yellowish brown with reddish brown streaks of iron stain; slightly calcareous. Some gray clay shale. Few fossils.

1a. Clay shale, 29.5' base covered; medium gray; non-fossiliferous. Upper 20'+ becomes sandy with banded color pattern, gray-green, brown, etc. Upper part bears plant fragments; weathers blocky.

Total..... 77.7

Section 4 (B-4, 5)

Measured from lowest exposures in shallow drainage ditch on east side of road, northward along roadcut, east to bench at top of unit 8a, offset to north along bench to small quarry, then to top of southeast quarry wall.
Ranger Limestone—

Limestone Member Pr₁ (see "Note" at end of Section 4a)—

8. Limestone and marl.....	33.0+
8e. Limestone, 4.0', brownish pink, sublithographic, brown weathering, algal, unevenly thick-bedded.	
8d. Marl, 2.0', brown, with 1" lenses of brown algal limestone.	
8c. Limestone, 1.5', grayish brown to pink, algal. Single bed, but occasional traces of uneven bedding.	
8b. Limestone, 6.0', gray, weathers brownish gray; algal; fossiliferous, contains abundant brachiopods (<i>Composita</i>) which readily weather out. Unevenly thin-bedded; unit recedes making definite bench at top of unit 8a (chert layer).	
8a. Limestone, 19.5+', gray, dense, sublithographic. Algal, structures more localized in lower half of unit. Irregular to uneven bedding; thick- to medium-bedded at base, thin- to medium-bedded in upper portion. Brown chert nodules and masses (to 1' in diameter) in upper layer. Bench formed at top of chert layer.	

Placid Shale (no members recognized)—

7. Shale, calcareous to marl, usually covered; brown. Highly fossiliferous; excellent preservation, fossils weathered free on surface; brachiopods, gastropods, crinoids, etc., similar to those found in unit 1e of Section 3.....	10.5
6. Marl, red-brown, ferruginous; fossiliferous, bioclastic debris. Crumbly texture.....	0.8
5. Shale, tan, sandy.....	1.5+
4. Sandstone, gray with brown mottling, weathers red-brown to brown in rounded slabs. Cross-bedded, ripple marks. Highly irregular thick-bedded to massive. Varies from 1-4'.....	4.0—
3. Shale, sandy, tan to gray; with tan, ferruginous sandstone stringers (1-2" thick).....	12.0+
2. Limestone, dark brown, impure, fusulinid coquina.....	0.4
1. Shale, sandy, or shaly sandstone; tan. Base covered.....	1.0

Total..... 63.2

Section 4a (B-5)

Measured north along roadcut on east side of road, approximately 1000' north of Section 4, then northeast along private ranch road to top of Cretaceous (Trinity) conglomerate.

Trinity Group (Cretaceous; no formations or members)—

3. Conglomerate, purple, massive, cross-bedded. Grains vary 1-4mm, poorly sorted, various degrees of rounding. Entirely siliceous. Possibly a thin shale at base..... 25.0+

Ranger Limestone—

Limestone Member Pr₃*—

2. Limestone, brown to yellowish brown, weathers brown with highly pitted surface. Bioclastic, crinoid fragments most abundant. Unevenly thin- to medium-bedded. Finely crystalline to sublithographic. Recedes greatly from Limestone Member Pr₁ and is commonly covered by Trinity conglomerate..... 1.5+

Shale Member Pr₂ (base covered)—

1. Shale, variegated purple and pale green. Generally covered. Base of exposure within 10' of top of Limestone Member Pr₁ (unit 8, Section 4)..... 5.0+

Total..... 31.5+

* Note: Thick Cretaceous cover and limited areal exposures prohibited mapping individually the members of the Ranger Limestone in Sections 4 and 4a. The undifferentiated Ranger Limestone is represented by symbol "Pr" (Pl. 1).

Section 5 (B-8)

Measured from creek bed on east side of road, north along the road, then east to top of small outlier of Limestone Member Phc₁ of the Home Creek Limestone.

Home Creek Limestone—

Limestone Member Phc₁—

10. Limestone, pinkish brown, gray weathering, algal, sublithographic. Shaly parting near base. Upper beds more coarsely crystalline and bioclastic. Base and top poorly exposed. Caps small hill, and is correlated with unit 3 of Section 5a..... 6.0

Colony Creek Shale (no members recognized)—

9. Covered, shale..... 5.5

8. Limestone, reddish brown, gray weathering, single bed. Medium to coarsely crystalline, slightly sandy, bioclastic. Contains abundant fusulines. Caps small bench in front of unit 10; is correlated with unit 1, Section 5a..... 0.4

7. Sandstone; lower third yellowish brown, weathering dark gray to brown; grayish white in upper two-thirds. Fine grained, calcareous, cross-bedded; evenly thick-bedded at base to thin-bedded at top..... 19.0

6. Covered; a lot of brown, gray weathering sandy shale in float.. 29.0

5. Sandstone, gray, brown to reddish brown weathering, calcareous, fine grained. Contains carbon particles. Cross-bedded; evenly thin-bedded..... 1.0

4. Covered, shale.....	11.0
Ranger Limestone—	
Limestone Member Pr ₃ —	
3. Limestone, gray to brown (fresh and weathered), dense, finely crystalline, fossiliferous. Numerous crinoid fragments. Unevenly thin- to medium-bedded.....	5.5
Shale Member Pr ₂ —	
2. Marl, yellowish brown and white mottled, weathers with popcorn texture. Few fossils, some crinoid fragments.....	6.0
Limestone Member Pr ₁ (base covered) —	
1. Limestone, medium gray, weathers dark gray to brown. Varying amounts of algal matter. Irregularly medium-bedded, thin-bedded, to nodular.....	13.0+
Total.....	96.4+

Section 5a (A-9)

Measured from exposure of thin limestone north of earth dammed tank on west side of road, north to Cretaceous cover. Approximately 3000' north of Section 5.

Home Creek Limestone—	
Limestone Member Phc ₃ —	
5. Limestone, pinkish brown to gray mottled, brown to gray weathering; sublithographic to finely crystalline, bioclastic. Unevenly medium-bedded. Caps escarpment.....	9.0
Marl Member Phc ₂ —	
4. Marl, yellowish brown with gray streaks. Fusulinid coquina 10" thick occurs in two layers 4' above unit 3.....	6.3
Limestone Member Phc ₁ —	
3. Limestone, same as unit 10, Section 5. Bench at top.....	7.0
Colony Creek Shale (no members recognized) —	
2. Covered, shale.....	5.0
1. Limestone, same as unit 8, Section 5.....	0.4
Total.....	27.7

Section 6 (F-14)

Measured along roadcut on north side of road, west to base of first limestone (unit 4), then offset to other side of road and continued west to top of second limestone.

Home Creek Limestone—	
Limestone Member Phc ₁ *—	
6. Limestone, mottled reddish brown to black, weathers brown. Massive to poorly bedded; coarsely bioclastic (foraminiferal). Black fragments give speckled appearance.....	1.3
5. Covered, shale.....	3.0
4. Limestone; variegated brown, pink, gray; weathers yellowish brown. Bioclastic, algal, sublithographic to finely crystalline. Irregularly massive.....	0.6+

Colony Creek Shale (no members recognized)—

3. Shale, mostly covered, yellowish brown, clayey, calcareous at top.....	15.0+
2. Sandstone, grayish white to brown, brown weathering, fine grained, friable. Evenly medium-bedded, weathers in rectangular faces and blocks. Ripple marks common between beds.....	4.0
1. Clay shale, base covered, brownish purple with yellowish brown streaks throughout. Weathers yellowish brown. Gray-white to brown sandy shale at top; fine grained, friable, ripple marks.....	11.0+
Total.....	34.9+

* Note: Units 4-6 of Limestone Member Phc₁ probably correlative with unit 4a of Section 21 (Member Phc₁). Higher beds not exposed here because of Cretaceous cover.

Section 7 (G, H-14)

Measured from culvert, generally westward along roadcut on south side of road to top of Limestone member Pr₁, then northwest across road to top of cherty limestone unit (Limestone Member Pr₃).

Ranger Limestone—

Limestone Member Pr₃—

8. Limestone, brown, dark gray weathering, very finely crystalline, slightly algal. Single uneven bed. Cherty, with brown nodules up to 8". Greatly receded from scarp capped by unit 6..... 1.0

Shale Member Pr₂—

7. Covered, shale 11.0

Limestone Member Pr₁—

6. Limestone..... 26.0

6e. Limestone, 3.0'; similar to unit 6d, except irregularly thick-bedded. Lot of solution pitting. Cap of thin, gray, chalky limestone. Caps prominent escarpment.

6d. Limestone, 6.5', yellowish brown to brown (fresh and weathered), algal, sublithographic, highly irregularly medium-bedded.

6c. Limestone, 3.0', gray; shaly, highly irregular bedding. Fossiliferous, contains abundant large brachiopods.

6b. Limestone, 7.0', medium gray to light gray (fresh and weathered), bioclastic. Irregularly thin-bedded with thin intercalated calcareous shale partings; becomes chalky and nodular at top.

6a. Limestone, 6.5', gray (fresh and weathered), unevenly thin-bedded, sublithographic to finely crystalline. Bioclastic with some algal lentils. Bottom layer 8" thick and highly bioclastic.

Placid Shale—

Shale Member Ppl₃ (base covered)—

5. Shale, gray and brown. Calcareous, probably by secondary contamination from above limestones..... 6.0

4. Sandstone, ferruginous, brown, weathers light brown. Fine grained, evenly thin-bedded with shale partings. Plant fragments. Calcareous toward top.....	4.0
3. Shale, medium gray, clayey. Brown sandy layer with plant fragments, 2.5' below top.....	6.5
2. Sandstone, brown, ferruginous, fine grained, friable. Evenly thin- to medium-bedded, blocky slumping. Ripple marks.....	2.0
1. Covered, shale. Base in culvert by road.....	14.0
Total.....	70.5

Section 8 (I, J-14)

Measured from creek bed below bridge, generally westward along south side of road, through roadcut to top of Winchell Limestone.

Winchell Limestone (no members recognized)—

4. Limestone, top forms very wide bench.....	41.5
4h. Limestone, 8.0', medium to dark gray, weathers nodular and gray. Algal, fine grained to coarsely crystalline, highly irregularly thin-bedded. Medium-bedded at top.	
4g. Limestone, 1.5', grayish pink, weathers grayish white to brown. Dense, sublithographic to lithographic. Medium-bedded. No fossils.	
4f. Limestone, 2.0', medium gray to brownish pink. Sublithographic to fractured appearing. Contains abundant iron-stained fusulinids.	
4e. Limestone, 7.0', medium gray, weathers brown to grayish white and rounded. Unevenly medium-bedded; beds thinner in lower half. Bioclastic and fossiliferous in lower beds. Upper 3' algal.	
4d. Limestone, 9.5'; gray, bioclastic, finely crystalline, thick-bedded, at base; grades upward to thin-bedded and algal. Zone of gray to black chert in middle.	
4c. Limestone, 3.0', light gray, algal, finely crystalline, evenly medium-bedded.	
4b. Limestone, 2.5', similar to 4a but contains abundant nodules of mottled black and gray chert. Chert contains light-colored fusulines.	
4a. Limestone, 8.0', medium gray to grayish white, weathers yellowish brown to gray. Fine grained, bioclastic, fusulines, abundant throughout. Black shale partings between beds, contain white fusulines. Limestone unevenly medium- to thin-bedded, weathers with sharp faces. Base makes sharp contact with underlying shale.	
3. Clay shale, gray to brown, brown weathering, calcareous.....	4.8
2. Limestone, dark gray with brown specks, brown weathering, single massive bed. Medium to coarsely crystalline; hash of bioclastic material. Weathers rounded. Generally covered by shale from unit 3.....	1.7
1. Covered, primarily. Shale exposures and large boulders (6'+ diameter) of fine grained, cross-bedded, ferruginous sandstone in	

creek bed. Sandstone is part of channel deposit exposed along creek bank on other side (east) of road. Section started in creek bed on southwest side of road.....	32.5
Total.....	80.5

Section 9 (J-14)

Measured from road level, just west of county boundary marker, north-northeast to top of Winchell Limestone escarpment.

Winchell Limestone (no members recognized; units equivalent to units 4f-h of Section 8 have receded downdip and are not present in this section)—

8. Limestone; units closely correlative with those of same letter in unit 4, Section 8. Base covered.....	25.5+
8e. Limestone, 4.5', caps scarp. Medium to dark gray. Finely to medium crystalline, nodular to marly and bioclastic at base. Upper 3' thick-bedded. Lowermost of thick beds is algal, others bioclastic. Weathers rounded in big blocks.	
8d. Limestone, 13.0', probably correlative with unit 4d and lower bioclastic part of unit 4e, Section 8. Medium gray, light gray weathering; finely to medium crystalline; bioclastic, fusulines found; unevenly thin-bedded.	
8c. Limestone, 3.0', light gray, medium crystalline, bioclastic, unevenly medium-bedded. Fusulines common. Shaly limestone layer at base forms undercut.	
8b. Limestone, 1.5', similar to 8a except contains mottled gray and white chert nodules (up to 10" in diameter) with included fusulines.	
8a. Limestone, 3.5'+, base covered. Light gray to tan, finely to medium crystalline, bioclastic, unevenly medium-bedded. Fusulines common. Units 8a, b weather dark gray in continuous smooth face.	

Wolf Mountain Shale (no members recognized)—

7. Covered, shale (?). Includes base of Winchell Limestone.....	41.0—
6. Sandstone, single bed; medium to coarse grained, tan, brown to gray weathering and rounded.....	1.0
5. Covered, shale.....	4.5
4. Sandstone, tan, weathers brown to gray and rounded, medium to coarse grained, calcareous cement. Massive to very thick-bedded; cross-bedded. Probably a channel deposit.....	47.5
3. Covered shale.....	16.5
2. Sandstone, base very uneven because of cross-bedding and channelling. Tan to grayish white; fine to medium grained; thin- to very thick-bedded, even bedding to highly cross-bedded; ripple marks; red to purple iron specks; shale partings between beds.....	23.0+
1. Clay shale, yellow-brown to olive drab, tan weathering. Generally covered. Contains abundant organic matter. Partially removed by overlying sandstone channel. Base covered.....	5.0+

Total.....	164.0+
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Section 10 (0, P-9)

Measured from drainage ditch by road, west along south side of road to top of limestone member Pk₄, then in the same direction, after leaving the road, to the top of the Palo Pinto Limestone escarpment.

Palo Pinto Limestone (no members recognized)—

13. Limestone, base covered. Light to medium gray; finely to coarsely crystalline, to fragmental; very fossiliferous; crinoidal hash throughout but most prominent in lower third; some algal material and abundant brachiopods in upper two-thirds. Unevenly thin-bedded to nodular. Weathers chalky white to gray and supports dense growth of post oak and cedar. Difficult to measure because of dense cover. Upper beds recede. Caps scarp and makes long, prominent bench..... 12.0+

Keechi Creek Shale (of Strawn Group)—

Shale Member Pk₅—

12. Covered, shale (?). Much slump from Palo Pinto Limestone. Top and base uncertain..... 26.0+

11. Sandstone, base and top covered, medium gray with reddish brown iron specks, weathers brown to black and rounded, fine grained. Lower 4'+ thick- and cross-bedded, with 1' of sandy shale and more sandstone above. Both sandstones calcareous. Upper sandstone has cap of medium to coarse grained sandstone with abundant crinoid fragments..... 6.5

10. Covered, shale (?), abundant limestone and sandstone float from above units..... 112.0

Limestone Member Pk₄—

9. Limestone, sandy, light gray, brown weathering, dense, finely crystalline. Evenly medium- to thick-bedded. Crinoid fragments. Forms prominent bench which road traverses..... 3.5

Shale Member Pk₃—

8. Shale, light gray to tan, sandy; purple and reddish brown iron concretions; white calcareous streaks..... 4.0

7. Sandstone and sandy shale, tan, calcareous, fossiliferous. More calcareous toward top..... 10.5

6. Sandstone, calcareous, brown to gray, fine grained, fossiliferous. Capped by hard layer of sandstone with abundant brachiopods. Weathers rounded..... 3.8

5. Shale, sandy, grading to argillaceous sandstone; gray to brown, brown weathering. Mostly covered..... 11.0

4. Sandstone, dark gray, ferruginous, weathers brown-black, fine grained. Fossiliferous, with brachiopods. Ripple marks. Lensing (1"-6') single bed..... 0.2+

3. Shale, similar to unit 1..... 12.5

2. Limestone, impure, sandy, to calcareous sandstone; medium gray, weathers black to brown; highly fossiliferous (brachiopods and crinoids); very fine grained to coquinid, single bed; flow markings on top..... 0.2+

1. Shale, base covered; dark gray to olive-brown; Clay-ironstone nodules abundant; weathers gray to brown.....	12.5
Total.....	214.7+

Section 11 (L-8)

Measured from road level, generally south up steep escarpment face to top of Fambro Sandstone.

Posideon Formation—

Fambro Sandstone Member—

16. Sandstone, base covered; ferruginous, yellowish to reddish brown; gray to reddish brown weathering; fine to medium grained, massive to very thick-bedded, cross-bedded, friable. Pitted surface common—formed by differential weathering of numerous small, brown clay-ironstone nodules from more resistant sandstone. Weathers into large, fairly well rounded boulders which generally cover underlying slopes and rest on ledge formed by Palo Pinto Limestone. Very prominent unit; caps hill and contrasts in color with underlying gray limestone ledge..... 39.5+

Shale Member Pp₁ (included with Ppf on Pl. 1)—

15. Covered, shale, many Fambro slump blocks..... 10.0—

Palo Pinto Limestone (no members recognized)—

14. Limestone and marl, top generally covered by blocks of Fambro Sandstone..... 20.0+

14f. Marl, 2.5' +, poorly exposed, gray.

14e. Limestone, 1.5', light to medium gray, nodular, hard, bioclastic, medium crystalline. Forms slight bench above main ledge made by units 14a-c.

14d. Marl, 4.0', poorly exposed, weathers yellowish brown with "popcorn" surface. No fusulines in this or overlying units of Palo Pinto.

14c. Limestone, 1.0', light to medium gray, nodular, practically a coquina of fusulines. Recedes from unit 14b.

14b. Limestone, 0.8', massive, bioclastic, dense, coarsely crystalline, with abundant fusulines.

14a. Limestone, 10.2', gray, finely to coarsely crystalline, highly irregularly thin-bedded to nodular, very fossiliferous (brachiopods primarily), bioclastic, jointed. Forms thick, prominent ledge below Fambro Sandstone; bench at top of variable width.

Keechi Creek Shale (of Strawn Group)—

Shale Member Pkc₅—

13. Covered, shale (?); large, thick (1') slabs of red crinoidal limestone found in float but could not be found in place..... 38.0

12. Shale, gray, fissile..... 3.0

11. Shale, sandy, similar to unit 9..... 1.5

10. Sandstone, similar to unit 4..... 0.9

9. Shale, sandy, light gray to tan, iron-stained..... 2.0

8. Sandstone, similar to unit 4..... 0.3

7. Shale, similar to unit 1, only more sandy..... 4.5+

6. Sandstone, massive, pinch and swell character; otherwise, similar to unit 4.....	0.4+
5. Shale, similar to unit 1.....	3.5+
4. Sandstone, grayish brown, fine grained, massive, micaceous, contains organic matter.....	0.8
3. Shale, similar to unit 1.....	19.0+
2. Sandstone, lensing, tan to gray, hard, very fine grained, micaceous, plant fragments.....	0.9+
1. Shale, grayish green, iron-stained, tan to brown weathering. Base covered.....	9.5+

Total..... 153.8+

Section 12 (L-8)

Measured from creek bed north of railroad tracks, northwest to top of hill capped by Fambro Sandstone.

Posideon Formation—

Fambro Sandstone Member—

10. Sandstone, similar to unit 16, Section 11, except with more coarser grained sand and abundant fossil wood (logs, etc., up to 8'+ long, in boulders). Base covered.....

Shale Member Pp₁ (included with Ppf on Plate 1)—

9. Covered, shale (?)..... 4.0+

Palo Pinto Limestone (no members recognized)—

8. Limestone and marl..... 20.0+

8d. Marl, 2.0'+, poorly exposed, gray.

8c. Limestone, 1.5', dense, gray, finely crystalline, bioclastic, nodular weathering.

8b. Marl to chalky nodular limestone, 6.5', brown to gray, highly bioclastic, abundant colonial coral (*Syringopora*) in lower 1.5'.

8a. Limestone, 12.0', gray, bioclastic, finely to coarsely crystalline, irregularly thin-bedded, fossiliferous. Upper layer (6.8") contains abundant fusulines. Thick ledge-forming unit. Bench of variable width at top.

Keechi Creek Shale (of Strawn Group)—

Shale Member Pk₃—

7. Covered, shale..... 20.0

6. Limestone, impure, dark gray, highly fossiliferous (brachiopods, crinoid fragments), medium-bedded..... 1.0

5. Covered, shale..... 11.0

4. Sandstone and sandy shale, light brown to tan, alternating. Sandstone very thick-bedded, large-scale cross-bedding, fine grained, lensing, show ripple marks and other bottom features. Base covered.....

25.0+

3. Covered, shale..... 24.0—

2. Sandstone, light brown to gray, massive, very fine grained, weathers rounded. Base covered..... 1.0+

1. Covered, shale..... 48.5+

Total..... 195.5+

Section 13 (K-8)

Measured from base of shale exposures just below edge of concrete spillway, west and then south to highest exposure of Fambro Sandstone.

Posideon Formation—

Fambro Sandstone—

9. Sandstone, tan to reddish brown, ferruginous; friable; fine to medium grained, well sorted; grains primarily quartz, rounded to subrounded; very little organic material; very thick-bedded to massive, cross-bedded. Difficult to tell whether Shale Member Pp₁ is present below due to slump blocks of Fambro..... 42.0
- Palo Pinto Limestone (no members recognized)—

8. Limestone 20.5

8b. Limestone, 8.5', gray, weathers grayish white and nodular, bioclastic, finely crystalline, irregularly thin- to medium-bedded. Mostly covered by Fambro slump blocks.

8a. Limestone, 12.0', light gray, finely to coarsely crystalline, fossiliferous (brachiopods and crinoids), weathers gray to brown and rounded. Unevenly thin-bedded. Fusulinids abundant in 10" bed at top. Forms prominent ledge with bench of variable width at top.

Keechi Creek Shale (of Strawn Group)—

Shale Member Pk₃—

7. Covered, shale (?) 9.5

6. Limestone, gray, very finely crystalline, highly fossiliferous (brachiopods, crinoid fragments), unevenly thin-bedded to nodular 1.0

5. Shale; three color intervals: gray-green, purple, gray-green.... 3.0

4. Limestone, brown to yellowish brown, bioclastic, weathers brown to gray and rounded..... 0.5

3. Shale, gray-green, fissile..... 10.5

2. Sandstone, grayish white, very fine grained, evenly medium-bedded with intercalated 3" beds of gray shale, finely laminated. Top bed is 8-10" thick: grayish white calcareous sandstone with interspersed lenses of purple crinoidal limestone (coarsely crystalline) 5.0

1. Shale 40.0

1b. Shale, 33.5', grayish green with brown iron streaks, weathers brown to gray.

1a. Shale, 6.5', base covered, blue-gray with reddish brown iron stain.

Total..... 132.0

Section 14, (1-8, 9)

Type Locality of Wiles Limestone

Measured from northwest corner of foundation of old Wiles train station, northwest to top of bench capped by Wiles Limestone, offset to north approximately 2500 feet along base of Wiles to good exposure of latter at junction of private ranch road and dry creek bed, then generally northward to top of Winchell Limestone escarpment.

Winchell Limestone—	
Limestone Member Pw ₃ —	
26. Limestone, brown, sublithographic, algal, irregularly thin-bedded. Caps escarpment, exposed in exceedingly long and broad dip-slope	9.0+
Shale Member Pw ₂ —	
25. Shale and limestone, alternating. Shale: gray, calcareous to marl. Limestone: light gray, lithographic, completely perforated by worm borings; four beds, 2-4" thick, evenly distributed within shale interval	6.0
Limestone Member Pw ₁ —	
24. Limestone	22.0
24d. Limestone, 1.5', massive, dark gray, coarsely crystalline, bioclastic, bench of variable width at top.	
24c. Limestone, 14.5', gray, finely to medium crystalline, bioclastic, fusulines, gray chert nodules and masses containing fossil fragments and fusulines. Irregularly thin- to medium-bedded.	
24b. Limestone, 2.5', two equal beds, bioclastic, medium crystalline. Lower bed gray, sandy; upper bed brownish gray.	
24a. Limestone, 3.5', massive, gray, medium to coarsely crystalline, bioclastic.	
Wolf Mountain Shale (no members recognized)—	
23. Covered, shale (?), littered with slump from Winchell	53.0
22. Sandstone, tan to reddish brown, ferruginous, friable, fine to medium grained, very thin- to very thick-bedded, evenly to cross-bedded	38.0
21. Shale, gray, clay-ironstone nodules	17.0
20. Sandstone, similar to unit 18, but weathers more rounded ...	5.0
19. Shale and siltstone, tan	11.0
18. Sandstone, tan, ferruginous, fine to medium grained, friable, well sorted, evenly medium- to thin-bedded, little cross-bedding, blocky (rectangular) fracture and weathering	23.0
17. Covered, shale	6.0
16. Sandstone, tan, weathers reddish brown and rounded, fine to medium grained, well sorted, ferruginous, friable, thick- and cross-bedded	10.0+
15. Shale, exposed only in drainage ditches; gray, with clay-ironstone nodules and thin siltstone lenses (1/2-1")	60.0+
14. Sandstone, gray, highly calcareous, fine grained, very fossiliferous (brachiopods, bryozoa, crinoids, fusulines), irregularly thin-bedded, brown weathering. Possible remnant of Staff Limestone Member (Pwm ₂)	3.5
13. Shale, gray, with numerous layers of brown clay-ironstone nodules	47.0
Posideon Formation—	
Wiles Limestone Member—	
12. Limestone, gray, sublithographic, irregularly thin- to medium-bedded, fossiliferous, some algal material. Weathers rounded and	

readily slumps. Best exposed at north end of offset. Caps small scarp and forms bench of variable width.....	4.0
Shale Member Pp ₃ —	
11. Shale, generally covered with slump blocks of Wiles Limestone. Measurement made at south end of offset.....	21.5+
Limestone Member Pp ₄ —	
10. Limestone, base covered, medium gray with tan veins, weathers medium to dark gray, sublithographic to finely crystalline, fossiliferous (brachiopods, some corals), irregularly thin-bedded to nodular. Nodular weathering. Makes bench.....	2.5+
Shale Member Pp ₃ —	
9. Covered, shale (?); much nodular material in float, presumably from unit 10, but could contain another unit of Member Pp ₄	18.0—
Limestone Member Pp ₂ —	
8. Limestone, medium gray, tan weathering, massive, dense, sublithographic to very finely crystalline, sparingly fossiliferous, crinoid fragments common. Prominently jointed, weathers into large rounded blocks. Forms prominent bench.....	2.5
Shale Member Pp ₁ —	
7. Covered, shale.....	4.0
6. Sandstone, base covered, light gray, brown to yellow weathering, calcareous, fine to very fine grained, evenly thin-bedded, worm trails.....	0.5
5. Covered, shale.....	17.0
4. Limestone, brown, sandy, fine grained; highly irregular pitted surface with fucoids, ripple marks, etc., on bottom. Fossiliferous (brachiopods, bryozoa).....	0.3
3. Shale, gray, calcareous.....	1.0
2. Limestone, grayish green, brown weathering, sandy; highly fossiliferous with well preserved brachiopods, bryozoa, corals, pelecypods.....	0.3
1. Covered, shale.....	4.0
Total.....	386.1+

Section 15 (N, 0-8)

Measured from fusulinid bed at top of lower thick unit of Palo Pinto Limestone, east-northeast to top of Wiles Limestone outlier, then offset to southeast end of outlier, and remeasurement from approximately 30 feet below Wiles to U.S.G.S. Bench Mark (1957) at top of Wiles Limestone. Posideon Formation—

Wiles Limestone Member—

8. Limestone and marl.....	13.5
8c. Limestone, 4.5', similar to unit 8b but less algal and more bioclastic, fossiliferous, and dense. Brown and gray mottled.	
8b. Limestone, 5.5', brown at base becoming brown and gray mottled upward, sublithographic to coarsely crystalline, highly algal, nodular to irregularly thin-bedded. Intercalated thin layers of yellowish-brown marl, diminishing upward.	

8a. Marl, 3.5', yellowish brown, fossiliferous (crinoids, bryozoa).	
Shale Member Pp ₃ —	
7. Sandstone.....	18.0
7c. Sandstone, 7.0', grayish white, brown at top, medium- to thick-bedded, cross-bedded. Top ferruginous, base slightly calcareous.	
7b. Sandstone, 5.5', tan, speckled reddish brown, very fine grained, non-calcareous, ferruginous, friable, irregularly thick-bedded and cross-bedded.	
7a. Sandstone, 5.5', grayish white, friable, very fine grained, non-calcareous, medium- to thin-bedded, cross-bedded.	
Limestone Member Pp ₄ (base questionable)—	
6. Limestone, sandy, brown and gray mottled, finely crystalline, foraminiferal. Gray is filling of clam (?) borings. Thin interbed of well indurated calcareous sandstone (2" thick). Forms slight bench in front of Wiles. Heavily slumped.....	2.0
5. Marl and chalky nodular limestone, poorly exposed. Weathers with nodular, rubbly surface. Base questionable.....	15.0(?)
Shale Member Pp ₃ (top questionable)—	
4. Covered, shale (?).....	23.0(?)
Limestone Member Pp ₂ —	
3. Limestone, medium to dark gray, brownish in lower 3", finely to very finely crystalline, fossiliferous. Base ferruginous; top argillaceous, shaly parting, minutely jointed. Weathers gray-brown. Massive; jointed, breaks apart into large rectangular blocks.....	2.5
Shale Member Pp ₁ (base questionable)—	
2. Shale, mostly covered, gray, with occasional thin (1-2"), brown to gray, argillaceous coquinas of bryozoa, brachiopods, crinoids (all well preserved). Shale calcareous. Surface littered with slump blocks from unit 3. Base covered.....	72.0(?)
Palo Pinto Limestone (no members recognized)—	
1. Marl and nodular limestone, chalky, bioclastic, exposed only at base. Upper limit estimated from highest occurrence of nodular limestone in float. Rests on fusulinid layer at top of bench formed by thick (approximately 12') lower unit of Palo Pinto Limestone. This bench very extensive.....	10.0(?)
	<hr/>
Total.....	156.0

Section 16 (K-12, 13)

Measured from base of Wiles Limestone exposed in creek bed, generally westward, around north side of earth dammed tank, along erosion gullies to top of Winchell Limestone escarpment.

Winchell Limestone (no members recognized)—

15. Limestone, base covered. Description difficult due to slump and cover; units recede leaving a generally rounded profile for the whole unit. Generally gray, finely crystalline at base, to brown (with gray specks), sublithographic above; bioclastic, fusulines throughout, other fossils locally abundant (crinoids especially)

35.0+

Wolf Mountain Shale (no members recognized)—	
14. Covered, shale (?).....	11.0—
13. Sandstone, tan, ferruginous, weathers brown to red and rounded; fine to coarse grained, well sorted (exceptions locally) but not according to composition; plant fragments common. Unevenly thin- to very thick-bedded, cross-bedded.....	44.0
12. Shale, gray, and thin sandstone stringers. Layers of brown clay-ironstone nodules common.....	38.0
11. Limestone, brownish gray, very sandy, to sandy limestone. Irregularly very thin-bedded. Fusulinid coquina lenses in lower part.....	11.0
10. Shale, gray, alternating with thin layers of brown clay-ironstone concretions. Occasional thin (1") sandstone stringer.....	37.0
9. Sandstone and shale.....	11.0
9d. Sandstone, 1.0', thin-bedded, similar to unit 6.	
9c. Shale, 1.5', gray.	
9b. Sandstone, 2.0', medium- to thin-bedded. Similar to unit 6.	
9a. Shale, 6.5', gray, brown clay-ironstone nodules.	
8. Sandstone, medium-bedded, cross-bedded, plant fragments. Similar to unit 6.....	2.0
7. Siltstone and shale, tan.....	14.5
6. Sandstone, tan, dark brown iron specks, ferruginous, weathers brown to reddish brown and rounded. Evenly thin-bedded, slightly cross-bedded. Plant fragments. Fine grained, well sorted.....	10.0
5. Shale, gray, with occasional layers of brown clay-ironstone concretions.....	16.5
4. Siltstone, gray, tan weathering, very thin-bedded, calcareous, evenly bedded.....	0.5
3. Shale and siltstone, tan to olive, base covered.....	19.0+
2. Covered, shale (?), high terrace alluvium and Quaternary alluvium (in creek bottom).....	28.0—
Posideon Formation—	
Wiles Limestone Member—	
1. Limestone, dark gray, bioclastic, argillaceous, single bed, shaly fracture. Could not be found to the north, believed to pinch out. Exposed only in creek bed.....	0.5
Total.....	
	278.0+

Section 17 (E-8, 9)

Measured from base of thin limestone unit below Winchell Limestone exposed in gully, generally northward up gully to bench formed by sandstone (unit 8), then southeast to top of Ranger Limestone escarpment.

Ranger Limestone—

 Limestone Member Pr₁—

16. Limestone.....	31.5
16c. Limestone, 8.0'+, recedes from bench at top of unit 16b. Similar to unit 16a, except irregularly thin-bedded, algal.	
16b. Limestone, 1.5', similar to unit 16a, but contains irregular masses and nodules of brown chert. Bench at top.	

16a. Limestone, 22.0', gray to brownish pink, gray weathering, sublithographic, fossiliferous in zones, unevenly medium-bedded. Thick ledge-forming unit; jointed, whole unit often separates intact from ledge.

Placid Shale—

Shale Member Ppl₃—

15. Covered, shale (?); thin stringer of sandstone in middle; brown, fine grained, thin-bedded, 2" thick..... 46.5

Limestone Member Ppl₂—

14. Limestone, gray to pinkish brown, sublithographic, massive, weathers gray with rubbly-looking surface. A few fossils in upper part. Forms slight bench. Becomes very sandy to south, thickens to north and west..... 1.5

Shale Member Ppl₁—

13. Shale, gray to grayish green. Occasional beds (1") of brown clay-ironstone concretions. Clayey to fissile..... 49.0

12. Limestone, dark gray, brown weathering, extremely bioclastic, argillaceous, variable thickness, fossiliferous (well preserved gastropods, pelecypods, nautiloids, brachiopods, crinoids, corals). Forms bench. Fossil horizon persistent throughout most of area..... 0.4+

11. Shale, gray to brown, calcareous..... 5.5

10. Sandstone, brown to gray, brown weathering, fine grained, very thin-bedded, ripple marks..... 4.0

9. Shale, gray to olive, clayey, thin (1-2") sandstone stringers.... 21.0

8. Sandstone, reddish brown, ferruginous, weathers dark brown to black, fine to medium grained, evenly thin- to very thin-bedded, ripple marks. Forms bench..... 1.5

7. Marl, to chalky nodular limestone, gray, non-resistant, rubbly weathering..... 7.0

6. Shale, gray to olive, mostly covered, thin layers of brown clay-ironstone nodules throughout. Greatly receded on top of Winchell Limestone..... 21.0

Winchell Limestone—

Limestone Member Pw₃—

5. Limestone, medium gray, finely crystalline to sublithographic, algal, irregularly thin-bedded. Upper 1½-2': bioclastic, dark brown to dark gray; argillaceous, with shaly fracture, grades into olive-drab shale of unit 6..... 7.0

Shale Member Pw₂—

4. Shale, gray, generally covered..... 11.0

Limestone Member Pw₁—

3. Limestone..... 23.0

3b. Limestone, 12.5', similar to unit 3b, except void of chert; upper 3-4' becomes dark brown to black, argillaceous, very thin-bedded, gradational into unit 4.

3a. Limestone, 10.5', gray to grayish brown, fine to coarsely crystalline, bioclastic, abundant fusulines, irregularly medium-bedded. Contains chert masses and nodules; black with white

fossil fragments. All beds including those of unit 3b recede to give a rounded profile for the member.

Wolf Mountain Shale—

Shale Member Pwm₃—

- 2. Shale, generally covered by slump from Winchell; gray to tan... 14.0
- 1. Limestone, dark brown, argillaceous, bioclastic, medium crystalline, irregularly thin-bedded..... 2.5

Total..... 246.4+

Section 18 (D, E-10)

Measured from top of Winchell Limestone, generally westward to top of Ranger Limestone.

Ranger Limestone—

Limestone Member Pr₃—

- 10. Limestone, yellow-brown to grayish pink, bioclastic, dense, sublithographic, irregularly medium-bedded. Contains irregular masses of yellowish brown chert in upper layer; chert (often several feet in diameter) weathers mottled orange-black with rough texture, and stands in relief on smooth, gray-weathered surface of limestone. Caps low rise receded from edge of escarpment formed by Member Pr₁..... 5.5

Shale Member Pr₂—

- 9. Marl, brown; weathers with rubbly surface; makes gentle slope 8.5

Limestone Member Pr₁—

- 8. Limestone and marl, cap major scarp above Winchell Limestone 32.5
- 8c. Limestone, 7.0', light gray to white, sublithographic to fragmental, bioclastic, little algal matter, weathers dark gray, irregularly medium-bedded. Receded on unit 8b.
- 8b. Marl to nodular limestone, 4.0', gray to brown, rubbly weathered surface. Non-resistant, permits bench at top of unit 8a. Becomes more resistant laterally.
- 8a. Limestone, 21.5', gray, finely crystalline to sublithographic, algal, unevenly to irregularly thick-bedded at base to medium-bedded at top. Jointed.

Placid Shale—

Shale Member Ppl₃—

- 7. Shale, brown, sandy and clayey..... 8.0
- 6. Sandstone 6.0
- 6b. Sandstone, 0.7', gray, calcareous, well indurated, fine grained, massive.
- 6a. Sandstone, 5.3', yellowish brown, friable, fine grained, ferruginous, thin-bedded, cross-bedded, ripple marks, worm burrow molds.
- 5. Covered, shale..... 30.5

Limestone Member Ppl₂—

- 4. Limestone, light gray, finely crystalline, sublithographic at base, bioclastic, unevenly medium- to thick-bedded. Prominent bench at top. Jointed..... 7.0

Shale Member Ppl₁—

3. Shale, olive, with thin layers of brown clay-ironstone concretions. Numerous calcareous, fossiliferous lenses in lower 15'. Fossils (bryozoa, crinoids, most abundant) weather free.....	54.0
2. Sandstone and siltstone, tan, calcareous, evenly very thin-bedded, worm burrow molds. Lenses of fossil hash: brachiopods, bryozoa, crinoids, pelecypods, gastropods. Caps rounded knolls. Faunal horizon believed correlative with unit 12, Section 17.....	3.0
1. Shale, gray to olive, clayey, with brown clay-ironstone nodules. Base on bench at top of Winchell Limestone.....	29.5
Total.....	184.5

Section 19 (C-9)

Measured from approximate base of Ranger Limestone, generally northward to top of Ranger Limestone.

Ranger Limestone—

Limestone Member Pr₃—

3. Limestone, yellow-brown to gray, bioclastic, algal, dense, sublithographic, unevenly medium-bedded. Wide, extensive bench at top; greatly receded from unit 1.....	5.0+
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Shale Member Pr₂—

2. Covered, shale, gentle slope.....	7.0
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Limestone Member Pr₁—

1. Limestone, base covered.....	45.0+
1d. Limestone, 7.0', light gray, finely crystalline to sublithographic, bioclastic, algal, unevenly medium- to thick-bedded. Prominent bench on top.	
1c. Limestone, 15.0', brown to brownish gray, sublithographic, no chert, fossiliferous (brachiopods), very thin-bedded to nodular. Lower half eroded back leaving narrow bench at top of unit 1b.	
1b. Limestone, 3.0-', light gray, finely crystalline, bioclastic, brachiopods, massive, variable thickness, bench at top.	
1a. Limestone, 20.0'+, base covered (within 1-3'), light to medium gray, finely crystalline to sublithographic, bioclastic; echinoid, crinoid fragments abundant between beds; fossiliferous (brachiopods); brown chert with abundant fossil fragments, common throughout unit; unevenly thin- to medium-bedded.	
Total.....	57.0+

Section 20 (D-6)

Measured from top of Winchell Limestone, just west of road, northwest to bench at top of unit 4, offset west-southwest approximately 800', north-northwest to top of unit 6, then east-northeast to top of Ranger Limestone. Ranger Limestone (no members recognized)—

7. Limestone; bottom layers gray, sandy, thin, finely crystalline, gradational with underlying sandstone; above beds gray, sublithographic, algal. Middle and upper beds: brown to yellowish

brown, sublithographic, algal, capped by layer with brown chert. Irregularly medium-bedded. Exact breaks could not be picked because of slumping.....	45.0
Placid Shale (no members recognized)—	
6. Sandstone, tan to white (light at top), weathers black to tan and rounded, ferruginous, fine grained, thick-to medium-bedded, cross-bedded. Gradational into Ranger.....	22.0
5. Shale, gray, with brown clay-ironstone nodules. Upper portion mostly covered by slump blocks.....	53.0
4. Limestone, impure, gray, brown weathering, argillaceous to sandy, massive, highly fossiliferous (mollusks, crinoids, etc.). Believed correlative with unit 12, Section 17.....	0.5+
3. Sandstone and silty shale, tan, calcareous in various layers, few plant fragments, ripple marks.....	26.0
2. Sandstone, light tan, fine to very fine grained, friable, abundant plant fragments, calcareous in certain layers; generally evenly very thin-bedded, one very thick (3') bed at top, little cross-bedding. Weathers mottled light brown and black.....	13.0
1. Shale, gray to olive, brown clay-ironstone nodules common in thin layers. Forms gentle slope on bench at top of Winchell Limestone	26.0
Total.....	185.5

Section 21 (D-12)

Measured from top of Ranger Limestone, northwest to top of unit 4, offset approximately 1000' along top of unit 4 to northeast and remeasurement from 25' below unit 4 to top of unit 4, offset again 300' to west along top of unit 4, then measurement continued to top of Home Creek Limestone and Cretaceous conglomerate.

Limestone Member Phc₃—

1b. Limestone, 3.0', light gray, finely crystalline, bioclastic, graphic, bioclastic, irregularly medium-bedded. Thin cover of Trinity (Cretaceous) conglomerate.....	5.0+
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Marl Member Phc₂—

5. Marl and nodular limestone, mostly covered, weathers with rubbly surface	21.0—
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Limestone Member Phc₁—

4. Limestone, bench at top.....	10.0
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 4b. Limestone, 5.0', dark gray, dense, sublithographic, bioclastic, weathers dark gray to yellowish brown, irregularly medium-bedded; beds recede from top of unit 4a.

 4a. Limestone, 5.0', gray mottled, highly bioclastic and fossiliferous, coarsely crystalline to sublithographic, unevenly very thick-bedded (at base) to medium-bedded. Weathers light gray with solution pitted surface.

Colony Creek Shale (no members recognized)—

3. Siltstone, shaly, and silty shale; tan. More silty at base	20.0
2. Sandstone, tan, fine-grained, massive, weathers rounded.....	2.5

1. Shale, base covered, gray, brown clay-ironstone concretions common in layers. Thickness approximate (\mp 5'). Base of unit (=top of Ranger) determined by sighting from exposed top of Ranger Limestone across small gully to covered slope where section measurement started. Units 1-3 described in remeasurement after first offset.....	12.5
Total.....	71.0

Section 22 (H, 1-14)

Measured from top of Winchell Limestone at junction of small creek bed and private ranch road, west to bench at top of Limestone Member Ppl₂, then northwest to top of Ranger Limestone escarpment.

Ranger Limestone—

Limestone Member Pr₁—

6. Limestone, caps escarpment.....	18.5+
6b. Limestone, 14.0'+, tan to gray-tan, sublithographic, bioclastic becoming algal toward top. Layer with brown chert masses near base. Unevenly thin- to medium-bedded, recedes from unit 6a.	
6a. Limestone, 4.5', gray, sublithographic, bioclastic, fossiliferous, weathers black to gray, unevenly thin-bedded.	

Placid Shale—

Shale Member Ppl₃—

5. Covered, sandstone and shale; bench in upper part, formed by slump blocks from Ranger. Blocks of sandstone, 8-10" thick, appear in float but no exposure found. Their occurrence on slope indicates they come from about 5-10' below base of Ranger.....	70.0
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Limestone Member Ppl₂—

4. Limestone, medium gray with some gray-brown streaks, bioclastic, fossiliferous (essentially same fauna as in unit 3); sublithographic for most part, to finely crystalline. Orange-brown iron streaks common. Unevenly thick-bedded at base, becoming medium- to thin-bedded toward top; weathers rounded, dark gray to black. Supports heavy growth of cedar and post oak. Prominent bench at top.....	7.0
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Shale Member Ppl₁—

3. Shale, gray, clayey, calcareous, clay-ironstone concretions in layers. Fossiliferous, with well preserved brachiopods, solitary corals, gastropods, crinoid fragments, bryozoa—all weather free. Upper part of unit covered by unit 4 slump blocks.....	31.5
2. Sandstone, gray to brown, weathers brown to black, friable to well indurated, fine grained, calcareous, medium to cross-bedded. Forms low bench.....	1.5
1. Shale, mostly covered, gray to tan, silty below unit 2. Recedes, leaving wide, extensive bench at top of Winchell Limestone.....	16.0

Total.....	144.5+
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Section 23 (J-6)

Measured from base of Palo Pinto Limestone in creek bed, southwest to top of unit 1a, offset to north-northwest along top of unit 1a across wide stream flat; measurement continued to northwest up opposite bank to bench at top of Limestone Member Pp₂, offset to west about 250 feet, then measurement from 10' below Member Pp₂ northwest of top of sandstone above Wiles Limestone.

Wolf Mountain Shale—

Shale Member Pwm₁—

13. Sandstone, brown, ferruginous, fine grained, thick-bedded, cross-bedded. Caps hill above Wiles scarp..... 30.0+
12. Shale, mostly covered, gray, layers of clay-ironstone concretions 45.0+

Posideon Formation—

Wiles Limestone Member—

11. Limestone, gray, bioclastic, fossiliferous (brachiopods, some corals), basically sublithographic with lenses of more coarsely bioclastic material. Thick to very thick-bedded at base, upper units irregularly medium-bedded. Weathers with rough, pitted surface; jointed; prominent bench at top..... 9.0

Shale Member Pp₃—

10. Covered, shale (?), surface littered with Wiles slump blocks.. 10.0—

Limestone Member Pp₄—

9. Limestone, nodular, top and base covered, gray, sublithographic, with marl intercalated. Bioclastic, fossiliferous: abundant solitary corals, *Lophophyllidium*, *Camphophyllum*. Weathers into nodular chunks about 1/2" in diameter; forms rounded bench 29.0+

Shale Member Pp₃—

8. Covered, shale..... 5.5—

Limestone Member Pp₂—

7. Limestone, gray, sublithographic, bioclastic, massive to thick-bedded, shaly parting at top. Strongly jointed; weathers into rectangular blocks approximately 14" thick. Overall thickness very uniform. Prominent bench at top..... 2.5

Shale Member Pp₁—

6. Sandstone, reddish brown, ferruginous, fine to medium grained, thin-bedded, cross-bedded. Often protrudes beyond base of unit 7 and develops a bench at top..... 3.0

5. Shale, gray..... 5.0

4. Limestone, gray, argillaceous, sandy, conglomeratic; profusely fossiliferous with well preserved brachiopods, crinoids, bryozoa, etc. Detritus, with exception of fossils, averages coarse to medium pebble size and well rounded..... 0.8

3. Shale, gray, mostly covered except in erosion gullies. Numerous seams of brown clay-ironstone concretions. Debris from overlying beds, including well preserved fossils from unit 4, litter slopes..... 56.0

2. Claystone, calcareous, orange, hard, sublithographic, no fossils. Weathers with rubbly surface..... 4.0

Palo Pinto Limestone (no members recognized)—

1. Limestone	23.0
<p>1b. Limestone, 12.5', gray, marly at base, becoming more nodular and resistant at top; medium to coarse grained; bioclastic hash with occasional well preserved brachiopods. Weathers with gray to white rubbly surface. Generally receded from top of unit 1a.</p> <p>1a. Limestone, 10.5', gray, variable; irregularly thin-bedded, chalky to marly in lower 3'; finely crystalline to sublithographic, chalky. Extremely fossiliferous in lower marly layers (brachiopods, gastropods, some cephalopods), becoming more bioclastic and algal toward top; a few fusulines at top. Weathers with pitted, uneven surface. Upper beds exposed in wide stream flat. Gray calcareous shale below.</p>	
Total.....	222.8+

Section 24 (E-4, 5)

Measured in abandoned quarry from base of Winchell Limestone, southwest to top of upper Winchell member.

Winchell Limestone—

Limestone Member Pw₃—

3. Limestone, gray, sublithographic to finely crystalline, algal (brown algal structures stand in relief on gray-weathered limestone). Irregularly medium- to thick-bedded. Very few fossils or bioclastic matter. Base covered.....	4.0+
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Shale Member Pw₂—

2. Covered, shale, makes extremely broad, gentle slope. Difficult to measure accurately. Grass covered, very few trees.....	13.0—
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Limestone Member Pw₁—

1. Limestone: only this unit quarried. Base of quarry reaches underlying gray shale of Wolf Mountain Shale.....	26.0+
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1c. Limestone, 5.0'+, gray, algal, sublithographic to finely crystalline, irregularly thin-bedded to nodular. Beds recede, covered at top.

1b. Limestone, 11.5', gray, sublithographic to coarsely bioclastic, very fossiliferous (crinoids), some algal matter. Very little if any chert. Irregularly thin- to medium-bedded. Thin beds at top, receding. Coarse bioclastic layers especially common along bedding planes; often contain limonite pseudomorphs after pyrite. Weathering profile somewhat rounded. Strongly jointed with underlying unit. Sharp line of separation at base.

1a. Limestone, 9.5', base at quarry floor, gray shale underlying. Gray to dark gray, extremely bioclastic and fossiliferous, finely crystalline to coarsely bioclastic. Gray shale (calcareous and very fossiliferous) commonly found along bedding planes; well developed, 4-5" thick, at top of unit—permits base of unit 1b to be undercut. Black chert with white fossil fragments common in layers in lower 6' of unit. Crinoid fragments

most abundant, but fusulines, brachiopods, bryozoa, corals common. Irregularly thin- to medium-bedded.

Total..... 43.0+

Section 25 (B-13)

Measured from lowest point in quarry (water level), southward to top of quarry face (approximate top of Home Creek Limestone).

Home Creek Limestone—

Limestone Member Ph₃—

1. Limestone, gray, sublithographic, nodular to highly irregularly thin-bedded, stylonitic. More highly weathered and receding in upper 2-3'. Extremely bioclastic and fossiliferous: brachiopods, fusulines, crinoids, gastropods dominant; some brown crystalline algal structures. Water approximately 3' deep; base of unit not exposed above water level. Top of quarry wall within 5' of top of Home Creek..... 16.0+

Total..... 16.0+

Section 26 (J, K-8)

Measured from base of Palo Pinto Limestone, northwest approximately 600' up small gully, then west to top of Wiles Limestone scarp.

Posideon Formation—

Wiles Limestone Member—

11. Limestone, grayish white and pinkish, gray weathering, sublithographic to coarsely crystalline, bioclastic, algal, fossiliferous, irregularly medium-bedded. Caps escarpment; top exposed for long distance downdip (northwest). Base covered..... 7.5+

Shale Member Pp₅—

10. Covered, shale..... 25.5—

Limestone Member Pp₄—

9. Limestone-pebble conglomerate, well exposed. Pebbles: fine to medium, gray, sublithographic. Fossiliferous, corals predominantly. Ferruginous clay common matrix: gives pinkish tint to unit. Pebbles weather free and litter slope below. Bench at top.... 5.5

Shale Member Pp₃—

8. Covered, shale (?)..... 14.0

Limestone Member Pp₂—

7. Limestone, gray, sublithographic, bioclastic, massive, strongly jointed, prominent bench at top..... 2.5

Shale Member Pp₁—

6. Shale, gray..... 2.5

5. Sandstone, brown, ferruginous, fine grained, evenly thin-bedded 7.0

4. Covered, shale; much slump from units 5 and 7..... 9.0

3. Shale, gray, and alternating thin stringers (1/2-1") of limestone: dark gray, finely to medium crystalline, argillaceous, bioclastic, highly fossiliferous (well preserved productid and chonetid brachiopods weather free)..... 6.0

2. Shale, gray, with thin lenses (0-1") of sandstone: fine grained, brown, calcareous, containing prolific and well preserved fauna (pelecypods, gastropods, crinoid fragments, small brachiopods, bryozoa). Lateral equivalent of Fambro Sandstone, which is present and fully developed only 200-300' to northeast.....	36.0
Palo Pinto Limestone (no members recognized)—	
1. Limestone	20.0
1b. Limestone, 9.0', gray to gray-brown, finely to medium crystalline, bioclastic, fossiliferous, nodular; weathers very rubbly. Beds recede; bench at top, but not as prominent as one at top of unit 1a. Upper part often covered.	
1a. Limestone, 11.0', gray, finely crystalline, bioclastic, fossiliferous, irregularly thin-bedded. Prominent bench at top.	
Total.....	135.5

Section 27 (M, N-6)

Measured from base of Limestone Member Pk₄ in shallow gully, northwest to top of escarpment capped by unit 3a of Palo Pinto Limestone, offset to west approximately 2200' along top of south edge of scarp, measurement continued to northwest up deep gully to bench at top of Limestone Member Pp₂, then generally southwest to top of Wiles Limestone Scarp.

Posideon Formation—

Wiles Limestone Member—

11. Limestone, base covered, gray, sublithographic at base to coarsely bioclastic at top, bioclastic, fossiliferous, irregularly medium-bedded. Jointed, heavily slumped. Caps escarpment; beds recede giving rounded profile; spotted cover of Trinity (Cretaceous) conglomerate

9.0+

Shale Member Pp₅—

10. Covered, shale (?), much slump from Wiles.....

22.0—

Limestone Member Pp₄—

9. Limestone, base and top covered, gray, chalky sublithographic to finely crystalline, nodular, abundant solitary corals (*Campbophyllum*). Beds poorly exposed; weather with rubbly surface (Fig. 6); form rounded bench 25' above unit 7.....

16.0+

Shale Member Pp₃—

8. Covered, shale.....

9.0—

Limestone Member Pp₂—

7. Limestone, gray, dense, medium-crystalline, bioclastic, massive. Strongly jointed; prominent bench at top.....

2.5

Shale Member Pp₁—

6. Shale, gray, calcareous.....

2.5

5. Sandstone, tan, ferruginous, brown to red weathering, fine grained, calcareous, evenly thin-bedded.....

6.5

4. Shale, gray, with brown clay-ironstone concretions common in layers. Generally very calcareous, fossiliferous, with well preserved fauna of gastropods, pelecypods, crinoids, brachiopods. Similar fauna found in same stratigraphic interval of Sections 26, 15, 23, and Localities 6, 12. Fambro Sandstone present in interval 1500' to southwest.....

59.0

Palo Pinto Limestone (no members recognized)—	
3. Limestone	24.5
3c. Limestone, 4.5', orange-brown, sublithographic, argillaceous. Very little bioclastic matter. Weathers very rubbly.	
3b. Limestone, 6.0', nodular, gray, medium crystalline, very bioclastic, fusulines common. More resistant in upper 2'; weathers rubbly.	
3a. Limestone, 14.0', gray, finely to coarsely crystalline, bioclastic, irregularly thin-bedded. Very fossiliferous (abundant brachiopods). Some algal material; fusulines locally present at top. Jointed; forms thick ledge with prominent bench at top.	
Keechi Creek Shale—	
Shale Member Pk ₃ —	
2. Shale, gray, with intercalated brown clay-ironstone concretions; a few thin sandstone lenses toward top, not more than 1' thick and thin-bedded. Upper third generally covered by slump from Palo Pinto Limestone. A lot of earth sliding	165.0
Limestone Member Pk ₄ —	
1. Limestone, sandy; nodular; upper 6-8" is gray, sublithographic to very finely crystalline; lower beds very argillaceous, ferruginous, yellowish brown, becoming shaly and coquinitid at base. Forms low bench. Underlain by gray-green shale	3.5
<hr/>	
Total.....	319.5+

Section 28 (A-2)

Measured from base of Ranger Limestone in small abandoned quarry to top of Ranger exposures.

Ranger Limestone (no members recognized)—	
1. Limestone	15.5
1b. Limestone, 4.0', similar to 1a, except contains brown chert masses, and irregularly very thick-bedded. Cretaceous conglomerate cover in places. Caps scarp.	
1a. Limestone, 11.5', brown to gray, sublithographic, bioclastic, algal, irregularly medium-bedded, gray weathering. Underlying gray shale exposed in places.	
<hr/>	
Total.....	15.5

Localities

- 1 (M-5)*. Posideon Formation. Limestone Member Pp₄ well exposed above earth dammed tank. Consists of 3' of nodular limestone and an overlying limestone breccia, 2' thick. Latter contains numerous fossil fragments and solitary corals. Whole member makes only slight bench. Top of Limestone Member Pp₄ is approximately 22' above Limestone Member Pp₂ and 20' below Wiles Limestone. Shale exposed above and below Member Pp₄. Entire Posideon Formation well exposed.
- 2 (M-5). Trinity conglomerate (Cretaceous) resting on Wiles Limestone. Conglomerate: overall pink color, coarse grained sand to coarse pebble,

* (Coordinates, Pl. 1)

- some boulders (up to 1' diameter), cross-bedded, massive. Varicolored constituents, siliceous, well rounded, generally polished.
- 3 (M-6). Posideon Formation. Limestone Member Pp₄ mostly covered by heavy growth of vegetation. Limestone Member Pp₂ forms slight bench and is underlain by thin (5'), thin-bedded sandstone. Fambro Sandstone absent below Posideon; shale in its place has promoted much land slumping in this and surrounding areas.
 - 4 (K, L-5). Posideon Formation. Sequence from Limestone Member Pp₂ through Wiles Limestone well exposed. Limestone Member Pp₄ consists of two units: a rubbly weathering, chalky nodular limestone or marl, 14.5' thick, and an overlying sandy, limestone-pebble conglomerate, 2.0' thick. Both units fossiliferous with abundant solitary corals (*Campophyllum*), brachiopods, and crinoids. Small but prominent bench present at top of Member Pp₄. Underlying Shale Member Pp₃ well exposed by creek bed; consists of 9' of dark gray shale. Sharp contact between latter and marl of Member Pp₄. Limestone Member Pp₂ exposed in creek bed and characteristically strongly jointed. Wiles Limestone Member caps surrounding hills.
 - 5 (L-6). Fossil collecting site in Limestone Member Pp₄—conglomeratic limestone. Large branching bryozoa (*Tabulipora*, *Fistulipora*) and solitary corals (*Neozaphrentis*) most abundant. Individual valves of the productid brachiopod *Marginifera lasallensis* show excellent preservation of muscle scars.
 - 6 (M-6). Fambro Sandstone has changed facies laterally into alternating thin sandstone and shale sequence, which ultimately becomes entirely shale. A fairly well bedded thin (6-8') sandstone present immediately below Limestone Member Pp₂ but not lateral equivalent of Fambro. Land slumping and sliding common in shale interval (Pp₁) void of Fambro. Excellent fossil collecting site in Shale Member Pp₁ (at position of black dot). Fauna small, weathering free from calcareous shale: brachiopods, crinoid fragments, bryozoa, pelecypods, gastropods; strikingly similar to other faunas collected at same stratigraphic position where Fambro is absent. Specific elements of fauna vary in abundance from place to place.
 - 7 (K-8). At top of ledge-forming unit of Palo Pinto Limestone: good fossil collecting locality. Productid brachiopods, colonial coral *Syringopora*. Some spirifers.
Well developed channel sandstone exposed in cross section below Palo Pinto Limestone.
 - 8 and 9 (L-10, 11). Very thick, massive, cross-bedded sandstone occurs above and possibly scours into Wiles Limestone and Limestone Member Pp₄. Blocks 15-20' thick of the ferruginous, fine grained sandstone litter slopes of the two small hills.
 - 10 (K-11). Wiles Limestone present as single bed of gray argillaceous limestone, only 8-12" thick, weathers with distinctive rough texture into large rectangular slabs. Slabs separated along joint planes. Thick ferruginous sandstone present above Wiles and separated from latter by a thin, gray calcareous shale. Sandstone caps long bench. Wiles is 43' above Limestone Member Pp₂. Limestone Member Pp₄ present between and fairly well exposed.

- 11 (K-11). Posideon Formation: Limestone Member Pp₄ not found north of this locality. Thick alluvium (high terrace deposits) in front of Winchell escarpment. Wiles found in scattered erosion gullies; but Limestone Member Pp₄ being considerably less resistant was not found.
- 12 (M-12). Small outlier of Fambro Sandstone: Fambro appears to be thinning to east. At this locality calcareous shale interval, much thicker than usual, present below Fambro. Several thin (2-3"), fossiliferous limestone stringers present in shale interval (Shale Member Pp₁). Their position in shale stratigraphically much higher than base of Fambro to west. Collection made from weathered fossiliferous limestone stringers. Gastropods, pelecypods, crinoid fragments, bryozoa, occasional trilobite, chief elements of fauna; similar to that of Section 27, unit 4, etc. Fusulines still found at top of resistant Palo Pinto Limestone unit.
- 13 (M-12). Outlier of Limestone Member Pp₂ on dip slope of underlying thin sandstone. Member Pp₂ usually outcrops as massive unit, but occasionally develops weak bedding planes and recedes along several layers. Such is case here; only remnants of lowest layer present. Overall thickness of Limestone Member Pp₂ appears to be constant throughout area—2.5'. Thickness, generally massive character, and prominent jointing make it easily recognizable unit. Pp₂ commonly underlain by thin, thin-bedded sandstone, as here. Sandstone not related to Fambro.
- 14 (M-10). Sequence between Palo Pinto Limestone and Limestone Member Pp₂ of Posideon Formation typically exposed. Consists in ascending order of Palo Pinto Limestone (bench at top of resistant lower unit), thin shale (generally covered), Fambro Sandstone (40-50' thick, massive, ferruginous, cross-bedded, bench at top), thin shale, thin-bedded sandstone (5-10' thick, generally bench at top), and Limestone Member Pp₂ (prominent bench at top). Sandstone underlying Member Pp₂ and separated by thin shale from Fambro appears to have no genetic relationship to latter: (1) presence of both do not necessarily coincide, and (2) when both present, as here, are separated by shale. Shale and sandstone above Fambro mapped as Shale Member Pp₁. Thin shale between Fambro and Palo Pinto too small to show, included with Fambro (Ppf).
- 15 (L-12). Posideon Formation: thick sandstone above Limestone Member Pp₂ forms hill, top of which is approximately 45' above latter. No evidence or trace of Limestone Member Pp₄.
- 16 (L-12). Excellent exposure of Limestone Member Pp₂ (Posideon Formation) in stream bed. Jointing very striking. Mostly massive, but nature of inherent bedding revealed where water has cut unit back at different levels. Overall thickness 2.5'.
- 17 (J-11). Wolf Mountain Shale: outcrop of sandy limestone and fusulinid coquina, only few feet thick, very thin-bedded. Probably correlative with calcareous beds of Locality 19. Possible Staff equivalent; however, positive correlation with northern-most exposure of Staff Limestone Member (Locality 29) could not be made due to lack of exposures.
- 18 (I, J-5). Two small hills on Wiles Limestone dip slope: Both capped by thick (20'±) sandstone: ferruginous, fine to medium grained, medium- to very thick-bedded, cross-bedded. Sandstone separated from Wiles by approximately 40' of gray shale bearing brown clay-ironstone concretions.

- 19 (J-10). Wolf Mountain Shale: thin, sandy, fossiliferous fusulinid limestone with underlying thin-bedded sandstone cap well exposed section of gray shale; small bench formed. Limestone possibly remnant of Staff Limestone Member (Pwm₂); however, no positive correlation could be made with last Staff exposure (Locality 29). Similar outcrop at Locality 17.
- 20 (G-10). Staff Limestone present as thin-bedded, flaggy, sandy limestone. Weathers brown; gray, finely crystalline on fresh surface. Fusulines generally abundant, coquinid in some flags. Beds poorly exposed.
- 21 (J-8). Posideon Formation. Limestone Members Pp₂, Pp₄, and Wiles well exposed. Bench at top of each member. Wiles cap hill, forms wide bench.
- 22 (J-8). Quaternary alluvium (Qal) attains thicknesses in excess of 20'. Primarily composed of boulders of limestone. Only the more resistant limestone units of the Canyon Group exposed in steam bed; form wide stream flats, width being related to resistance.
- 23 (H-8). Limestone Member Pp₂ (of Posideon Formation) outcrops in bed of Palo Pinto Creek; 2.5' thick; very prominent, characteristic joint pattern.
- 24 (H-8). Limestone Member Pp₄ (of Posideon Formation), 6.5' thick, outcrops in stream bed of Palo Pinto Creek; irregularly thin-bedded, sub-lithographic, bioclastic.
- 25 (H-8). Wiles Limestone Member (of Posideon Formation), 6.0' thick, outcrops in bed of Palo Pinto Creek; unevenly medium- to thin-bedded, bioclastic, algal, grayish brown, sublithographic to finely crystalline.
- 26 (G-9). Top of Staff Limestone Member (of Wolf Mountain Shale) in creek bed; thin-bedded, sandy, fusulinid coquina. Thin marl layers (0.5") between sandy limestone (coquina) layers. Beds receding.
- 27 (G-9). Staff Limestone Member outcrops on north side of North Fork of Palo Pinto Creek. Limestone, 5.0', silty to argillaceous, dark gray, irregularly thin-bedded, bioclastic to coquinid with fusulines. Shale separations between beds; cause beds to recede. Immediately underlain by sandstone: 4.0', massive, top becoming highly calcareous with abundant fusulines.
- 28 (H-5). Staff Limestone Member forms wide bench. Limestone, 6.0', sandy, gray, bioclastic, unevenly thin- to medium-bedded, with intercalated thin (1/4"+) layers of shale. Difficult to find complete vertical exposure due to receding character of beds. Fusulinid coquina, 2-3" thick, found approximately 3' above Staff. Sandstone, calcareous at top, medium- to thin-bedded, underlies Staff and forms wide benches or caps small hills.
- 29 (H-9). Staff Limestone Member has become very sandy and loses identity to east. Very few fusulines present. Much slump and cover from overlying beds make further field tracing virtually impossible.
- 30 (I-10). Winchell Limestone has lost shale interval characteristic of Shale Member Pw₂ to the south. Section 14 (just south of here) shows 6' interval of alternating shale (marl) and limestone stringers occurring approximately 9' below top of Winchell. Further south Member Pw₂ is entirely shale. North of this locality interval is entirely limestone. Overall thickness of Winchell remains approximately same.

- 31 (G-12). Limestone Member Ppl₂ (of Placid Shale). Limestone, 7.0', very thick- to medium-bedded and uneven; forms prominent bench. Top of Ppl₂ is 77' below base of Ranger Limestone. Ranger immediately underlain by thin-bedded sandstone.
- 32 (E-8). Placid Shale. Limestone Member Ppl₂ first appears, 45-50' below Ranger Limestone; absent to south, where only siltstone and shale present at this position; limestone, 1.5', massive and uneven, brown, sandy, highly bioclastic. Present also on west flank of this escarpment.
- Mollusk fauna present at Section 17, unit 12, also present here in calcareous sandstone stringers below Limestone Member Ppl₂.
- Along most of escarpment below Ranger Limestone occurs a prominent bench. Bench was formed by massive slump blocks from Ranger. Is strikingly uniform and persistent, but blocks contained therein assume all attitudes, thus alleviating any possibility of faulting.
- 33 (D-6). Placid Shale. Sandstone, approximately 30' thick, ferruginous, cross-bedded, developed in Placid. Top of sandstone 74' below base of Ranger Limestone. Faunal assemblage containing well preserved gastropods, pelecypods, cephalopods, found in thin calcareous sandstone, approximately 115' below base of Ranger; is similar to and probably correlative with that of Locality 32, Section 17 (unit 12), Section 18 (unit 2), Section 22 (unit 3).
- 34 (C-4). Placid Shale being quarried and burned for use as light-weight aggregate. Other than the shale, only a few thin sandstone stringers present in the Placid. A fossiliferous calcareous sandstone, one foot thick, present 103' below base of Ranger; contains well preserved mollusk fauna, similar to that of Localities 32 and 33. Total thickness of Placid Shale approximately 150-160'.
- 35 (A-9). Limestone Member Pr₁ of Ranger Limestone exposed by creek bed. Two benches formed in Pr₁, 12' and 27.5' above base. Brown chert nodules with abundant fossil fragments confined to unit below lower bench. Lithology and weathering profile strikingly different than that of Ranger exposed at Section 19.
- 36 (B-8). Limestone Member Ppl₂ of Placid shale; approximately 50' below base of Ranger Limestone: limestone, 5.0', dark gray to brown, argillaceous, bioclastic, unevenly medium-bedded to massive.
- 37 (B-11). Limestone Member Phc₁ of Home Creek Limestone; makes bench in front of upper limestone (Member Phc₃): limestone, brown to gray, sublithographic, very fossiliferous with crinoids, echinoid fragments, algal material. Two cephalopods found (straight and coiled). Much sandstone channelling evident; sandstone masses 10-35' thick found scouring through Member Phc₁. Sandstone: massive to thick-bedded, ferruginous; changes laterally and abruptly into shale.
- 38 (N-4). Limestone Member Pkc₄ of Keechi Creek Shale (Strawn Group) well exposed in creek bed. Unit is actually sandstone, highly calcareous, well indurated, hard, gray, brown weathering, fine grained, fossiliferous, cross-bedded, evenly medium- to thin-bedded, ripple marks. Makes fair bench. Total thickness 2.5'. Intermittently exposed between here and Section 10, at Farm-to-Market Road 2372. Maintains thickness of approximately 3'. Varies from well indurated calcareous sandstone to sandy limestone.

39 (P-6). Limestone Member Pkc₂ of Keechi Creek Shale (Strawn Group) caps small scarp and nearby knoll; scarp approximately 30' high; limestone, 5.6', sublithographic to very silty, gray, very fossiliferous (brachiopods, echinoid fragments), irregularly thin-bedded to nodular. Fossils show much distortion due to compaction.

Member Pkc₂ underlain by shale, gray and purple, with occasional stringer of sandstone, brown, fine grained, thin (1-2"). Ripple marks and bottom markings.

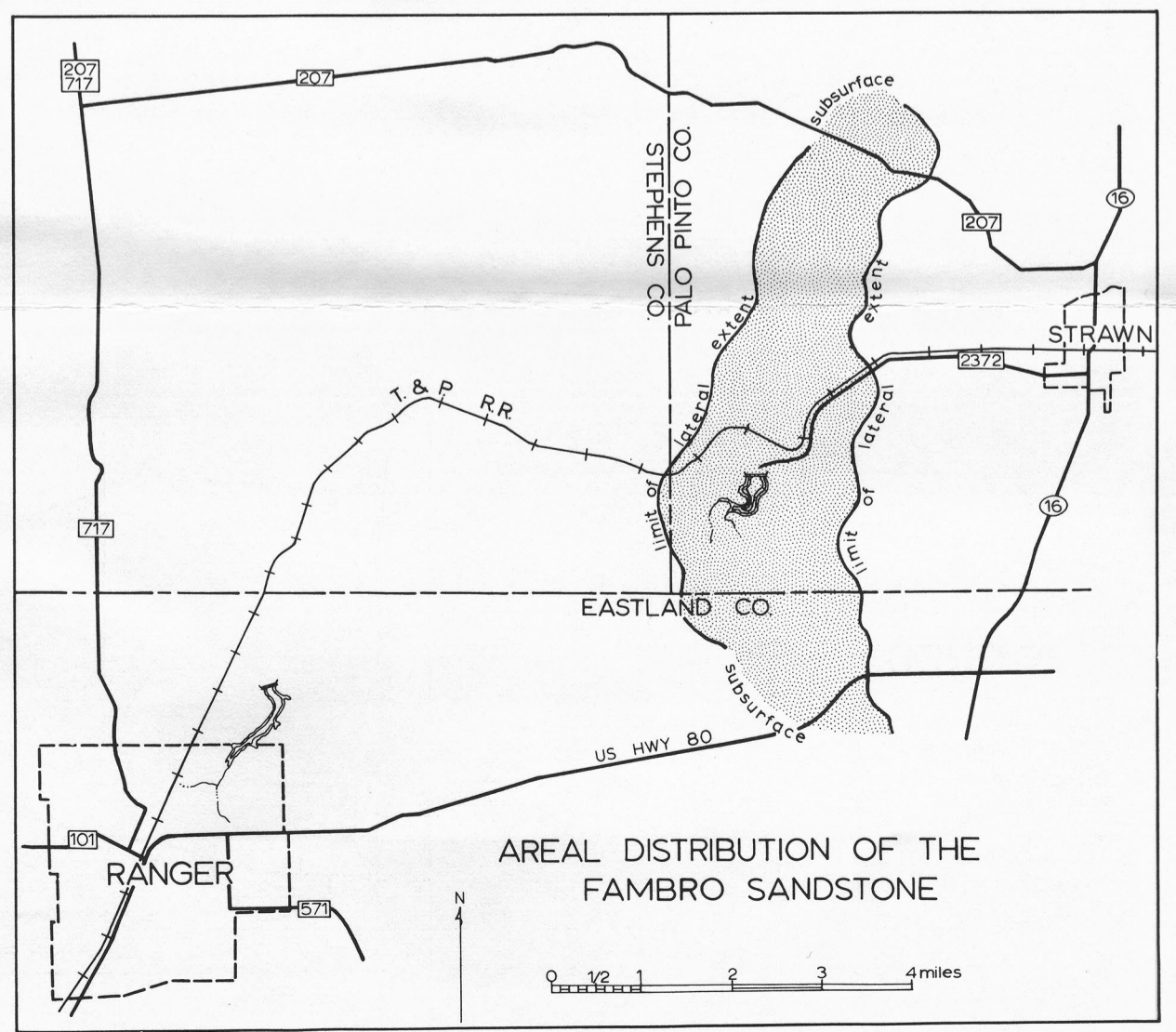
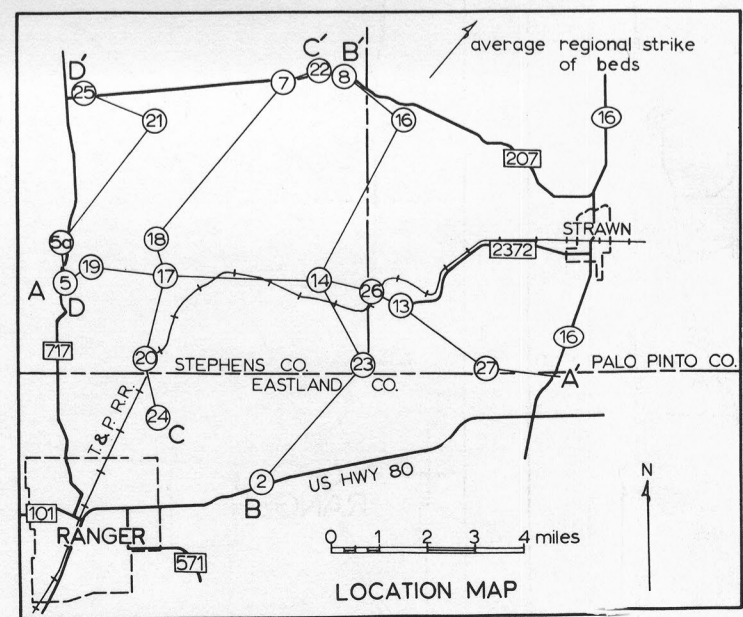
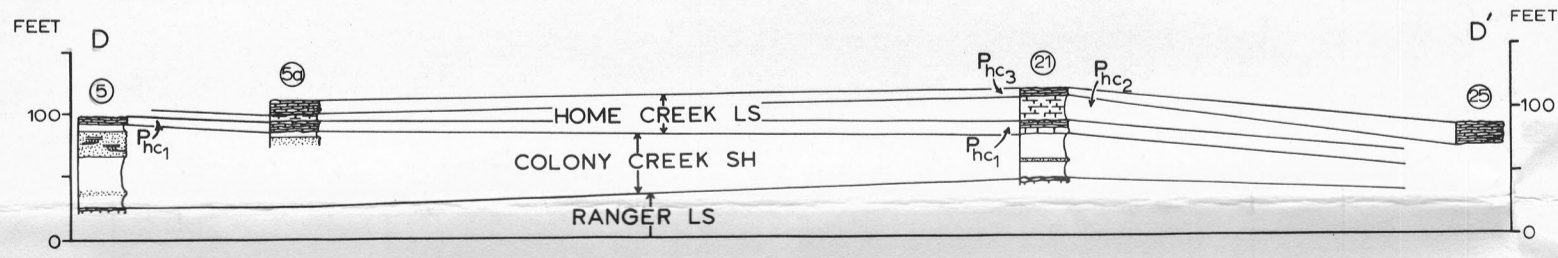
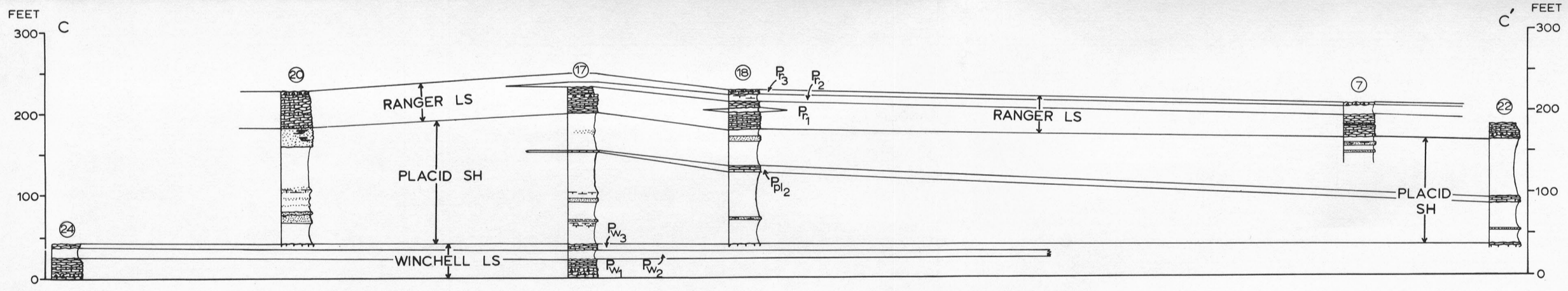
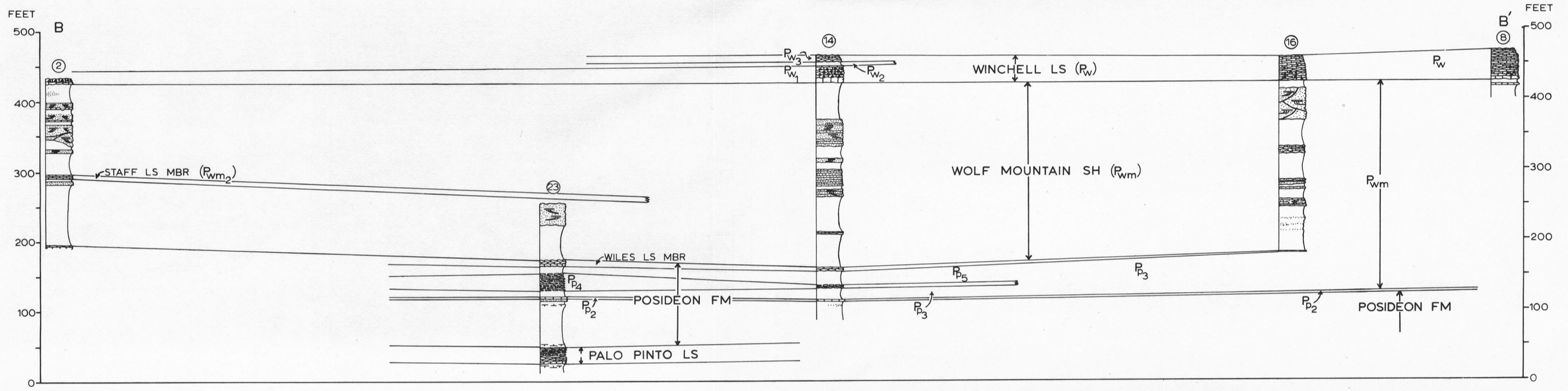
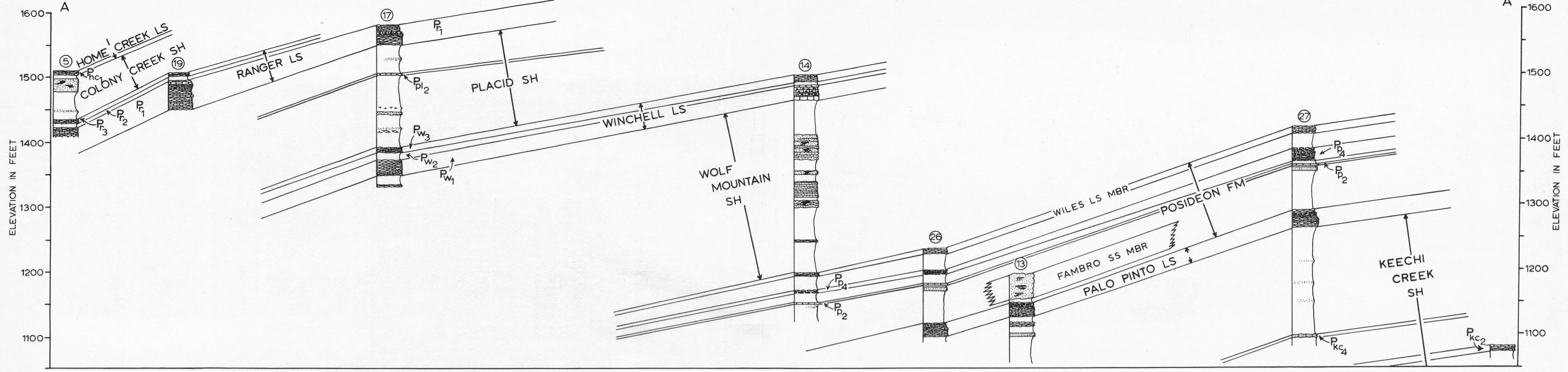
To north, Limestone Member Pkc₂ changes laterally, within one mile, into a series of sandstone beds, brown to gray, calcareous, well indurated, medium-bedded; weathers into large, rectangular blocks 4-6" thick. Overall thickness 1-3'. Sandstone extends northward to town of Strawn and caps scarp upon which most of town built (Locality 42). Contact of Limestone Member Pkc₂ discontinued where identity as limestone is lost.

40 (N-9). Limestone Member Pkc₄ of Keechi Creek Shale outcrops making wide stream flat; limestone, 3.0', massive, sandy fossiliferous. Northward becomes inconsistent, varying from several layers of brown weathering, gray calcareous sandstone and sandy limestone, 2.0' thick, to locally occurring conglomeratic limestone. Conglomeratic limestone composed of well rounded limestone and claystone pebbles and cobble; abrupt lateral changes to fossiliferous calcareous limestone lentils (Locality 41).

41 (O-11). Keechi Creek Shale (Strawn Group). Limestone-pebble conglomerate outcrops locally, described under "Locality 40"; possible lateral equivalent of Limestone Member Pkc₄.

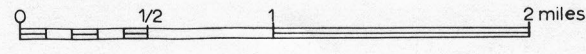
42 (P-10). Keechi Creek Shale. Scarp-capping thick beds of fine grained sandstone outcrop. Bottom markings and cross-bedding common. Thickness approximately 3.0'. Probable lateral equivalent of Limestone Member Pkc₂.

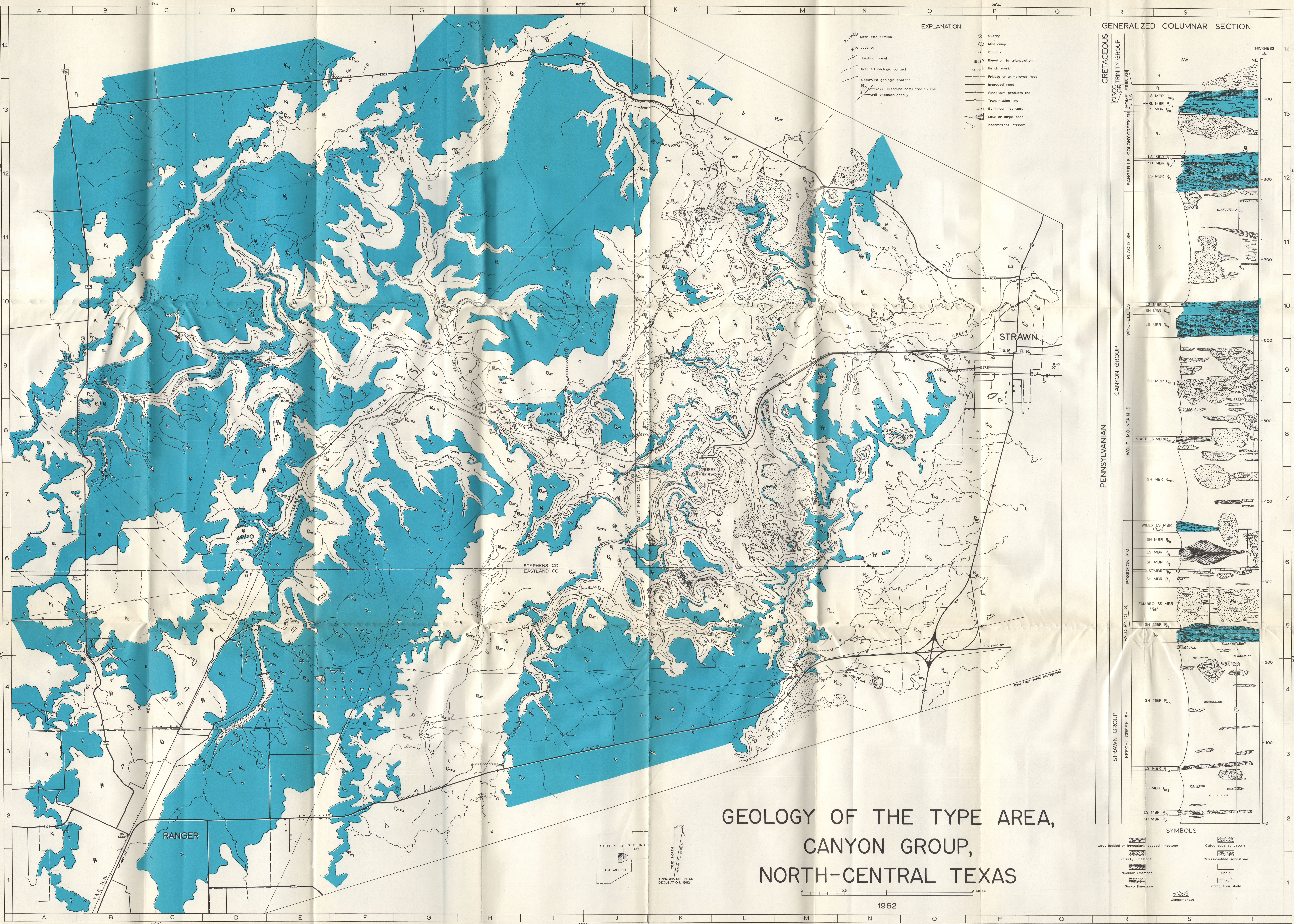
43 (Q-9). Keechi Creek Shale. Thick gray shale sequence, underlying sandstone of Locality 42, being quarried and burned as light-weight expanding aggregate.



CROSS SECTIONS IN THE CANYON GROUP TYPE AREA

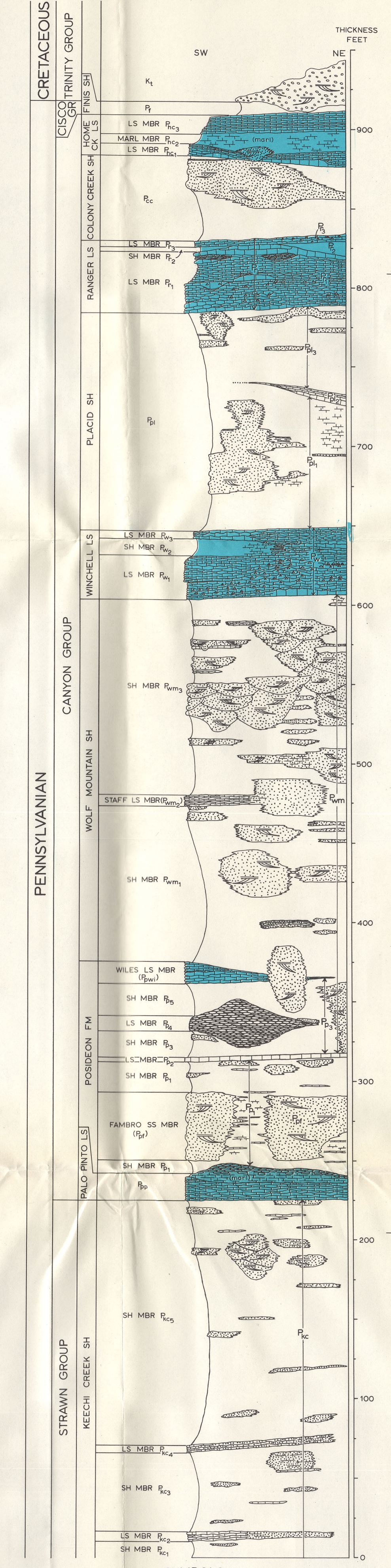
APPROXIMATE HORIZONTAL SCALE





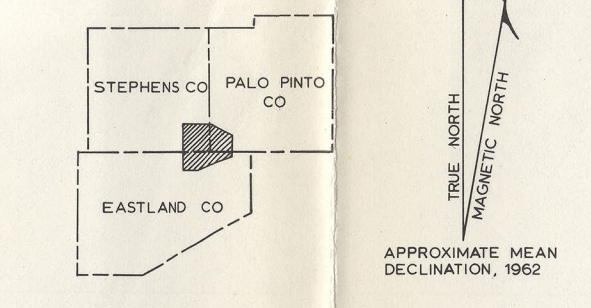
- EXPLANATION**
- Measured section
 - Locality
 - Jointing trend
 - Inferred geologic contact
 - Observed geologic contact
 - areal exposure restricted to line
 - unit exposed areally
 - Quarry
 - Mine dump
 - Oil tank
 - Elevation by triangulation
 - Bench mark
 - Private or unimproved road
 - Improved road
 - Petroleum products line
 - Transmission line
 - Earth dammed tank
 - Lake or large pond
 - Intermittent stream

GENERALIZED COLUMNAR SECTION



- SYMBOLS**
- Wavy bedded or irregularly bedded limestone
 - Cherty limestone
 - Nodular limestone
 - Sandy limestone
 - Calcareous sandstone
 - Cross-bedded sandstone
 - Shale
 - Calcareous shale
 - Conglomerate

**GEOLOGY OF THE TYPE AREA,
CANYON GROUP,
NORTH-CENTRAL TEXAS**



1962 1 MILE