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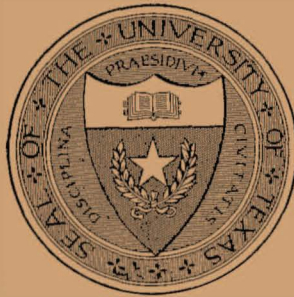
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REPORT ON THE COLORADO COAL FIELD OF TEXAS

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

REPORT

ON THE

COLORADO COAL FIELD* OF TEXAS

By N. F. Drake.

INTRODUCTION.

The region embraced in the following report lies between 31° 10' and 32° north latitude and 98° 30' and 100° west longitude. This area, about 4,000 square miles, includes nearly all of Brown and Coleman counties, Runnels county east of Norwood, the northeast part of Concho county or that part lying east of Paint Rock and north of Eden, McCulloch and San Saba counties north of Brady creek and the town of San Saba, the northwest corner of Lampasas county, Mills county west of the Gulf, Colorado and Santa Fe Railway, and a small area in Comanche county north and northwest of Comanche.

Preliminary examinations of the Carboniferous beds of this area have been made by Messrs. W. F. Cummins† and R. S. Tarr,‡ and like investigations of the Cretaceous areas have been made by Messrs. R. T. Hill and J. A. Taff.

These geologists have determined the stratigraphic relations of the divisions and terranes of these formations, and their classifications have for the most part been followed in this report. The work of the present season has been of a more detailed character than that hitherto undertaken. Each bed has been studied with reference to its extent, stratigraphic relations, lithologic characteristics, fossil forms, and economic features.

HYDROGRAPHY

The whole of this region, except that portion embraced in Comanche county, is drained by the Colorado river and some of its tributaries. While it is practically all in the same hydrographic basin, it has branching basins, which are of considerable extent, and are more or less distinct within themselves. So we may consider this area under its main and two other principal branching basins. These three basins are as follows: In the south we have the lower part of the San Saba river basin drained by the lower course of that river, with Brady creek and other smaller streams emptying into it from the north; the central portion comprises a part of the Colorado river basin, drained by the Colorado river and its numerous small tributaries from either side, together with a little of the lower course of the Concho river; and the northeastern part is drained by the Pecan bayou, with its tributary creeks, Wild Horse, Willis, and Jim Ned from the west, and Elliott, Brown, Bull, Elm, Hog, Paint, and other creeks from the east and north.

*The above is used because the region embraced lies in the Colorado river drainage basin. See First Annual Report.

†First Annual Report Geological Survey of Texas, pp. 145-181. Second Annual Report Geological Survey of Texas, pp. 541-544 and 546-549.

‡First Annual Report Geological Survey of Texas, pp. 201-216.

TOPOGRAPHY

The general slope of the country is to the southeast, but this slope is modified to form the above named basins. The San Saba river and Brady creek basin slopes to the east, the main Colorado river basin to the southeast, and the Pecan bayou to the south. These three basins converge towards a common point near the northeast corner of San Saba county.

There are two principal or general phases of the topography, one characteristic of the Cretaceous, and the other of the Carboniferous. The Cretaceous formation, lying nearly horizontal and composed of beds of increasing hardness from the base upwards, with some horizons that slightly alternate in hardness, presents bluff, bench, or terraced undulations along the edges of these outcropping beds, and has flat tops of greater or less extent, according to the amount of the capping material of the harder horizons.

The Carboniferous, composed of beds dipping to the west and northwest, has a topography characterized by parallel ridge-like undulations which extend northeast and southwest, or more exactly N. 20° to 30° E. and S. 20° to 30° W. These ridges slope so gently on the west side that they may be more properly called escarpments or benches. The bench or the escarpment faces east, while the slope of the surface to the west and northwest is slightly less than the dip of the underlying strata and in the same direction. The lowest level reached on the northwest side of these ridges or benches does not quite extend down to that on the southeast side; so that going northwest, each ridge or escarpment goes over places one at a slightly higher elevation than the preceding one, thus making the average slope of the country to the east and southeast, while most of the surface slope is to the northwest. This character of topography exists because of the dip of the beds N. 60° to 70° W., and because of the different degrees of hardness of the beds. The softer beds rapidly erode and are carried away, leaving the harder beds projecting at the top of the escarpments, and forming the surface rock to the west and northwest, nearly to the base of the next escarpment of overlying beds.

RELATIONS AND EXTENT OF FORMATIONS

The whole of this area was once covered by Cretaceous strata, which rested unconformably on Carboniferous, the former dipping very slightly to the southeast, and the latter dipping 25 to 300 feet per mile to the northwest. Most of this Cretaceous cap has been carried away by erosion, leaving the underlying Carboniferous beds exposed.

Unequal erosion over this area has left the Cretaceous with an irregular border and in isolated areas; or the Cretaceous areas in this field are now as follows: In isolated buttes, such as Santa Anna Mountain, Bead Mountain, Robinson Peak, etc.; in areas of considerable extent, as that south of Brownwood and that north of Talpa; and others in ridges or spurs, like the Brady mountains, running out from the main Cretaceous area.

The Carboniferous beds of this field comprise the southern extension of the central Carboniferous area, which extends from a little south of the Colorado river in San Saba county northward nearly to the Red river in Montague county. This Colorado river coal field is almost cut off from the main body of the Coal Measures to the north by the overlying neck-like extension of the Lower Creta-

ceous beds stretching from the west corner of Comanche county, across the southwest corner of Eastland and southern part of Calahan, into Runnels county.

ACKNOWLEDGMENTS

During the past field season the amount of work accomplished is largely due to the young men placed with me. Prof. B. S. Brown, Mr. Homer Miller, and Mr. C. H. Drake performed faithful service in collecting specimens, mapping beds, and other work during the field season.

Mr. R. A. Thompson joined the party on June 20, and assisted in geological work the remainder of the field season, and since that time has made the two maps accompanying this report, and in many other ways performed valuable assistance, and it is largely his untiring zeal that has made possible the amount of work accomplished during the year.

GENERAL GEOLOGY.

CRETACEOUS.

By reference to the accompanying map, the extent of the Cretaceous formation worked over may be seen. As previously stated, only the isolated areas and bordering Cretaceous beds were studied, and the present report includes only terranes of the Bosque and Fredericksburg, or nothing higher than the Caprina limestone.

The order of the Lower Cretaceous terranes up to the Caprina limestone, as their development in Texas has been determined by Messrs. Hill and Taff, is as follows:

Fredericksburg Division.	{ Caprina limestone.	
	{ Comanche Peak limestone.	
	{ Texana limestone.	
' Bosque Division.	{ Paluxy sand.	
	{ Glen Rose, or Alternating bed.	
	{ Trinity sands.	{ Trinity sands.
		{ Trinity conglomerate.

All of these terranes except the Comanche Peak and Caprina limestone vary very much in thickness in different localities, and in fact do not appear to have extended over the whole of this area; but the higher terranes of the Comanche Peak and Caprina limestones did extend over the whole area without very much variation.

The Trinity conglomerate, thickest in the western part of Lampasas and Mills counties, thins out and disappears in the northwest. The Trinity sand, almost lacking in the western part of Lampasas and Mills counties, thickens rapidly to the north from about the locality of Brownwood. The Alternating beds, with a thickness of from 50 to 100 feet in western Lampasas and Mills counties, thin and disappear to the northwest. The Paluxy sand is only slightly represented along the eastern border of the area. The Texana limestone thins to the west and northwest, and at some localities is practically absent.

As will be seen later, the same geological horizons are not strictly represented by the same character of rock throughout. The base of the Cretaceous system, elsewhere in Texas so regularly formed

of the characteristic Trinity sands, has a marked variation along the Colorado river, where basal Cretaceous is exposed, especially in this field, where it is not usually sand, but a massive, thick, sandy, calcareous conglomerate and grit. This conglomerate is so extensive that we have classed it as a distinct bed of the Trinity sands.

At the beginning of the Cretaceous times the land area was subsiding, and the deposits along the coast were rapid and partook of the nature of the material along or near the coast line. The Silurian formation and the Bend limestone of the Carboniferous in Burnet, San Saba, and McCulloch counties furnished mostly hard crystalline limestones to be worn, carried down to the sea, and deposited. Farther to the north, in Brown and Eastland counties, softer sandstones, clays, and some limestones of the Coal Measure were eroded and deposited along the shore; so north along the basal Cretaceous, from Nix, Lampasas county, for many miles there are immense deposits of Trinity conglomerate composed largely of crystalline limestone. Farther north the conglomerate thins and is gradually replaced by sands, which, although belonging to the same horizon, are derived from softer material.

The basal Cretaceous thus changes very much in the composition of its strata. Rapid deposition is further evidenced by the fact that the Carboniferous floor on which the Cretaceous was laid down was not well leveled before the Cretaceous beds were deposited. As the Cretaceous beds are worn away the old topography of the Coal Measures is revealed, with its rolling and characteristic features.

South of the mouth of Blanket creek the Carboniferous is overlaid by a remnant of the Trinity conglomerate, the contact between the Carboniferous and the Cretaceous is exposed along branches from near Pecan bayou back two miles south to the highest part of the Pecan bayou-Colorado river divide, and the Trinity conglomerate is usually twenty-five to thirty feet thick, being little or no thicker higher on the divide than near the bayou, though there is fully 150 feet difference in elevation between the top of the divide and the base of the Cretaceous near the bayou.

The contact between the Carboniferous and the Cretaceous on the east side of Deep creek, where the Carboniferous beds are clay, is lower than on the west side of the creek, where the harder Carboniferous limestone outcrops; and the Trinity conglomerate on the east side is thirty to fifty feet thick, while on the west side only thin patches of the conglomerate occur, and these lay in depressions of the old Carboniferous floor. The Cretaceous which rests on the more elevated Carboniferous beds belongs to higher horizons.

Northwest of Brady, on the north side of Brady creek, there is a good development of the Trinity sands and conglomerate, while south and southeast of Brady, the basal Cretaceous belongs to a higher horizon, the Texana limestone, or practically the Comanche Peak bed, since usually there is but from four to ten feet of the Texana limestone. East and West mountain, four miles southwest of Byrd's store, is a butte seventy to eighty feet high, the base of which is Carboniferous clays and sandstone, and the upper half Cretaceous grit and sandy limestone. The top of this butte has the same elevation as Coon mountain, which is three-fourths of a mile to the west, but Coon mountain is capped by Carboniferous sandstone. Many other localities show the same condition. It is frequently the case, however, that the lower or Trinity sands and conglomerate beds do not end at points where this old Carboniferous

floor was above the general elevation on which those beds were deposited. In this latter case, as the subsidence of the early Cretaceous times continued, and as higher beds were being deposited over the Trinity conglomerate and sand at sea, along this encroaching shore line more conglomerate and sands were being deposited, thus making a somewhat regular cover of these lower beds, mantling the old Carboniferous. This newer, or in this area, northwestern receding shore line, received its Trinity sands and conglomerate deposits partly during the Alternating and Texana times of accumulation. These later beds had but a short time for the accumulation of their typical deposits, and they are consequently feebly represented. By the time of the commencement of the Comanche Peak limestone deposits, this shore line was far away, and like conditions of deposit existed over all the field, hence the uniformity of that bed.

TRINITY CONGLOMERATE

This conglomerate is principally composed of crystalline limestone pebbles one to five inches in diameter, but chert, sandstone, and some quartz pebbles are usually present. The matrix is sand or grit of quartz grains with a lime cement. The bedding is massive, and the change of material from one horizon to another is gradual and not marked by bedding planes. The limestone, chert, and sandstone pebbles are large and usually not well rounded, showing that they were derived from beds near where they were deposited. The quartz pebbles, however, are small and well rounded, showing that they had a more distant origin. The prevailing color of the beds is pink, with patches of lighter or deeper red scattered through it. At places the bed loses its conglomeritic nature more or less and passes into a hard sandstone, compact sand, grit, clay, sandy clay, or more rarely into limestone. By reference to map, the areal extent of the conglomerate may be seen.

From just west of Nix, Lampasas county, as far north as Clio, on the east side of Colorado river at Pecan bayou, the conglomerate is finely developed, and also between the bayou and Colorado river south of Brownwood, at and around Bangs, east of San Saba, between the Colorado and San Saba rivers on some of the higher elevations, and at other places as shown on the map.

Just west of Nix, at the head of Lynch creek, the conglomerate is very thin, but thickens rapidly northward. West of Twin Sister Peaks it is fully fifty feet thick. A considerable part of the bed from Nix to Senterfitt consists of massive bedded pink sands, usually calcareous and forming quite firm rock masses. In the bed of Salt creek, at Senterfitt, the conglomerate is well exposed and is composed of sub-angular pebbles of hard crystalline limestone imbedded in a hard calcareous matrix; and east and west of this point pink calcareous sands and clays may be seen interstratified with the conglomerate. The stratification, however, is local and generally not well marked. At the head of Antelope creek the conglomerate bed is more than 100 feet thick, and mostly a hard mass with no bedding planes, though local and irregularly marked horizons have different degrees of hardness, causing it to weather with a wavy or rough rounded surface. Most of the matrix is sand, but calcareous matter is present to a greater or less extent. At places the bed becomes almost or entirely pure sandstone, and more rarely clay. The pebbles of the mass are usually from one to five inches in diameter, and some are even larger, though at places where the conglomerate graduates into a sandstone they become very small and

rare. Most of the pebbles are hard limestone, but many flint, chert, sandstone, and some quartz pebbles are present. The color of the mass is pink, with small parts of lighter or deeper red scattered through it. In some places the bed is almost white.

The above conditions are approximately true of the conglomerate bed wherever it is found in this field. At San Saba Peak it is 175 feet or more in thickness, and the upper part graduates through a decidedly hard, calcareous, crystalline rock mass, only slightly conglomeritic, into overlying Alternating beds.

The base of the Cretaceous near Pecan bayou, west of Mullin, is strongly conglomeritic. The pebbles are usually from two to four inches in diameter, with some angular hard sandstone boulders two to three feet in diameter. This highly conglomeritic mass is fifteen feet thick, and is overlaid by friable sandstone that shows some bedding planes; this sandstone is in turn overlaid by calcareous, hard, light pink rock that is slightly conglomeritic. Bedding planes, which are rare, and usually false, are becoming more common. Most of the conglomerate bed, up Pompey and Blanket creeks, shows fine illustrations of false-bedding, but it is generally a red and rather friable sandstone, instead of a regular conglomerate. Along Stepp creek in the vicinity of Ricker, the base of the conglomerate bed is red clay, varying in thickness in closely connected localities. Along the branches of Delaware creek there is none of this clay, while on most of the eastern branches of Stepp creek it is nearly 100 feet thick. Above this clay is a coarse grit or conglomerate, composed of white sand and rounded limestone and sandstone pebbles. The mass is slightly calcareous.

The conglomerate bed changes rapidly towards the north; at the head of Stepp creek it is about 125 feet thick and composed of white grit, conglomerate, and red clay. The clay usually lies at the base, composing the greater part of the bed, which is overlaid by the Trinity sands. At Salt creek the conglomerate is only represented by a thickness of four to five feet on either side of the creek, and the Trinity sands have rapidly increased in thickness and replaced it.

The basal Cretaceous north of Sidney and Comanche has some conglomerate, but its character is usually somewhat modified from that along Colorado river and Pecan bayou. About one mile below Sidney, in the banks of both Sweetwater and Jimmy's creek, is a deep red, slightly sandy clay, thirty to forty feet thick, which is underlaid by a hard conglomerate composed of small limestone, sandstone, and siliceous pebbles in a matrix of white sand, and this is in turn underlaid by red clay. The stratification of this bed northeast of Sidney continues only for a short distance; farther down the creek the bed may be seen at a number of places showing a section of from twenty to fifty feet, and at nearly every place varying in proportion and relative position of its conglomerate and clay strata. Sometimes quite pure sandstone appears in this bed, as may be seen at the top of the section at Cottonwood Springs on Sweetwater creek. The bed also, at places, contains material very similar to the Trinity sands, showing the close relation or even transition of one into the other, as may be seen about one-half mile down the creek from Cottonwood Springs, where the bed consists of ferruginous, compact sand containing a great many red, pink, brown, or nearly black siliceous pebbles, some hard sandstone pebbles, some nearly pure compact sand, some hard conglomerate strata, and a little blue or reddish clay. The basal Cretaceous strata farther down, on the southeast side of Sweetwater creek, were

found to have no continuous stratigraphy, and to change almost entirely into the Trinity sands material to the northwest of Comanche.

The fifty to seventy-five feet of basal Cretaceous along Rush creek north of Comanche is largely composed of a conglomerate of siliceous pebbles and grit of white quartz grains with occasional red ones. In places, as along Petit branch, this conglomerate is almost a mass of these white and occasional pink pebbles, and it is all false-bedded. The conglomerate is usually friable, though at some places it is quite hard, as in Jimmy's creek.

North of Rush creek, on the divide between it and Leon river, are some remnants of a conglomerate which has somewhat more of the appearance of that east of Pecan bayou.

From five to six miles east of San Saba, between Horse and Camp creeks, and at the head of China creek, there are small remnants of the characteristic Cretaceous conglomerate. At many other places on the divides the conglomerate has so lately been eroded that its most enduring pebbles remain scattered over the surface, reminding one very much of the drift of the later geological epochs.

From near Richland Springs, eastward for five miles, the higher lands are capped by Cretaceous conglomerate. The true conglomerate is probably not over twenty feet thick, and is overlaid by a chalky limestone that crumbles and forms a "hard-pan," as seen along the San Saba-Richland Springs road.

The Cretaceous area extending northwest and southeast between Pecan bayou and the Colorado river, south and southeast of Brownwood, is over twenty-five miles long and has an average width of about five miles. The base of this, at nearly all places, is the characteristic Trinity conglomerate, but over the central part there is at and near the top from zero to thirty feet of arenaceous or gritty limestone strata, in some places quite pure limestone, but barren of fossils. Probably at no point in this Cretaceous area is the strata more than 100 feet thick, though a greater thickness of geological horizons is represented. This comes from the fact that it was not deposited on a level floor, but on a topography very much like the present, the pre-Cretaceous drainage basins corresponding very closely to those of the present time, as the following will show. On the divide between the bayou and Colorado river, south of the mouth of Blanket creek, the conglomerate bed seems to be nowhere more than twenty-five to thirty feet thick, and there is fully 150 feet difference in the elevation between its base next to the bayou and its top on the divide. The small branches have cut through it as far back as the top of the divide, exposing the Carboniferous rocks. The Cretaceous strata near the bayou are of the characteristic Trinity conglomerate, though at places a red sandstone, generally friable, occurs. Higher on the divide the material becomes somewhat more calcareous and less conglomeritic, though in contact with Carboniferous rocks.

About seven miles southeast of Brownwood, along Devil's branch, the basal Cretaceous consists of twenty to thirty feet of characteristic Trinity conglomerate, overlaid by eight to ten feet of red, tough, slightly calcareous sandstone, which contains only a few pebbles. A rather friable arenaceous limestone overlies this sandstone, and forms much of the present Cretaceous cap rock south of Brownwood. Due south of Brownwood there is not much of the typical conglomerate; pink or yellowish friable sandstone or grit, a compact yellowish sand, arenaceous limestone and some white sandstone containing but little grit, form most of the strata there, and some outcrops show a number of variations in the material along the same stratum in closely connected places. The following is the change shown at one place: Yel-

lowish friable sandstone or compact sand, graduating into red calcareous friable sandstone, and this graduating into pink arenaceous limestone, and all immediately underlying a uniform stratum of yellowish white limestone, which is in turn overlaid by a red calcareous sandstone, and this capped by a nearly white limestone that contains only a little sand. On the south side of this area, northeast of the head of Indian creek, the conglomerate is not very abundant, but the associated deposits of pink calcareous sandstone or grit, sandy limestone, and at the top a nearly pure limestone, show the close connection with the conglomerate bed. The upper limestone strata are quite uniform in material and have regular bedding planes.

The Cretaceous east and south of Cowboy and that at the lower elevation east and south of Brady mountains, is the characteristic conglomerate, though red sandstone is usually interstratified with it west of Deep creek or at the east end of Brady mountains.

A small Cretaceous area covers the Carboniferous at and around Bangs to a depth of forty to fifty feet. It is not all conglomerate material, the upper ten to twenty-five feet being especially variable and consisting largely of pink sandy clay, bluish sandy clay, white friable or compact grit, with some of the true conglomerate. The latter consists largely of pink crystalline limestone pebbles, with some chert, quartz, and sandstone pebbles in a matrix of grit, sometimes argillaceous or ferruginous, and nearly always calcareous. Well sections and railroad cuts, one-half mile east of Bangs, show that at that place the base of the Cretaceous is white compact sand, interstratified with conglomerate and calcareous sandy clay. Towards the top there is a limestone of nodular structure with only a small per cent of grit or sand. The base of almost the entire border of this remnantal area consists of the typical conglomerate, small patches of which cover the higher points four to five miles northwest and west of Bangs.

About one and a half miles southwest of Atoka, or near the head of the South Fork of Jim Ned creek, the higher points below the Cretaceous escarpment have some of the Trinity conglomerate, which is from 75 to 100 feet lower than the base of the Trinity sands at Blue Gap.

The conglomerate up Brady creek, except that northwest of Brady, differs considerably from the regular Trinity conglomerate. It has small siliceous pebbles with some large crystalline limestone pebbles in a matrix of white lime rock, the lime being in excess of the pebbles. There is also considerable white sand along Brady creek at the base of the Cretaceous, and part of the belt marked on the map as conglomerate could as well be referred to Trinity sands.

TRINITY SANDS.

On the east side of the Colorado river, from Nix northward to opposite Brownwood, the strata referable to the Trinity sands are thin, irregular, and somewhat different from the characteristic sands in that they have more or less clay and lime. There is usually, however, twenty to thirty feet of red sand and clay present belonging to the Trinity sands. Northeast of Brownwood, at the head of Stepp creek, there is fifteen to twenty-five feet of the typical sands overlying the conglomerate, but these sands at places show stratification beds of white compact sands, bluish clay, and, more rarely, red clay. At the head of Salt creek, east of Salt mountain, nearly the whole of the conglomerate bed has been replaced by Trinity sands, which are eighty to ninety feet thick. The sand is compact, composed principally of white grains, with some red grains scattered through it. There are some layers of

ferruginous sand which are a little firmer, and a very little bluish and red clay occurs in the bed, especially towards the top.

At and west of Clio and May, along the headwaters of Salt, Elm, and Hog creeks, the Trinity sands have a greater thickness and an outcrop from two to three miles wide of regular sand beds, which support a thick growth of small oaks. Around Sidney and Comanche, along Sweetwater, Little, Jimmy's, Duncan, and Indian creeks, the sands are finely developed.

In Jimmy's creek, at Sidney, there is a rather firm, slightly ferruginous sandstone, bedded in layers from one to eighteen inches in thickness, above which is a white compact sand containing some small well-rounded siliceous pebbles, and partly interstratified with bluish sandy clay. At the base of these beds, in the vicinity of Sidney, a deep red, slightly sandy clay is common. Along Petit branch, north of Comanche, there is a series of alternating bluish sandy clay beds and compact white sand, which at places show a reddish cast on the weathered surface. Fossil wood is very common at the base of these sands.

There is but very little Trinity sands at the base of Brady mountains, and this is modified by clay and calcareous material. Along Brady creek, ten to twelve miles west of Brady, there is some sand interstratified with conglomerate, the whole of which might be referred to the Trinity sands.

The conglomerate bed south of Brownwood contains very little material referable to the Trinity sands. The base of Santa Anna mountains, however, has a fine development. The section of strata referable to the Trinity sands is as follows:

6. White sand, rather coarse and containing occasional red grains. It is rather compact and crumbles readily on being jarred, and a very few thin calcareous hardened clay bands run through it.....	30 feet
5. Conglomerate in a coarse sand matrix. The conglomerate pebbles are small, well rounded and mostly white quartz	5 feet
4. Yellow, calcareous, indurated conglomeritic sand and yellowish clay interstratified	15 feet
3. Pure, fine white compact sand	20 feet
2. Red clay	15 to 20 feet
1. Coarse sand and pebbles	10 to 15 feet

The Cretaceous area in the northwestern part of Coleman county, west of Coleman and north of Valera and Talpa, has Trinity sands at its base, but not of uniform thickness. Near Talpa and Valera the sands are very thin, but thicker to the north; near Novice they are from 50 to 100 feet thick and their outcrop is from two to three miles wide. Southwest of Glen Cove they are about twenty-five feet thick, and are often yellowish in color from iron. At Robinson Peak there are about fifty feet of the sands, with a central stratum of firm, yellow, rather nodular, sandy limestone. Just north of Talpa there are not more than fifteen to twenty feet referable to the Trinity sands, and this is somewhat argillaceous, containing some fossil wood and a thin stratum of very hard and fine-grained, almost quartzitic, sandstone, which weathers with a pink surface, but on fresh break it is very white. This stratum occurs in the Trinity sands in all the western part of this area. Ten miles north of Talpa the sands show to be from forty to fifty feet thick, and at Blue Gap, five or six miles farther north, they are from sixty to seventy-five feet thick, white and compact at the base, and false-bedded grit at the top.

At the top of the Trinity sands in Bead mountain, Robinson Peak and the southwestern part of the above area, there is a highly calcareous sandstone which weathers to a brownish color and rough surface, and which contains an *Ostrea*, most likely the *O. franklinii*, Coquand. In Robinson Peak this bed is from fifteen to twenty feet thick; in Bead mountain it is from six to eight feet thick; north of Talpa it is from four to six feet thick, and is lacking in the northwestern part of this Cretaceous area.

ALTERNATING, PALUXY, AND TEXANA BEDS

The Paluxy sands do not occur in any definite bed in this field, and their occurrence in Comanche county was not studied.

Both the Alternating or Glen Rose and Texana beds west of the bayou are thin and often altogether lacking. Their connection is so very close that it would have been difficult to separate them at all points where both are represented. In mapping, the two beds have been placed together, and will be discussed together. These and higher beds were only partially studied east of Pecan bayou, so we shall only consider their occurrence to the west.

The Alternating beds consist of alternating layers of marls, impure soft limestone, sandy or gritty limestone, and at places some hard crystalline limestone in thin layers. The Texana bed consists of marls and impure limestone made especially distinctive by the occurrence in it of the *Exogyra texana*, Roemer.

East and West mountain, a small butte, four miles southwest of Byrd's store, is capped with what seems to be the upper part of the Trinity sands and the lower part of the Alternating beds. The top of the butte has twenty to twenty-five feet of hard calcareous sandstone, which is bedded in layers one to three feet thick, and weathers to very irregular rough surfaces. Under this are thirty to forty feet of reddish sandy clay, with bands of lighter color and highly sandy material; these latter, however, are few.

A small portion of the upper part of the Cretaceous area south of Brownwood probably belongs to the basal part of the Alternating beds.

The basal Cretaceous beds of the Brady mountains are nearly all of the Alternating and Texana horizons, but as they were the first strata laid down on the Carboniferous floor, they are more or less modified by being more sandy, more argillaceous, and not so calcareous. On the upper Milburn-Brady road, twelve miles south of Milburn, at the east end of Brady mountains, there are fifteen feet of yellowish marls, with some soft marly limestone below the Comanche Peak limestone, which contain numerous *Exogyra texana* and small *Gryphaca pitcheri*. Below this there are ten to twenty feet of reddish sandy limestone, a white chalky slightly sandy limestone, a harder brownish crystalline limestone, and some marly material. The lower bed rests on the Carboniferous limestone, without the intervening sands or conglomerate of the Trinity division.

South of Onion Gap of Brady mountains, the basal Cretaceous consists of twenty to thirty feet of pink and bluish white sandy clay, and immediately underlies the Texana bed, which is about thirty feet thick. In Lost Gap, at the head of Lost creek, the pink sandy clays underlying the Texana bed are well exposed in sections of twenty-five to thirty feet, and its total thickness is forty to fifty feet.

On the west side of Cow Gap the Cretaceous section, from the top downward, is as follows:

- | | |
|--|--------------|
| 3. Marly limestone containing <i>E. texana</i> | 4 to 5 feet. |
| 2. Pink clay, with a little yellowish impure limestone distributed through it..... | 50 feet. |
| 1. Pink, white spotted, argillaceous sandstone, interstratified with some pink clay. The sandstone contains white splotches and is rather coarse grained | 25 feet. |

This last twenty-five feet could probably better be referred to the Trinity sands. In the western part of Brady mountains the Alternating and Texana beds are practically wanting. The Texana bed forms the basal Cretaceous southwest of Brady, but is usually only four to five feet thick. In Santa Anna mountains there are practically no strata referable to either the Alternating or Texana beds. At Robinson Peak these beds are thirty to thirty-five feet thick, at Bead mountain, twenty to twenty-five feet; north of Talpa, twenty feet; and at Blue Gap, twenty feet. The combined average thickness of these beds in the Cretaceous area north of Talpa is from twenty to twenty-five feet, and they are quite regularly marly limestones and marly clays.

COMANCHE PEAK LIMESTONE

The Comanche Peak bed forms most of the surface rock of Brady mountains. The capping stratum on the east end of the mountains, almost as far west as Cow Gap, is Comanche Peak limestone. This terrane forms the basal Cretaceous along the upper part of Brady creek, and is practically at the base of the Cretaceous northeast, south, and southwest of Brady, and along the north side of Brady mountains, south of Paint Rock. At Lost Gap this bed is about forty feet thick, and at Cow Gap it is sixty feet thick. There seems to be a slight modification of parts of this bed north of Eden, where some of it is a slightly sandy, marly, friable limestone of a grayish color. At Santa Anna mountains it is about twenty feet thick; north of Talpa and Valera it is from twenty to thirty feet thick and slightly thins to the north. There is usually a slight increase of induration in the Comanche Peak limestone towards the upper horizons, but this change is very gradual, and the whole bed is practically one mass, which weathers into a rolling topography. It accumulates but little soil, and its surface is more or less barren. Where the underlying strata are soft and the overlying hard Caprina limestone still exists, the outcrop of the bed is narrow, and forms the lower part of escarpments; but where the conditions are reversed, so that a hard bed underlies it, and nothing or only soft material overlies it, its outcrop is more extensive and more gently rolling.

CAPRINA LIMESTONE

The Caprina limestone areas of Brady and Santa Anna mountains and that of the northwestern part of Coleman county, are the only ones included in this field. The Caprina limestone of Brady mountains is a narrow and remnantal strip, extending from just east of Cow Gap to the west, and varying from zero to seventy feet in thickness. The Caprina and Caprotina fossils are usually abundant, and the limestone is massive, white and chalk-like. Flints are not present in the eastern part of this strip, but in the western part they occur abundantly. At the west side of cow Gap there are forty-five

feet of Caprina limestone, in massive layers from two to six feet thick, and without flints. Near the center of this section there is a stratum of three feet of marly material, which contains an occasional *E. texana*.

Santa Anna mountains are capped with about twenty feet of Caprina limestone, which contains no flints, and is a massive, evenly-textured, which, chalky rock.

The greater part of the Cretaceous area in the northwestern part of Coleman county is capped with Caprina limestone. The light colored flint horizon is well developed in the western part of the area; some thin and marly limestone layers are interstratified with the massive limestone. The limit of the Caprina limestone in these areas is usually marked by abrupt terminations of the strata in bluffs, and the upper surface of the bed is level, so that it forms table-lands, flat-topped peaks, and mesas.

CARBONIFEROUS

The Carboniferous formation in this part of the State has been divided by Mr. W. F. Cummins into divisions as follows:

- (e) Albany.*
- (d) Cisco.
- (c) Canyon.
- (b) Strawn.
- (a) Bend.†

The Bend division was not worked, but some of its outlines will be given to make more clear the positions of the overlying divisions. The Bend division consists for the most part of massive hard limestone, but at the top there is usually a bed of black clay shale. This division rests upon the older Silurian rocks, forming a narrow belt on the north and northeast of that continental area.

The other divisions are unconformable with this, but conformable to each other, which conditions are shown in the accompanying map and sections. The strike of the beds of the Bend division is nearly at right angles to that of the beds above, and each of the beds of the overlying divisions, at its southmost limit, laps back against the beds of the Bend division and there ends.

The Strawn, Canyon, Cisco, and Albany divisions are distinguishable from each other by lithologic and faunal characteristics. The following are the most prominent lithological distinctions:

Strawn: Consists of beds of sharp grained, moderately hard, evenly textured sandstone, alternating with beds of blue clay. Conglomerates and shales are not abundant, and limestones are of rare occurrence.

Canyon: Alternating beds of rather rough, evenly textured bluish limestone, blue clay, some sandstone, and conglomerate.

Cisco: Composed of beds of blue clay, which are shaly at some localities; of sandstone, usually conglomeritic, and often a pure conglomerate. Of limestone thinly bedded, and some coal.

Albany: Massive beds of blue, gray, and yellowish colored limestone, alternating with beds of blue clay, black or gray shale. Sandstone and conglomerate are almost entirely lacking.

*The stratigraphic and limited palaeontologic work of the past season indicate a probability of the Albany division being Permian.

†The Bend division has been referred to the sub-Carboniferous by Mr. R. S. Tarr, Geological Survey of Texas, First Annual Report, pp. 201-203. Later on the division was classed as Upper Carboniferous by Mr. W. F. Cummins, Second Annual Report Geological Survey of Texas, pp. 362-367.

The principal faunal characteristics of the divisions and beds will be briefly noted in connection with the descriptions of the beds. The lists of fossils given do not include the whole of the collection made in the Colorado coal field, but only those that have been hastily determined. They, however, include the majority of the forms found. The publication of a complete list of the fossils collected is intended to be made as soon as they can be determined, and the new forms described. The lists have been prepared to show, as well as possible, the succession of faunæ through the divisions.

These Carboniferous divisions, by their distinctive groups of strata, record different and quite uniform stages of deposition. The Strawn division is composed of beds of sandstone, alternating with beds of clay. Each bed is usually of considerable thickness and of uniform material throughout, thus denoting a rather regular, alternating succession of two kinds of periods. Along any given bed, however, there is often a change of sandstone to clays, or vice versa. Usually the sandstone beds thicken to the south, though this rule is occasionally reversed. The beds indicate a shore and near shore deposit, but as conglomerates, breccias, and grits are limited, excessively rapid currents must not have been common.

At the close of the Strawn division, as shown by the limestone and clay beds of the Canyon division, there was a slight subsidence of the sea floor, so that beds of deeper sea deposits were laid down.

In the Cisco division, there is quite a commingling of material, indicating varying conditions of deposition. Accumulated vegetation, clay, sandstone, and conglomerate of coast deposits, in quiet and turbulent waters, and deeper sea deposits of limestones, especially in the upper part, all enter into the general make-up of this division, and record it as a time of many changes. The irregular eroding and overlapping of some of the included beds also mark sudden and irregular changes.

The upper portion of the Cisco and all of the Albany division are more regular, and by their thick limestone beds and abundant marine fauna, indicate a deeper sea and more regular conditions. In this part of the field the limestone beds regularly thin to the north, and seemingly to the south from the Colorado river, clay or marls replacing the limestone strata as they thin. Sections six and seven, Plate III, and map illustrate these changes.

ORIGIN OF THE SEDIMENT OF THE STRAWN AND OVERLYING DIVISIONS

Lying almost against the Silurian and Cambrian systems of the central mineral region, as these beds do, and no other pre-Carboniferous being exposed near by, one would, without further knowledge, suppose that their material came from that older land area, and that these Carboniferous beds would be regularly distributed all along, each bed overlying a lower, throughout the coast line; but such are not the conditions, and instead the following exist:

First.—The outcrop or strike is almost at right angles to that of the present exposed old shore line.

Second.—Except very near it, the beds indicate deeper water and slower deposits towards this coast line, than away from it, or further to the north.

Third.—Each bed along its south side, near or at this coast line, dips under but few overlying beds before a higher bed overlaps its dipping or western edge, and in turn lies on the Bend division; so that anywhere out from this old shore line, the depth through the

Carboniferous strata to the Bend division beds is less than the sum total of all the thicknesses of the outcropping beds, from that point to the base of the Strawn division.

Fourth.—The conglomerates are more characteristic of the Cisco than any other division, and they extend almost to the Red river, and remain remarkably constant all along in the character of the material composing them, and always free from limestone and marble pebbles, which would have entered into them to some degree if they had been derived from the formations of the Central Mineral Region.

Fifth.—So far as has been investigated, the beds indicate a deeper sea to the westward.

It will be seen from these conditions that the material of these beds did not come from the south, or to a very limited extent. If it be supposed that these sediments came from the west, and that the Carboniferous sea lay to the east, then the above described manner of overlapping of the lower limits of the beds would be more difficult to explain, and the most eastward or, according to the fifth condition, seaward deposits could not be shallow and rapid, while those farther west were of deeper sea deposits. So it seems most probable that the sediments came from the east and northeast, and that this extensive old land area is now covered by later formations; and that it was once connected on the south side with the Central Mineral Region, and on the north with the Wichita mountains, seems quite probable.

The Central Mineral Region most likely projected out to sea from the larger land area to the northeast, and the rivers flowing westward through that large area, carrying sediment to sea, deposited it along a north and south coast line. The old shore line now revealed is therefore probably only a short part of its original length, and represents a part originally delineating peninsulas and headlands, from which little sediment was carried down, so that near this coast deep sea deposits accumulated as shown in the Albany division.

In the divisions examined a name has been selected for each bed from some place or thing located on that bed, so, to one who is familiar with the geography, the name pretty well locates the bed. The want of named places, however, has caused some modification of this general rule, and some small beds of no particular importance have been included in a larger bed in contact, and grouped together as one.

STRAWN DIVISION*

The beds of this division have an aggregate thickness of about 4,000 feet, and are principally sandstone and clay beds, which have been named as follows:

23. Ricker bed.
22. Antelope creek bed.
21. Indian creek bed.
20. Comanche creek bed.
19. Wilbarger creek bed.
18. Buffalo creek bed.
17. Rough creek bed.
16. Hanna valley bed.

*Section No. 1 is across this division and shows its outcropping beds, and also a little of the Trinity conglomerate.

15. Cottonwood creek bed.
14. Spring creek bed.
13. Brown creek bed.
12. Big Valley bed.
11. Bull creek bed.
10. Horse creek bed.
9. Fox ford bed.
8. Bed No. 8.
7. Shadrick mill bed.
6. Elliott creek bed.
5. Burnt branch bed.
4. Lynch creek bed.

4. *Lynch Creek Bed*

The lowest beds of the Strawn division exposed in this area are the Lynch creek beds, which lie principally on the north side of Lynch creek, west and northwest of Nix. Their outcrop is a small isolated area, bordered or underlaid on the southwest, west, and northwest by the shale and limestone of the Bend division, and overlaid on the east and northeast by Trinity conglomerate. At the base of the beds there is usually from fifty to seventy-five feet of bluish sandy clay, graduating upward into sandstone, and downward into shale. Most of this material is no doubt a re-working of the Bend shale, and one can not locate any abrupt changes between the two. Similar contact material exists at nearly all points between the Bend and higher divisions. About two miles southwest of Nix, near the head of Lynch creek, good exposures of this contact material may be seen. There it is mixed with thin sandstone strata, and the sections exposed graduate from blue clay to sandy blue clay at the top, and to black clay shale at the base. One and one-half to two miles north of northwest of Bend similar conditions exist. This contact material is overlaid by 75 to 100 feet of sandstone, varying from shaly to massive. Two miles north of the mouth of Lynch creek there is a very massive, moderately hard sandstone which forms a bluff escarpment. Higher in the bed at this point, and lower in it west of Nix, the strata are more commonly shaly or flabby, and rather soft, readily weathering into sands.

5. *Burnt Branch Bed*

This next higher bed exposed is principally sandstone, though, as is usual, there is at the contact with the Bend limestone some bluish clay. In some places, however, as at points south of the Colorado river, the sandstone rests directly upon the Bend limestone. This sandstone bed is about 125 feet thick. Its best exposed developments are along Burnt branch, south of the Colorado, and along Antelope creek, north of the river. At the mouth of Antelope creek the basal contact clays are twenty-five feet thick, and are overlaid by forty to fifty feet of flaggy sandstone. These flags are the prevailing nature of the bed higher up the creek. On either side of the San Saba-Lometa road crossing of Antelope creek, there are beautiful smooth flags, forming the bed of the creek and outcropping along its banks. The best exposures of this bed, however, are along Burnt branch, especially for two or three miles from just above its mouth. There the basal, seventy-five to eighty feet, is massive, white, evenly grained, compact sandstone, having sufficient

toughness for ordinary building purposes. At places the sandstone shows solid beds of uniform structure, from ten to fifteen feet thick, and forms high bluffs along the branch. The top part of the bed is somewhat flaggy, but not so uniformly as along Antelope creek.

6. Elliott Creek Bed

This bed, which is about 100 feet in thickness, is composed mainly of bluish gray clays, slightly shaly at places, but toward the base and top it is somewhat interstratified with thin sandstones. It is more or less arenaceous throughout, frequently including pocket-like layers of clay ironstone, which on exposure readily break into small pieces. It also contains some sandstone, the surface of which is made rough by concretionary irregular winding elevations and depressions over it. The bed outcrops along the head of Burnt branch, west side of Red bluff, towards the head of Antelope creek, and along Elliott creek. Its outcrop regularly forms a valley between the outcrops of the overlying and underlying sandstone beds. The only fossiliferous horizon found was on Elliott creek, about two and one-half miles from its mouth. The fossils found are as follows: *Cynthosaura?*, *Syringopora* sp.? *Eupachyrinus tuberculatus?*, *Zacrinus acanthophorus?*, *Chonetes vernuitiana*, *Spiriferina kentuckiensis*, *Spirifer cameratus*, *Aviculopecten* sp.?, *Productus longispinus*, *P.* sp.?, *Naticopsis wheeleri*, *Bellerophon nodocarinatus*, *B. crassus?*, *Pleurotomaria* sp.?, *Murchisonia* sp.?

7. Shadrick Mill Sandstone

This sandstone bed, of about 150 feet in thickness, outcrops in a narrow belt running N. 25° E. and S. 25° W. from just west of the head of Burnt branch, along the west side of the Colorado river, opposite Red bluff, and along the east side of the river below and at Shadrick Mill, and from faulting or rapid change of stratigraphy, or both, is only slightly represented on to the northeast, on the north side of Elliott creek. Other parts of the bed seem to have been faulted and somewhat folded, so that some parts, naturally underlying other strata further to the west and north, have been brought up again on the north side of the Colorado in the James bend.

Massive strata usually characterize this bed. A general section of the bed west of Red bluff is as follows:

d. Sandstone, mostly flaggy.....	45 feet.
c. Sandstone, mostly massive	40 feet.
b. Conglomerate with a sand matrix, and small, sub-angular siliceous pebbles.....	5 feet.
a. Massive sandstone	15 feet

The following section, giving the character and thickness of each layer of the bed, was made at and below Shadrick mill:

Shaly sandstone	5 feet.
Massive sandstone	2 feet.
Shaly sandstone	3 feet.
Massive sandstone	2 feet.
Clay	½ foot.
Massive sandstone	3 feet.
Shaly clay and dark blue sandstone.....	3 feet.
Sandstone	3 feet.
Flaggy sandstone	5 feet.
Sandstone	3 feet.

Smooth, flaggy sandstone.....	2 feet.
Massive sandstone	4 feet.
Massive sandstone	5 feet.
Massive sandstone	3 feet.
Shaly sandstone	2 feet.
Massive sandstone	5 feet.
Massive sandstone	4 feet.
Shaly sandstone	1 foot.
Massive sandstone	6 feet.
Massive sandstone	10 feet.
Massive sandstone	4 feet.
Flaggy sandstone	4 feet.
Massive sandstone	6 feet.
Massive sandstone	3 feet.
Massive sandstone	3 feet.
Shaly and massive sandstone.....	7 feet.
Clay	2 feet.
Massive sandstone	5 feet.
Flaggy sandstone—layers varying from 3 to 6 inches.....	15 feet.

The dip of this bed along the river, or to the north, is fully 100 feet per mile, and the strata are well enough exposed to get almost an exact section by working down or up the river and noting each layer as it outcrops above the river bed or bottom. It will be observed from the sections that the lower part is usually massive sandstone, while the upper part is flaggy. The strata, whether massive, flaggy, or shaly, vary considerably along their outcrop, in that they change from one to the other of these. The lower part of the bed is quite persistent in its massive strata, though the layers may often be seen to unite, making a thicker stratum, or divide, making thinner layers.

In Elliott creek, a little above its mouth, the top of this bed outcrops in beautiful smooth flaggy sandstone, the flags are usually from six inches to three feet thick. The strata on the south side of James bend, which seem most likely to be this bed, are as follows:

Eighty to ninety feet of sandstone, near the base of which there is one massive stratum of evenly textured, firm sandstone; below this is a thin stratum of conglomerate with a sand matrix, and only a small per cent of pebbles, which are sub-angular, small, and nearly all siliceous rock of yellowish color. These pebbles generally change color on weathering, or the outer coating of the pebbles changes to a white color. The rest of the bed is composed of strata from a few inches to three feet thick, but a flaggy nature is not usual.

The dip in the western part of James bend is N. 20° W. 175 feet per mile. From the south part of the bend to Elliott creek the dip is to the southeast, at first gentle, but increasing towards Elliott creek, till it is fifty to seventy-five feet per mile. From Shadrick Mill back to the Bend limestone the dip is quite regular to the northwest, or a little west of northwest, and about 150 feet per mile.

Bed No. 8

Southeast and west of the mouth of San Saba river, the top of the ridge at Shadrick Mill, and most likely the clays underlying the Trinity conglomerate northwest of Elliott creek, all belong to a clay bed of from 250 to 300 feet in thickness, which overlies the Shadrick Mill sandstone bed. This clay is somewhat variable, the lower half being much interstratified with sandstone, so that at some localities the sandstone is more prominent than the clay. The upper half is

more nearly pure clay or sandy clay. It has a darker color than is usual for the Strawn clay beds, due most likely to an intermixture of the Bend shale on which it laps. The contact between the clay and shale can not be assigned to any exact line, the graduation of the one into the other being so gradual. The shale outcropping in the Colorado river on the west side of James bend, at and near Bird ford, is decidedly more like the Bend shale than the Strawn clays or shales. About one-half mile east of the mouth of San Saba river the clay is quite fossiliferous, containing the same forms as are found in the Elliott creek bed.

9. Fox Ford Bed

Overlying the above clays, to the west of Fox ford on the Colorado river, and from the mouth of Shaw creek seven or eight miles southwest, is a sandstone bed of about 500 feet in thickness. The dip is usually to the west, from 150 to 200 feet per mile. The lower part of the bed is beautifully exposed on the west side of the river opposite Fox ford, where its outcrop forms bluffs, showing in places fifteen feet of solid rock face without bedding planes.

The lower massive part of the bed is about 200 feet thick; the upper part contains a little clay, and the sandstone near the top is ferruginous, so that it weathers to a redder color than the lower rock. The part of the bed exposed below the mouth of Shaw creek shows some modification, the massive part containing some characteristic carboniferous conglomerate, and the upper thirty to forty feet containing sandstone, generally of a reddish brown or purplish color and uneven structure, weathering into irregular shapes. Over the greater part of this bed the surface is rough and rolling.

10. Horse Creek Clays and Shales

This, the next higher bed, comprises about 150 feet of clays and shales. The most eastern outcrop underlies the cretaceous conglomerate along Shaw and Nabor creeks, thence it extends westward on the north side of the river to Bull creek, thence south, forming the valley of Horse creek and the lower level lands further south along the San Saba-Goldthwaite road.

On Shaw creek the clays are very variable in color—purple, pink, blue, and some yellowish, all being locally represented. The color has, however, been affected by the overlying cretaceous conglomerate. Along Nabor creek there is an exposure of almost 150 feet, the upper 100 feet being usually blue clay, slightly sandy, and containing a few nodules of clay-ironstone, some of which are quite large. Below this, or the lower fifty feet, is a black clay shale, or at places a shaly black clay of nodular structure. The basal part of this fifty feet contains a great many nodules of hard sandstone, which are generally ferruginous, and nearly all contain more or less carbonaceous matter, giving them deeper or lighter shades of color. This bed is probably developed to a greater thickness in the valley of Horse creek than in any other place, but their fresh exposures are few except in the upper part of the bed, where the clay is sandy and contains some thin sandstone.

11. Bull Creek Sandstone

This bed occurs in a narrow thin band, outcropping below the Cretaceous conglomerate from Nabor creek to near Bull creek. At the latter place it thickens and forms a wider belt, running south-

westward along Bull creek valley, across the Colorado river, and from six to eight miles beyond, but thins and is replaced by clay. It is largely composed of flaggy layers, six inches to four feet in thickness; is white on freshly exposed surfaces, and weathers to a grayish color; and is smooth and of regular structure. Its finest exposed development is along Bull creek, where it is fully seventy-five feet thick. Five or six miles south of the river this bed is about fifty feet thick, and has almost the same character as along Bull creek.

The strata usually dip a little west of northwest, but along Bull creek at many places they dip to the north of northwest. Northeast of the mouth of Bull creek they dip to the east and southeast very rapidly over small areas, which will in part account for their extent to the south along the base of the Cretaceous as shown on the map.

12. Big Valley Beds

In this is comprised a lower and an upper clay bed, and an intervening sandstone bed, all of which outcrop in Big Valley, and to the southwest across the river. Both beds of clay extend from under the Cretaceous conglomerate on the north and northeast side of Big Valley to the Bend shale along Richland creek near its mouth. The sandstone bed is exposed along Prescott creek near its head, and is hidden in most of Big Valley by recent drift; it is finely developed and exposed along the river at the mouth of Rough creek, and especially along Rough creek. It is replaced by clay strata before reaching Jerry branch, but again appears capping the escarpments along Richland creek northwest of its mouth. The lower clay bed is about 200 feet thick, generally of blue clay, but containing considerable blackish shale and a very little sandstone. From Big Valley Postoffice down Prescott creek it has a number of good exposures.

The Central Sandstone Bed.—From two to three miles along the head of Prescott creek, or down to within one and a half miles of Big Valley Postoffice, this sandstone forms all of the outcropping Carboniferous. Its development on Rough creek, south of the river, is greater than at any other exposed locality. There it is about 150 feet thick, mostly massive strata, though part is flaggy and a little shaly. Near the top of the bed a little conglomerate is commonly present, and the central and upper parts contain considerable calcareous sandstone and a very little blue, hard, evenly textured, non-fossiliferous limestone. Some of the rock of this strata contains enough iron to give a deep red color to their weathered surface.

The sandstone strata capping the escarpments to the north and northwest of the mouth of Richland creek are usually massive and evenly textured, firm and white on freshly exposed surfaces. The bed here is from ten to thirty feet thick.

Upper Clay Bed.—This bed is fully 150 feet thick, with an outcropping width of about two miles at its north and south ends, but considerably narrower and somewhat thinner west of Rough creek. The clays are usually bluish and sandy, though at places almost black and somewhat shaly. They contain but very little sandstone. West of Big Valley, on the west side of the river, these clays form most of the face of a steep escarpment from 100 to 150 feet high.

13. Brown Creek Bed

This bed, in its outcrop, is continuous from Brown creek, south of Williams Ranch, to the Bend shale, one and a half or two

miles south of Richland creek, and is from one-half to two miles wide. The bed is thickest at the north, gradually thins toward the south, and will average fully 100 feet in thickness. At the mouth of Brown creek the bed has the following development:

- d. White friable sandstone, in layers from six inches to two feet thick..... 40 feet.
- c. Blue clay, through which there are thin partings of clay ironstone 25 feet.
- b. Friable white sandstone, with some thin layers of clay, and some moderately hard sandstone layers..... 75 feet.
- a. Smooth, evenly textured sandstone, the upper part of which is composed of layers from six inches to two feet in thickness.....100 feet.

East and south of the mouth of Pecan bayou the bed contains considerable clay, which, in local places, is more prominent than the sandstone of that horizon; but, as a sandstone bed, it is as a whole nowhere obscured by clay. The friable character of the rock, its white color and coarse sand grains, are characteristic features of most of the bed from the mouth of Pecan bayou to the south.

14. *Spring Creek Bed*

This bed, which is about 300 feet thick, forms a belt from one to four miles wide, and outcrops from Pecan bayou, southwest of Williams ranch, to Richland creek, six miles east of Richland Springs. From the Colorado river south the bed is quite regularly bluish, slightly sandy clay, but from the Colorado river north its middle and lower parts contain considerable sandstone. At the head of China creek there is some sandstone 100 feet below the top of the bed. At the mouth of Spring creek there are from fifteen to twenty feet of sandstone exposed at about the same horizon. From near the mouth of Pecan bayou to the northernmost outcrop of the bed, the following section, made west of the mouth of the bayou, roughly holds good:

- c. Blue clay, more or less sandy.....100 feet.
- b. Sandstone 50 feet.
- a. Clay, with some sandstone..... 50 feet.

The fifty feet of sandstone is finely exposed west and northwest of the junction of the bayou with the Colorado river, and on the east side of the bayou, two miles north of the mouth of Brown creek. Parts of the bed may be seen at the mouth of Spring creek in the Colorado river, and also on some high points two miles east of Rattler postoffice. This sandstone bed contains some calcareous sandstone, a very little hard blue limestone, and, towards the north, has considerable massive strata and some conglomerate. The part of the clay bed overlying this is quite regular in thickness and general characteristics throughout. It usually forms most of a face of an escarpment from 50 to 100 feet high, which extends from Richland creek to Pecan bayou.

15. *Cottonwood Creek Bed*

This bed has an average thickness of about 300 feet, is from one to five miles wide, and extends from Richland creek, northeast of Richland Springs, across Pecan bayou, at and near the mouth of Blanket

creek, to where its further northward extension is hidden by the Cretaceous. Between the Colorado river and Pecan bayou the upper part of its outcrop is covered by the Trinity conglomerate. It is widest and probably thickest in its southern part, and narrows somewhat regularly toward the north. The narrowing is principally due to more rapid erosion cutting back the bed to a more bluffly outcrop. Along Cottonwood creek it contains some clay. At the Colorado river, erosion, irregular bedding, and probably some disturbance, have caused an extension to outcrop as far up the river as the falls opposite Regency. The base or east limit forms the cap rock of an almost unbroken escarpment from Richland creek to Pecan bayou. The contact with the Bend division along Richland creek is marked by sandy clay strata which seems to be the same horizon as this bed and a re-working of the Bend shale.

A considerable part of this bed is composed of friable sandstone of nearly white color, which disintegrates easily. This is especially the case on the divides away from the more erosive action of the streams; so in the southern part, away from the streams, most of the strata are hidden under a loose sand covering. Along Cottonwood creek, Colorado river, King creek, and Pecan bayou the sand is mostly carried away as the rock disintegrates and the strata are better exposed, or often exposed in bluffs and benches. The beds are usually massive, and in many places outcrop, showing a thickness of from ten to twelve feet without bedding-planes. Some of these beds are very hard and usually of even texture and structure. Along Pecan bayou about half the bed is composed of massive strata, the layers of which are from three to twelve or even fifteen feet in thickness, and no part of the bed is shaly. The rock is moderately hard, but usually of uneven texture, as shown by the weathered surfaces, which are rough and very much cracked.

Occasionally small cavities may be seen, which are filled with limonite. The upper strata are especially ferruginous, and the sandstone and clay exposed are very red. Small fragments of siliceous rock are sparsely scattered through the greater part of the bed, and near the top is a stratum of conglomerate or breccia of this material.

16. Hanna Valley Bed

This clay bed extends from two miles east of Richland Springs to a little above the junction of Blanket and Pompey creeks, where it passes under the Cretaceous. It is also covered by Cretaceous conglomerate from the north side of Hanna valley to within about two miles of Pecan bayou. It varies very much in thickness and width of outcrop. At the south end it is very narrow and indistinct, and can be located mainly by its forming a small valley which rapidly widens to the north, exposing the nature of the strata. From about three miles almost directly north of Richland Springs there is an overlying sandstone bed which forms an escarpment facing the east and extending to just west of the head of Mesquite branch, or to within two and one-half miles of the Colorado river. At the south end of this escarpment no clay can be seen at its base, because the bed is thin and covered with sand from the overlying and underlying beds; but to the north the bed thickens, erosion is greater, and possibly the dip of the strata less, so the clay outcrops begin to show, and near the Colorado river the outlines of the bed are clearly marked. At that point the outcrop is over two miles wide and the bed about 200 feet thick. On the north side of the river it has even a greater development, spreading out over all Hanna valley. On Pecan bayou it is usually not more

than one mile wide. This bed contains some little shaly sandstone at places, as along Mesquite creek, south of the Colorado river, and near the top of the bed on the north side of Hanna valley.

The upper part of the freshly exposed outcrop is often of a purplish color, especially where it underlies the Trinity conglomerate, as along Pecan bayou. In some places the amount of sand is considerable, but never more than the clay.

17. Rough Creek Bed

This sandstone bed extends in a belt, two to three miles wide, from about one and a half miles north of Richland Springs to two miles north of Colorado river, where it begins to be interstratified with clay beds of considerable thickness. This modification of the bed increases to the north, so that along Pecan bayou, Blanket, and Pompey creeks, there are alternating beds of sandstone and clay, forming a belt about three miles wide. South of the Colorado river this bed, at the surface, is very much disintegrated, so that the sand obscures its true nature. On the north side of the river, and up Rough creek, some distance from its mouth, a considerable exposure occurs in bluffs, which shows the greater part to be massive, moderately tough, and hard sandstone. Along the outcrops of this bed soft flaggy sandstone, including sandy clay, is in places of considerable thickness, and near the head of Rough creek, these friable sandstones, with thicker beds of sandy clay, cover a considerable area.

Along Pecan bayou, Blanket, and Pompey creeks, the bed is divided into three distinct parts, and in some places into five. The lower part consists of about 150 feet of sandstones, usually massive and containing considerable conglomerate, especially at the top. Some of this conglomerate on the south side of the bayou is very hard and enduring, and forms a bluff from fifteen to twenty feet in height. Local masses of the rock are especially enduring, and while the main bed is eroded away to the westward, these local harder masses, some of which are from eight to ten feet in diameter, are left 200 or 300 yards away from the bluff or unbroken face of the bed. Above the sandstone and conglomerate is about fifty feet of sandy blue clay; this is in turn overlaid by from twenty-five to forty feet of sandstone, which is not so massive as the lower beds. The upper sandstone, along the bayou, is more or less divided near its middle by clay strata. The dip of this upper bed, as shown on the north side of the bayou, is only about sixty to seventy-five feet per mile.

18. Buffalo Creek Bed

This clay bed is about 125 feet thick and two miles wide along Pecan bayou; northeast of Hydesport, and at the head of Buffalo creek it is fully as wide, but from there towards the south it thins and narrows rapidly, so that south of the Colorado river, along Hog creek, it is but from one-fourth to one-half mile wide, and before reaching the Bend division on the north side of Richland creek entirely ends, or so nearly so that the sand from the disintegrating overlying and underlying sandstone entirely obscures it. The southern part of the bed is more sandy, and along Buffalo creek thin strata of sandstone occur in some localities. On Pecan bayou the lower part is slightly shaly, sandy, and of a blue color. The middle and upper portions of the bed vary in color from blue to purple and yellowish. The dip along the bayou, as indicated by the included sandstone strata at top and base of the bed, is not over seventy-five feet per mile.

19. Wilbarger Creek Bed

From one-quarter to one-half mile northwest of Richland Springs to four miles north of the Colorado river this bed of sandstone is quite regular, and from two to two and one-half miles wide, and about 200 feet thick. Along Pecan bayou, at the Mills-Brown county line, it is about a mile wide, and from 75 to 100 feet thick. South of the Colorado river, along Wilbarger creek, and north of the river along Rocky creek, the strata are very massive and very characteristic of the Strawn sandstone. Along the bayou the beds are as a rule less massive, but the rock possesses the same general character. The south end of the bed is covered by deep sand.

20. Comanche Creek Bed

From the north side of Richland creek valley, the outcrop of this clay bed runs quite regularly N. 20°-25° W., in a belt two and a half to four miles wide, to north of Comanche creek, where it is covered by Cretaceous conglomerate. Along Pecan bayou the bed includes the clays above the Wilbarger creek bed to a little above Doudle creek. It averages about 300 feet in thickness, and in the southern part, or from Comanche creek south, it is divided into three parts by a thin sandstone bed, which extends from Comanche creek to the southern limit of the bed with remarkable uniformity. Usually but from eight to ten feet of hard and massive sandstone are shown, but from ten to fifteen feet more of shaly friable sandstone and clay are associated with it. This sandstone forms an escarpment most of the way from the river south to Richland creek valley; but at and a little south of Martin's gin, on the Brownwood-Richland Springs road two miles south of the Colorado river, only loose sand marks the outcrop of the bed. The clays underlying this are about seventy-five feet thick, and generally very sandy. Good exposures of the clay and underlying sandstone may be seen on the north side of Bowser bend, and two to three miles north of the "Hall" springs on Richland creek. At this latter place the clay is about 100 feet thick and forms a beautiful level valley, covered with mesquite trees and grass.

The upper part of the Comanche creek bed is composed of bluish clay containing a very little sandstone. It is very sandy in some localities next to the overlying and underlying sandstone beds. Its outcrop forms a dark rich soil, and is usually marked by a growth of grass and mesquite trees. On Pecan bayou higher clay beds overlie this, and, their characteristics being the same, no exact limit can be placed for the top of the bed.

21. Antelope Creek Bed

The bed of sandstone is very variable and more of a local deposit. West of the head of Wilbarger creek it is one mile wide; three miles south of the Colorado river it is fully four miles wide; at the river it is two miles wide; southeast of Indian Creek Postoffice it is one-fourth mile wide, and is not definitely represented as a sandstone bed in Pecan bayou valley. The character of the rock varies from friable to hard, pure to clayey sandstone, contains a very little conglomerate, and along Antelope creek clay is common. The best exposures of the bed are along the north side of the Colorado river, and from there north to the Indian creek-San Saba road.

22. *Indian Creek Bed*

As shown on the map, this bed replaces quite rapidly the underlying and overlying sandstone to the north by a change of the sandstone to clay. At the head of Indian creek and along Pecan bayou it is fully three miles wide, and contains very little sandstone, though shaly, sandy clay is common. South of the Colorado river the bed narrows rapidly and can only be traced by an overlying escarpment of sandstone and the outcrop of clayey material near the base. Along the bayou the Antelope creek sandstone is wanting, so the Indian creek clay rests on the Comanche creek clay and makes an almost continuous clay bed along the valley below the Trinity conglomerate from two miles below the mouth of Doudle to Stepp creek.

23. *Ricker Bed*

Stepp creek basin extends through this bed down into the Indian creek clay, leaving the isolated butte at Ricker and the south and southwest facing escarpment south of Ricker capped with the sandstone and conglomerate of this bed, while the unbroken outcrop extends down the west side of Stepp creek, across Pecan bayou, and caps a high escarpment which runs east of south back to the Trinity conglomerate. At none of these outcrops is this bed more than one-half mile wide. It is only slightly represented on the south side of the Trinity conglomerate on some of the head branches of Indian creek. Further south, through Indian creek valley, it is replaced by clays until a point west of Indian Creek Postoffice is reached, from where it appears again and rapidly thickens, till, at the mouth of Clear creek, it is about 200 feet thick and one and one-half miles wide, and continues thus to the south to some four miles southeast of Milburn, where it overlies, or joins, the Antelope bed back to the Trinity conglomerate covering. The short, narrow belt of sandstone at the base of the Cretaceous on the south side, some two miles southeast of Lookout mountain, is the southernmost limit of the bed. At that point it laps on the Bend shale. The sandstone of this bed in the Colorado river basin is usually massive, firm, and of a light gray or brownish color. There are some local deposits of clay, and a very little conglomerate. In the Pecan bayou basin the bed is about fifty feet thick, and its character is more variable than in the Colorado river basin. On the south side of the bayou there is but little conglomerate, the sandstone is mostly white, fine-grained, and smooth surfaced, though some of it is slightly conglomeritic or ferruginous, or both. On the north side the sandstone is usually massive, firm and has enough iron to give the weathered surface a reddish color. Conglomerate is very common in all the outcrops, especially at Ricker. Both north and south of the bayou there are from twenty-five to seventy-five feet of clay overlying the sandstone. From its position it seems most properly to belong to the Strawn division. This clay is more or less sandy, contains selenite flakes in places, and generally has a bluish color, though purple or yellowish clays occur near the Trinity conglomerate on the north.

With this bed we practically have the close of the uniform series of shore or near shore deposits so characteristic of the Strawn division. So this bed has been placed the uppermost in that division.

CANYON DIVISION

This division is composed of clay and limestone beds with some included sandstone and conglomerate. It has a thickness of about

800 feet, and sections Nos. 2 and 3 across it show its beds and groups, which have been named as follows:

12. Camphophylum bed.
11. Bluff creek bed.
10. Home creek bed.
9. Hog creek bed.
8. Chert bed.
7. Bed No. 7.
6. Clear creek bed.
5. Cedarton bed.
4. Adams Branch limestone.
3. Brownwood bed.
2. Rochelle conglomerate.
1. Coral limestone bed.

1. Coral Limestone Bed

This bed, with a width of more than a mile, east of Brownwood, thins to the south, and practically ends four miles west of Indian Creek Postoffice. But one and one-half miles west of the mouth of Clear creek there is a limestone stratum from two to three feet thick belonging to it. It is probably not over forty feet thick at any place, and is considerably interstratified with clay east and south of Brownwood. South of Willis creek, along the San Saba-Brownwood road, and northwest of Indian Creek Postoffice, the bed is massive limestone from ten to twelve feet thick. It can be easily recognized wherever seen by the peculiar coral *Teradium?*, which it always contains in abundance, and which has been found in no other bed. The limestone is of uneven texture, and, when exposed, cracks and weathers into irregular shaped masses and rough surfaces.

Either the original bedding of this limestone was very limited, or erosion contemporaneous with deposition, cut off the bed to the west; for, from two to three miles west of its outcrop, deep well sections do not pass through it. The following are some of the fossils found in this bed: *Teradium?*, *Athyris subtilita*, *Athyris sp.?*, *Productus costatus*, *P. longispinus*, *Meekella striato-costata*, *Spirifer cameratus*, *S. organensis?*, *S. lineatus*, *Nuculana bellistriata*, *Schizodus sp.?*

2. Rochelle Conglomerate*

At the southern limit of the base of the Canyon division there is a conglomerate bed from twenty-five to fifty feet thick, which seems to have been deposited shortly after the coral limestone; for the strata near Milburn, which most likely form part of this bed, are somewhat above the base of the Brownwood clays. From Onion creek past Rochelle to the head of Deep creek it is very regularly from twenty to thirty feet thick, one-fourth mile wide, and a conglomerate more or less distinct from that usually found in the Colorado coal field. From north of Cowboy almost to Milburn there are from 25 to 100 feet of sandstones, clays, and conglomerates at the base of the Canyon division, which are most probably a further extension and modification of the Rochelle conglomerate bed. The conglomerate near Milburn is, however, more nearly the typical conglomerate of the Texas Coal Measures. The characteristics which distinguish the Rochelle conglomerates are as follows: Matrix and

*Preliminary Report on the Coal Fields of the Colorado River, by Ralph S. Tarr. First Annual Report Geological Survey of Texas, 1889, p. 205.

included pebbles exceedingly hard and susceptible of a high polish.† The included siliceous pebbles are small, angular, and of hues of white, brown, gray, yellow, red, and black. The matrix is a ferruginous sand of like material, with white quartz grains. In some places, where the rock is composed mostly of sand, it is almost a quartzite. In this bed there is a graduation from this conglomerate to the ordinary conglomerate and sandstone.

The boulders near the Brady-Menardville road, four miles south of Brady, are remnants of this bed, the part connecting it with the conglomerate to the north having been eroded and carried away by Brady creek. The local and variable character of the bed may be seen from its exposure southeast of Milburn, where from ten to fifteen feet of the conglomerate caps a thicker clay stratum, forming an escarpment facing west and north. The conglomerate does not occur west of this escarpment; its thinning edge to the west having been worn away, so that it is now left terminating abruptly. Farther to the south and east, the underlying clay includes lenticular beds of sandstone and conglomerate.

3. Brownwood Bed

This bed, principally clay, is quite uniformly two and one-half to three miles wide, and 200 to 250 feet thick, from two miles south of Clio to five miles south of Cowboy. From the latter place it narrows rapidly to the south and ends near Onion creek, southwest of Rochelle. The greater part of this bed is bluish, slightly sandy clay, though dark blue to black carbonaceous shaly clay, or even shale, is common at the southern end, and lenticular sandstone beds of considerable extent occur in places. It contains two quite persistent horizons of sandstone, one near the middle of the bed, and one at and near the top. These two horizons comprise nearly all of the sandstone strata of the bed. The lower sandstone extends from near the mouth of Salt creek, past the west side of Brownwood to Clear creek, with possibly some breaks. The Rochelle conglomerate may probably belong to this horizon. Southwest of Brownwood, at one of the best developed occurrences of this sandstone, it is from twenty-five to thirty feet thick, but has only five to six feet of pure sandstone, the rest being friable or more or less argillaceous. The better rock has been quarried for building purposes in Brownwood.

North of Clear creek to the Cretaceous conglomerate southwest of Brownwood, there are two sandstone horizons, each more or less marked by disintegrated sandstone at the surface. The sandstone horizon at and near the top, while very changeable and wanting at a number of places, is nevertheless usually present to some extent. Along the Pecan bayou it is from twenty to thirty feet thick and forms bluffs. Usually it is not more than ten to fifteen feet thick and of a coarse friable nature.

The clays are very rich in fossils at many localities, and show different groups of fauna at different places. The bed varies somewhat in character of material. South of Clio, across Salt and Elm creeks, its development is as follows: About 275 feet of clays, usually blue when first exposed, but change gradually to a purplish or yellow on long exposure, are more or less arenaceous, and at places slightly shaly, as along Salt creek, near the Brownwood-Cisco

†The surfaces of many of these outcropping conglomerate masses that have been long exposed are beautifully polished. See Geological Survey of Texas, Report 1889, p. 156.

road; and at nearly every outcrop there is clay ironstone in very thin nodular layers; sandstone and calcareous sandstone are interstratified, as the following section shows:

k. Blue clay	20 feet.
j. Sandstone, mostly massive and forming bluffy escarpments	15 to 25 feet.
i. Sandy clay	25 feet.
h. Sandstone, calcareous at places.....	4 to 5 feet.
g. Clay, highly fossiliferous.....	40 feet.
f. Sandstone, usually massive, but sometimes false-bedded and shaly.....	4 to 6 feet.
e. Clay, slightly shaly and fossiliferous at the top..	75 feet.
d. Sandstone, part of which is calcareous.....	4 to 5 feet.
c. Blue clay	25 feet.
b. Sandstone, calcareous at places.....	5 to 6 feet.
a. Blue clay, top part fossiliferous.....	50 feet.

Between three and five miles south of the Brownwood-San Saba road, the clays are interstratified with some thin ferruginous limestone which is rich in fossils, as is also the contact clay. Along Clear creek, at some localities, the clays are slightly shaly, especially near their base, where from two to three inches of coal has been found in five or six inches of pure shale. At Milburn similar coal seams and more shale have been passed through in some of the wells. Below Post's mill, on the Colorado river, carbonaceous or shaly clay outcrops, which is practically the base of the bed. Along the Colorado river, above the Brownwood-Milburn road crossing, the clay is usually of a blue color, sometimes purplish, and sometimes containing enough carbonaceous material to make it black. The black shale is mostly the lower stratum, and the dark color is usually increased by being moistened. At one point on the north side of the river there are fully thirty feet of shaly clay exposed, which contain three seams of calcareous, rough-surfaced sandstone; the lower seam towards its outcrop down the river increases in thickness and proportion of lime until it becomes two to three feet thick, with only a small proportion of sand. At Milburn calcareous, carbonaceous nodules are scattered through some of the shaly clay. West of Cowboy the upper part of the bed shows the following section:

d. Clay, highly calcareous and fossiliferous at the top....	35 feet.
c. Shale, black to purple, and full of <i>Calamite</i> impressions	8 feet.
b. Sandstone	6 feet.
a. Bluish clay	40 feet.

This bed, which contains some shale and a very little sandstone, underlays Deep Creek valley. The following are some of the fossils found in this bed: *Fusulina cylindrica*, *Palaeospongia*, *Lophophyllum proliferum*, *Michellina*, *eugeneae*, *Chetates*?, *Zeacrinus acanthophorus*, *Archaeocidaris*, *Chonetes verneuilliana*, *Discina convexa*, *Athyris subtilita*, *A. sp.*?, *Hemipronites crassus*, *Productus costatus*, *P. semireticulatus*, *P. longispinus*, *P. cora*, *P. punctatus*, *P. nebrascensis*, *P. symmetricus*, *Meekella striatocostata*, *Retzia mormoni*, *Spirifer planconvexa*, *S. cameratus*, *S. organensis*?, *S. lineatus*, *Spiriferina kentuckiensis*, *Terebratulina bovidens*, *Conularia crustula*, *Pleurotomaria sphaculata*, *P. tabulata*, *P. sp.*?, *P. brazoensis*, *Bellerophon sp.*?, *B. nodocarinatus*, *B. corbonarius*, *Euomphalus rugosus*, *E. sp.*?, *Macrochilus medialis*, *M. texanus*, *Nautilus sp.*?, *Goniatite sp.*?, *Orthoceras rush-*

ensis?, *Conocardium obliquum*, *Lima retifera*, *Aviculopecten occidentalis*, *A. sp.?*, *Allorisma subcuneata*, *Myalina sp.?*, *M. subquadrata*, *Nuculana bellistriata*, *Nucula ventricosa*, *Phillipsia sp.?*, *Petalodus destructor* (the last determined by E. D. Cope.)

4. Adams Branch Limestone

This bed extends from about two miles south of the mouth of Jim Ned creek to opposite the east end of Brady mountains, and possibly further south. It has a thickness of from twenty-five to thirty feet and an outcrop of about one and one-half miles in width. It thins rapidly to the north from northwest of Brownwood. From about five miles southwest of Milburn it thins to the south and forms only a narrow bench on the face of the escarpment on the west side of Deep creek valley.

This bed forms a prominent topographical feature almost throughout its entire length, it being the capping of an almost continuous escarpment from near Pecan bayou, north of Brownwood, to the head of Deep creek, and is usually well exposed throughout. Among the best typical outcrops is the one along the head of Adams branch, west of Brownwood, where it is about thirty feet thick, of a bluish color on weathered surfaces, though almost white before exposure; is hard, fossiliferous, unevenly textured, and weathers to rough-surfaced, seamy boulders. The bedding planes, though not well shown before the rock weathers, are very conspicuous in the edges of the outcrop; they are not smooth, but wavy and irregular. There is but little variation of a bed at different localities, but southwest of Milburn, where it decreases in thickness, its base is somewhat arenaceous, and the probable representative, four miles south of Clio, is as follows:

- c. Sandy limestone, with clay partings. 10 feet.
- b. Concretionary white limestone. 5 feet.
- a. Hard, brittle, evenly textured limestone. 2 feet.

The following fossils have been collected from this bed: *Fusulina cylindrica*, *Lophophyllum proliferum*, *Chonetes granulifera?*, *Athyris subtilita*, *Productus longispinus*, *P. cora*, *P. punctatus*, *Meekella striatocostata*, *Spirifer plano-convexa*, *S. lineatus*, *Bellerophon carbonarius*, *B. percarinatus*, *Euomphalus sp.?*, *Aviculopecten sp.*, *Myalina subquadrata*.

5. Cedarton Bed

Overlying the Adams branch limestone throughout its extent is a bed of sandy bluish clay containing some sandstone, the latter is usually gritty or conglomeritic. The bed is quite uniformly forty to sixty feet thick, but in extreme cases is from ten to eighty or ninety feet thick. Its outcrop is usually very narrow, since it occurs mostly in the face of an escarpment.

About three miles south of the mouth of Jim Ned creek, and from Willis creek to Cedarton, there is more or less coarse-grained and conglomeritic sandstone. The prevailing color of the clay is blue, but purple, red, and yellowish-colored outcrops may be seen at a number of localities.

From Cedarton to Clear creek the bed is somewhat thinner, and is not exposed in an escarpment, but from Clear creek to six or seven miles south of the Colorado river it is at the base of an almost continuous escarpment. From five to ten feet of coarse-grained

sandstone at the top of the bed continue most of the way from Cedarton to within three or four miles of the Colorado river. From the river, three or four miles south, the bed is almost regularly purple clay, from forty to sixty feet thick, and rich in fossils. From five miles south of the river it thins rapidly, so that six or seven miles south or west of south from Milburn it is but from ten to twenty feet thick, and is more calcareous, containing nodules and fragments of limestone. From this point to the head of Deep creek the bed is from ten to fifteen feet thick, and outcrops along a little bench at the top of the escarpment facing Deep creek valley on the west. Two miles west of the San Saba-Brady road crossing of Onion creek there is an escarpment of slight elevation, five to twenty feet high, to the east and south of which are blue clays that are very fossiliferous, and the fossils indicate that it is most probably the Cedarton bed. Only well sections could be seen, as the surface is level and unbroken.

Fossils of this bed are: *Lophophyllum proliferum*, *Chetetes?*, *Chonetes verneuiliana*, *Discina convexa*, *Athyris subtilita*, *Hemipronites crassus*, *Productus costatus*, *P. semireticulatus*, *P. longispinus*, *P. punctatus*, *P. nebrascensis*, *P. cora*, *P. flemingi*, *Meekella striato-costata*, *Retzia mormoni*, *Rhynchonella uta*, *Spirifer plano-convexa*, *S. cameratus*, *S. lineatus*, *S. texana*, *Spiriferina kentuckiensis*, *Terebratula bovidens*, *Pleurotomaria sphaerulata*, *P. sp.?*, *P. brazosensis*, *P. sp.?*, *Beleroophon carbonarius*, *B. percarinatus*, *B. nodocarinatus*, *Euomphalus rugosus*, *Macrocheilus primigenius?*, *M. medialis*, *M. texanus*, *Nautilus sp.?*, *Orthoceras sp.?*, *Conocardium obliquum*, *Aviculopecten occidentalis*, *Myalina subquadrata*, *Nuculana bellistriata*, *Nucula ventricosa*, *Longispina plicatula?*

6. Clear Creek Bed

This bed is practically all limestone from its southern limit to the Gulf, Colorado and Santa Fe Railroad. From this point north it contains considerable clay. The southern limit of the bed laps on the Bend limestone near the San Saba-Brady road, from two to four miles east of Brady. It extends under the east end of Brady mountains, and down either side of Corn creek to the Colorado river. This belt is from one to two miles wide, and the included limestone from twenty to forty feet thick.

From the Colorado river to Clear creek, southwest from Cedarton, the bed is but from one-half to one mile wide, and somewhat thinner than south of the river. From southwest of Cedarton to the north it thickens rapidly and widens, being from two to four miles wide, to the Gulf, Colorado and Santa Fe Railroad. From this point to the north it is divided by a clay bed from twenty to fifty feet thick, the upper limestone bed being from five to fifteen feet thick, and having an outcrop of about one-fourth of a mile wide. The clay bed forms a very narrow outcropping band. The lower limestone is from twenty-five to seventy-five feet thick, and has an outcropping belt from two to four miles wide.

The general characteristics of the limestone of these beds are approximately the same as those of the Adams branch limestone. There are, however, local variations, some of which will be briefly noted as follows: About four miles east of Brady the basal limestone makes a slight escarpment on the south side of Onion creek to the San Saba-Brady road, and with this exception there are no good exposures south of the Brady mountains. West of the head of Deep creek, Lookout mountain and Cowboy, the bed is about twenty-five

feet thick, and its basal part extends to, or nearly to, the escarpment, and contains some clay or argillaceous limestone horizons. West of Milburn a section of the bed is as follows:

- c. Hard crystalline limestone, which on weathered surfaces has a dark brown color..... 2 feet.
- b. Clay, mostly purple, sometimes bluish or yellowish.....10 feet.
- a. Massive blue, rough-surfaced limestone.....30 feet.

The two top strata may not belong to this bed, but from their occurrence seem to. West of Brownwood the bed is from fifty to sixty feet thick, and at a number of places, as shown by excavations for tanks and wells, has disintegrated to a depth of ten or fifteen feet, leaving only small nodules of solid limestone scattered through the soft white chalk-like disintegrated material. South of Jim Ned creek a section of the bed is as follows:

- c. Massive limestone..... 10 feet.
- b. Clay40 to 50 feet.
- a. Massive bedded, rough surfaced limestone.....25 to 30 feet.

All of these beds slightly thicken to the north. The clay bed extends on the east side of Pecan bayou, up the west and north side of Rocky creek, and near the mouth of Rocky creek is from fifty to sixty feet thick. The lower limestone bed, about four miles southwest of Clio, has the following development:

- b. Limestone, which, to a small degree, has the following qualities: Sandy, ferruginous, argillaceous, fossiliferous and shaly.....10 feet.
- a. Limestone, massive, bluish and slightly arenaceous at the base. It weathers to rough irregularly surfaced boulders and to small nodular pieces, the surface of which weathers to a porous structure.....30 feet.

There are also some lower strata that may belong to this bed, which, most probably, should be placed with the Adams branch limestone and Cedarton beds. Some of the fossils of this bed are the following: *Lophophyllum proliferum*, *Archaeocidaris* sp.?, *Athyris subtilita*, *Productus costatus*, *Spirifer cameratus*.

7. Bed No. 7

Overlying the Clear creek bed, throughout the Colorado Coal Field, there is a bed of clay 25 to 100 feet thick, and quite regularly 50 to 60 feet thick. Its occurrence south of the Brady mountains is obscured by the level nature of the surface, but it was approximately located at a few points.

From the Brady mountains north it forms the base and greater part of an almost unbroken escarpment to the north side of this field. From the north side of Brady mountains to four or five miles south of the Colorado river there is a thin limestone stratum near the middle of the bed. On either side of the Trickham-Milburn road for one or two miles there is some coarse-grained sandstone at the top of the bed, and from the west fork of Clear creek to near Jim Ned creek it contains from five to ten feet of coarse-grained sandstone and grit or conglomeritic sandstone. From Jim Ned creek to the south the clay is usually quite sandy, but north of that creek it is purer and more fossiliferous, especially along Pecan bayou. A few localities, representing the variations, are as follows:

About five miles southwest of Cowboy, or west of Lookout Mountain, the bed consists of from forty to fifty feet of clay, parted near the middle by two or three feet of dark colored limestone, which in some places is overlaid by a thin stratum of limestone. Due west of Milburn a section of the bed is as follows:

c. Clay	20 feet.
b. Limestone	5 to 8 feet.
a. Clay	20 feet.

The bed increases in thickness to the north for ten or fifteen miles. Southwest of Brownwood it is from thirty to fifty feet thick and the clay is sandy, reddish to purple in color, and capped by from five to six feet of grit or conglomeritic sandstone. South of Jim Ned creek a section gives the following:

c. Clay	15 feet.
b. Sandstone, cross-bedded and flaggy.....	10 feet.
a. Clay	40 feet.

North of Jim Ned creek the bed loses its sandstone and most of its sand, and the clays become very fossiliferous. Its exact outcrop on Hog creek is obscured by Trinity sand drift.

The following fossils were collected from this bed: *Lophophyllum proliferum*, *Athyris subtilita*, *Athyris* sp.?, *Meekella striato-costata*, *Productus cora*, *P. symmetricus*, *P. nebrascensis*?, *Rhynchonella*, sp.?, *Spirifer planoconvexa*, *S. cameratus*, *Spiriferina kentuckiensis*, *Terebratula bovidens*, *Conularia crustula*, *Pleurotomaria sphaerulata*, *P. tabulata*, *P. brazoensis*, *P. sp.*?, *Bellerophon carbonarius*, *B. nodacarinatus*, *Euomphalus rugosus*, *Platyceras nebrascensis*, *Orthoceras rushensis*?, *Conocardium obliquum*, *Aviculopecten occidentalis*, *Myalina subquadrata*, *Nucula ventricosa*, *Petalodus destructor*.

8. Cherty Limestone Bed

This bed is distinguished throughout by having abundant chert nodules, many of which contain *Fusulina* fossils. In some localities the chert is all through the bed, at other places it is confined to a special stratum, or to definite horizons. Chert occurs in only one or two other beds of the Canyon division, and in those beds it is extremely rare, so this cherty limestone bed is made especially distinct by the abundance of the chert nodules it contains. The limestone fractures readily on exposure, and is hard and massive. It has an average thickness of about sixty feet, though somewhat thicker along the Colorado river than further to the north.

On the south side of the Brady mountains level land, deep soil and slow erosion make the outline of the bed difficult to determine. On the north side of the mountains, however, the slope of the country is greater, erosion is more rapid, and there is not much accumulation of soil, so the bed is well exposed. Often the bare, massive, rough limestone is at the surface, and its outcrop from the mountains to the Colorado river is four to five miles wide. From the river to five or six miles north, or to the Trickham-Milburn road, it narrows till at the road it is but about one-half mile wide. The greater width of the bed along the river is principally due to the gentle dip of the strata, it being but twenty to thirty feet, or even less, per mile. The somewhat greater thickness of the bed also extends its outcrop there. From the above named road to the north its outcrop varies from one to three miles in width.

The bed passes under the Trinity conglomerate about two miles east of Bangs, crosses the Pecan bayou about four miles above the mouth of Jim Ned creek, and crosses Hog creek at the Cisco-Brownwood road.

The following section was made of the upper part of the bed on the south side of the Colorado river, near the mouth of Cedar creek:

- | | |
|---|----------|
| d. Massive limestone | 3 feet. |
| c. Wavy bedded nodular limestone, containing chert nodules | 5 feet. |
| b. Nodular structured limestone, with clay seams and pockets along the bedding planes | 10 feet. |
| a. Hard, brittle, massive limestone, with numerous chert concretions, some of which are almost pure flint.... | 10 feet. |

At the place of this section the base of the bed was not seen, but further down the river there is exposed, below stratum "a" about thirty feet of limestone including four to five feet of clay. About one mile above the mouth of Home creek the chert horizons are all united in one twenty-five foot stratum of hard, brittle, slightly brownish limestone, throughout which the flint or chert nodules lie in almost every plane. No single horizon seems to be more abundant in chert than another, and the irregular extension of the nodules lies in every place, apparently as common one way as another. This stratum weathers in angular fragments or boulders, which in turn crumble to angular small fragments. The face or surface of the outcropping rock is usually smooth, except for the numerous cracks and little crevices and angular openings where pieces of rock have fallen out. This stratum is overlaid by four to five feet of massive hard blue limestone and underlain by similar rock.

The bed thins to the north, till east of Bangs it is about twenty-five feet thick, but the chert still remains a prominent feature. Southwest of Brownwood the bed contains some ferruginous strata which weather to a dark brown, or in some cases to a yellowish color.

South of Jim Ned creek the bed is fully forty feet thick and has chert pretty regularly distributed through it. Between Jim Ned creek and Pecan bayou it is about thirty feet thick, and has a dip of thirty to thirty-five feet per mile. Just south of Jim Ned creek, along Rocky creek, there is a local area where the bed dips sixty to seventy feet per mile. East of the bayou and along Hog creek it is fully two miles wide and thirty to forty feet thick, the flints or chert nodules are of light color and are at and near the basal part of the bed.

Fossils collected from this bed are as follows: *Campophyllum torquatum*, *Zaphrentis*, *Lophophyllum proliferum*, *Cheteles*?, *Archaeocidaris* sp.?, *Chonetes granulifera*, *Chonetes verneuilliana*, *Discina nitida*?, *Athyris*?, *Athyris subtilita*, *Hemipronites crassus*, *Productus costatus*, *P. longispinus*, *Meekella striato-costata*, *Productus cora*, *P. symmetricus*?, *P. pertenuis*, *P. flemingi*?, *P. nebrascensis*, *Retzia mormoni*, *Rhynchonella uta*, *Spirifer plano convexa*, *S. cameratus*, *S. lineatus*, *S. texana*, *Spiriferina kentuckiensis*, *Terebratula bovidens*, *Pleurotomaria sphaerulata*, *Goniatite* sp.?, *Allorisma subcuneata*, *Nucula ventricosa*, *Phillipsia* sp.?

9. Hog Creek Bed

This bed, which overlies the cherty limestone, is in the southern part of the field, a mere parting between the higher and lower beds, but thickens to the north until from north of Home creek to the

north it is in most parts easily located. On the south side of Colorado river, along the west side of Clear creek, this bed can be located by its causing a slight bench to be formed above the cherty limestone bed. Near the mouth of Cedar creek it is ten feet thick and contains some thin impure limestone partings. Two miles above the mouth of Home creek it is ten to fifteen feet thick, and from there on to the West Fork of Clear creek it forms the basal part of a prominent escarpment. East of Trickham the bed is fifty feet thick and slightly fossiliferous. Two miles southeast of Bangs it is sixty to seventy feet thick, its outcrop, one-half to three-fourth of a mile wide, and is slightly fossiliferous. The clay is not very arenaceous; in fact there are no sandstone strata in the bed south of the Gulf, Colorado and Santa Fe Railroad, but north of the railroad, sandstone, and often conglomeritic sandstone, forms a prominent feature. South of Jim Ned creek it is seventy feet thick, the lower sixty feet a bluish to yellowish clay, very sandy in the upper part, while the top ten feet of the bed is white flaggy sandstone. This sandstone thickens toward the north, until where it crosses the bayou it is twenty feet thick and very massive; the weathered surface is of reddish color. The sandstone of this bed is very variable in its development, showing a wide difference in thickness in adjacent localities. This local variation is well shown along Hog creek, where the valley or basin of the creek extends down through the sandstone and most of the Hog creek bed. The isolated buttes or areas left on the east side of the creek have, at or near their tops, from fifteen to thirty feet of sandstone strata, while on the west side of the valley there are but four or five feet, or most generally none, which shows that the bed thins to the west, or does not extend far back under higher horizons, and that the erosion of Hog creek valley has carried away most of this thinning westward or seaward extension. From one to two miles up Hog creek from its mouth this bed is fully 100 feet thick, and almost all clay or sandy clay, with a very little shaly sandstone. The following section was made one mile west of the Brownwood-Cisco road crossing Hog creek:

h. Clay	20 feet.
g. Sandstone	1 foot.
f. Clay	4 feet.
e. Sandstone, rough surfaced	2 feet.
d. Clay	15 feet.
c. Sandstone, massive and rough surfaced at the top, but smooth, white and firm in the middle part	30 feet.
b. Blue clay	50 feet.
a. Cherty limestone bed	

10. Home Creek Bed

This limestone bed is twenty-five to fifty feet thick and forms an outcropping belt one-half to three miles wide. It occurs south and north of Brady, but its boundaries are indefinite. From the north side of Brady mountains to the Colorado river the outcrop of the bed extends from Cedar creek to Bluff creek, which belt is two and a half to three miles wide. From the mouth of Cedar creek to a little above Home creek the bed is about half a mile wide, its outcropping edge being worn back to a steep or bluff escarpment. It crosses Home creek about one and a half to two and a half miles above the mouth, and from there its outcrop widens rapidly for four or five miles to the north till it is about three miles wide, then narrows and remains quite regularly one to one and a half miles

wide. As shown on the map, it extends along the West Fork of Clear Fork of Clear creek south of Bangs, two to three miles east of Thrifty and along the west side of the lower part of Hog creek valley. South of the Colorado river the bed is twenty-five to thirty feet thick, and all limestone strata. West of the mouth of Cedar creek the exposed part is as follows:

- b. Friable limestone..... 10 feet.
- a. Massive blue limestone..... 12 feet.

Along Home creek, one and a half to two miles above its mouth, the bed is thirty to thirty-five feet thick, the lower twenty-five feet being hard blue rough-surfaced massive limestone. The dip along the Colorado river, near the mouths of Home, Cedar, and Bluff creeks, is so small that isolated patches or fragments lay back east of the main line of outcrop. From near Home creek to the north the bed is parted by a clay bed of ten to thirty feet in thickness, and north-east of Trickham the upper limestone bed is also parted by a thin clay bed. Along the West Fork of Clear creek the clay strata are usually highly calcareous and difficult to locate. North of Bangs, for three or four miles, the clay becomes more prominent and south of Jim Ned creek the bed is as follows:

Section No. 1

- c. Hard limestone, most of which weathers to a brown color, and at some places red splotches occur through the middle portion. *Syringopora* and *Fusilina* fossils are common..... 25 feet.
- b. Clay 10 feet.
- a. Hard limestone, which weathers to a brown color..... 4 feet.

Section No. 2

Two and a half miles north of Jim Ned creek.

- f. Smooth-surfaced hard limestone, which weathers to a deep yellowish color with red splotches scattered over it, and breaks with a conchoidal fracture..... 3 feet.
- e. Clay 2 feet.
- d. White, rather friable limestone..... 2 feet.
- c. Shaly sandstone 2 feet.
- b. Clay 15 feet.
- a. Hard, brown limestone..... 2 feet.

Section No. 3

South of Pecan bayou, four miles north of Section No. 2.

- f. Hard, brittle yellowish limestone, usually in one massive layer; red splotches are common in places..... 3 feet.
- e. Clay, varying in color from bluish to yellowish..... 10 feet.
- d. White, friable limestone..... 3 feet.
- c. Sandstone 3 feet.
- b. Clay, bluish in color..... 10 feet.
- a. Limestone, mostly massive, weathers to sharp angular fragments, the whole mass of rock is in many places cracked into small, sharp angular pieces..... 15 feet.

This lower stratum graduates through sandy limestone to a sandstone below, and is very variable in thickness in adjacent localities.

Section No. 4

Northwest of the mouth of Hog creek.

h.	Hard, brittle, evenly textured, yellowish weathering limestone, which contains red splotches and streaks scattered through it.....	3 feet.
g.	Bluish sandy clay.....	15 feet.
f.	White rough sandstone.....	4 feet.
e.	Hard yellowish limestone.....	1 foot.
d.	Sandy bluish clay.....	10 feet.
c.	Yellowish hard brittle limestone containing a great many <i>Fusulina</i> fossils.....	2 feet.
b.	Clay.....	2 feet.
a.	White friable limestone which is underlaid by calcareous sandstone.....	2 feet.

By comparing Sections 2, 3, and 4, their close resemblance will be seen, especially in the top limestone.

The fossils collected from this bed are: *Syringopora* sp.?, *Athyris* sp.?, *Athyris subtilita*, *Productus flemingi*?, *Spirifer plano-convexa*, *S. cameratus*, *Spiriferina kentuckiensis*.

11. Bluff Creek Bed

This bed is mostly sandy clay, and is from ten to seventy-five feet thick. It extends from the west side of Post Oak creek, west of Brady, under the Brady mountains at the head of Live Oak creek, down Bluff creek to the Colorado river, northward to three miles of Trickham, under the Trinity conglomerate at Bangs, two miles east of Thrifty, across Pecan bayou half a mile below Byrd's store, and along the west side of Hog creek valley two miles east of Byrd's store.

The escarpment on the west side of Post Oak creek, west of Brady, shows this bed as follows:

c.	Sandy clay.....	10 to 20 feet.
b.	Sandstone.....	8 to 10 feet.
a.	Sandy clay.....	50 feet.

Down Bluff creek the bed is at most places twenty-five to thirty feet thick, and is a sandy clay, commonly with two or three feet of sandstone at or near the top. Near the river it is about forty feet thick, and isolated small areas of it, capped with a little of the overlying limestone bed, lie to the east of the main outcrop. The sandstone is about twenty-five feet above the base of the clays, and is one to three feet thick, mostly knotty, ferruginous and rather friable, but near the "old military" crossing there is eighteen inches to two feet of smooth, evenly textured, tough sandstone, which is used for building purposes near by. Further to the north the bed is regularly a sandy clay, somewhat thinner and of but little prominence. From north of Bangs to Jim Ned creek it is about fifteen to twenty feet thick, and generally a yellowish sandy clay, which becomes less sandy, thicker, and slightly fossiliferous north of Jim Ned creek. Near the bayou, southwest of the mouth of Hog creek, the bed is twenty-five to thirty feet thick and highly fossiliferous. The clay is of a bluish color, only slightly sandy, and contains a carbonaceous seam three to four inches thick. East of Byrd's store the bed is about the same as above, except less fossiliferous.

The following are the fossils collected from this bed: *Fusulina cylindrica*, *Lophophyllum proliferum*, *Chonetes verneuilkiana*, *Chonetes granulifera*, *Lingula unbonata*?, *Discina convexa*, *Athyris* sp.?, *Athyris subtilita*, *Hemipronites crassus*, *Productus semireticulatus*, *P. longispinus*, *P. cora*, *P. nebrascensis*, *P. flemingi*?, *Retzia mormoni*, *Rynchonella* sp.?, *R. uta*?, *Spirifer plano-convexa*, *S. cameratus*, *S. lineatus*, *S. texana*, *Terebratula bovidens*, *Oonularia crustula*, *Pleurotomaria sphaerulata*, *P. tabulata*, *P. brazoensis*, *Bellerophon carbonarius*, *Euomphalus rugosus*, *E. sp.*?, *Macrocheilus primigenius* sp.?, *Polyphemopsis?* *inornata*, *Nautilus* sp.?, *Goniolite* sp.?, *Conocardium obliquum*, *Myalina subquadrata*, *Nuculana belistriata*, *Nucula ventricosa*, *Schizodus wheeleri*.

12. *Campophyllum* Bed

This limestone bed is especially distinguished by the great number of the cup coral (*Campophyllum torquium*) which it contains. There is probably no place where a full section of the bed is exposed that abundant specimens of this fossil do not occur, and only a few specimens have been found in any other bed. It is mostly a massive, rough-weathering, hard, blue limestone, but partings of marl or friable limestone occur at some localities.

This bed outcrops from the escarpment west of Post creek to the west along Brady creek to fully three miles west of Brady, and extends northward under the Brady mountains at the head of Live Oak creek; from the north side of the Brady mountains it extends down to the Colorado river between Bluff and Cow creeks. It crosses Home creek at the mouth of Camp creek, and widens from Home creek to the north, till opposite Trickham it is fully three miles wide. From three miles below Trickham to four or five miles above, the western outcrop or top of the bed extends along Mukewater creek. From five miles northeast of Trickham it narrows rapidly to the north, till one mile south of Bangs it is but about one mile wide. Thrifty is situated on the bed near its western outcrop, and at that place it is about two and a half miles wide. From Thrifty north it narrows, till near the bayou it is but about one-half to one-fourth mile wide, or even less. It extends up the bayou to within one-fourth mile of Byrd's store, and outcrops along the Brownwood-Belle Plain road one mile south of Byrd's store, then swings to the northeast along the west side of Hog creek valley.

Along Brady creek, two to three miles west of Brady, the outcrops are mostly massive, hard and rough-weathering strata. Along the north side of the creek, and along Live Oak creek, near its head, the cup corals are especially abundant. On the north side of the Brady mountains the bed is thirty-five to forty feet thick. The following section was made along the Colorado river:

- | | |
|---|----------|
| f. Hard limestone, slightly ferruginous, rough surfaced, containing a great many <i>Syringopora</i> and <i>Fusulina</i> fossils | 2 feet. |
| e. Bluish, hard, massive limestone, with wavy bedding planes, weathering in large rough boulders, some of which break up into small angular pebbles | 12 feet. |
| d. Limestone, containing some fossiliferous chert nodules. The fossils are mostly <i>Fusulina cylindrica</i> | 1 foot. |
| c. Massive limestone, with some thin clay partings near the base | 6 feet. |

- b. Limestone, some of which is slightly ferruginous and marly, containing abundance of cup corals, *Archaeodidaris*, *Syringopora*, and some *Athyris*, *Productus*, *Spirifer*, etc. 3 feet.
- a. Massive bluish limestone 10 feet.

East and northeast of Trickham there is some thin clay strata in the bed, and the most marked *Campophyllum torquium* horizon is near the base, which fact at places makes the eastern limit traceable by the corals being weathered out and scattered over the surface. It is thus traceable to within one-fourth mile of Bangs, on the south, where it passes under the Trinity conglomerate. North of Bangs to Jim Ned creek it is about twenty-five feet thick, nearly all massive limestone, with abundance of *Campophyllum torquium* fossils.

Two and one-half miles north of Jim Ned creek the bed is composed of twenty feet of bluish white limestone in rough-surfaced layers, with some thin clay partings. The base is almost a solid mass of cup corals and *Fusulina* fossils, the *Fusulina*, however, being in the thin clay partings and weathering out in great numbers.

Along the bayou the bed is about twenty feet thick and mostly massive limestone. East and northeast of Byrd's store it is slightly thinner, but in other characters does not materially vary from the outcrops further south.

The following fossils have been collected from this bed: *Campophyllum torquium*, *Syringopora* sp.?, *Hemipronites crassus*, *Productus costatus*, *P. cora*, *Retzia mormoni*, *Spirifer cameratus*, *Nucula ventricosa*.

CISCO DIVISION

This division is composed of clays, limestones, sandstones, conglomerates, and some shale and coal. Its total thickness is about 800 feet. Sections 3 and 4, plate III, are across it and show its different beds, which in the Colorado coal field are as follows:

19. Santa Anna branch bed.
18. Bed No. 18.
17. Santa Anna bed.
16. Horse creek bed.
15. Watts creek bed.
14. Camp Colorado bed.
13. Bed No. 13.
12. Stockwether bed
11. Coon mountain bed.
10. Camp creek bed.
9. Saddle creek bed.
8. Waldrip beds.
7. Chaffin beds.
6. Park's mountain conglomerate and sandstone bed.
5. Lohn bed.
4. Speck mountain limestone bed.
3. Speck mountain clay bed.
2. Bellerophon bed.
1. Trickham bed.

1. Trickham Bed

This is principally a bed of clay with varying proportions of sand. It has some limestone strata, and a number of local deposits of sand-

stone and conglomerate. On an average its width is one and a half to two miles, and its thickness 100 to 150 feet. While the bed retains its identity from the Brady mountains to the north part of the field, it varies somewhat in local development, and from the broken nature of the overlying bed it is difficult at some places to determine the upper limit of the Trickham bed. Typical exposures occur along the Colorado river, south and southeast of Park's mountain, west of Mukewater creek, four or five miles either north or south of Trickham, west of the Trinity conglomerate, southwest of Bangs, west and north of Thrifty along the Jim Ned creek, and along Elm creek four miles south of Byrd's store.

On Brady creek the upper limit of the bed is not clearly defined, owing to modifications of its nature north of Brady mountains, but it is probably two miles wide and mostly limestone strata. From the north side of the Brady mountains to five or six miles north of the Colorado river the Trickham bed consists of a lower stratum of sandy clay, a middle or sub middle stratum of limestone and calcareous sandstone, and an upper stratum of sandy clay. This included limestone is thickest near the Brady mountains, and thins to the north until it disappears along Mukewater creek. There is some sandstone with this limestone near and on either side of the river, and at some places the sandstone graduates into limestone. or *vice versa*.

A section three or four miles south of the river is as follows:

c. Sandy clay	125 feet.
b. Sandy limestone.....	5 to 10 feet.
a. Bluish clay, graduating to a lighter color, and a more sandy clay at the top.....	50 feet.

The lower part of "a" is rich in fossils, as determined by a well section on the south side of the river, and as shown in outcrops one and a half miles northeast of the Mitchell crossing of the river. The upper clay bed "c" is finely exposed at the southeast end of Park's mountain in the high escarpment facing the river. It is highly fossiliferous there, and while mostly bluish sandy clay, some horizons are gray or decidedly black clay shale. At the base of "a," along Home creek, the number and variety of species of fossils are abundant and characteristic of this bed. Two miles southwest of Trickham, the bed is 75 feet to 100 feet thick, mostly bluish clay, but shaly at places, and has two to three feet of sandstone near the base and two to ten feet of sandstone at the top, which top strata vary from flaggy to massive. This upper sandstone begins southwest of Trickham and extends five or six miles to the north, with its greatest development northwest of Trickham, where it is ten to twenty-five feet thick, and has an outcrop three-fourths of a mile wide. All the way from Trickham to the railroad the clay is fully 100 feet thick, and even of a greater thickness in places, and has but little interstratified sandstone.

The top sandstone, however, after a short break, continues along Mukewater creek, and to the northwards, outcropping about three miles west of Bangs. The clays west of Bangs, where long exposed, are usually purplish in color. Northwest of Bangs and southwest of Thrifty, along Sandy creek, this top sandstone becomes the most prominent part of the bed; it is fifty feet thick, or even more, and at places is mostly a conglomerate of sub-angular fragments of siliceous material, some of which is cemented by iron. This conglomerate and sandstone seem to have been deposited after the underlying clay was

somewhat irregularly eroded. Three miles south of Thrifty it is about fifty feet thick, most of it quite sandy, and some containing clay ironstone nodules and an abundance of fossils, many of which are like those found at the base of the bed along the Colorado river and Home creek. Small isolated areas of this bed, with the sandstone and conglomerate capping them, are left east of Sandy creek and Thrifty. Along Sandy creek, south of Thrifty, however, the basal clays still connect, the creek only having cut down through the sandstone, conglomerate, and upper part of the clay. North of Jim Ned creek, for about four miles, the top sandstone is much thinner and mostly interstratified with sandy clay, but farther to the north it again becomes thicker, or fully fifty feet thick, and a large part is either conglomerate or conglomeritic. From where the bed begins to thicken its lowest outcrop rapidly extends eastward until its total outcrop is fully two miles wide. At Jim Ned creek north to where the bed begins to thicken the clay is fully 100 feet thick, but as the sandstone and conglomerate thickens, the clay thins, till at the most eastern outcrop of the conglomerate there is scarcely any clay between the conglomerate and the *Campophyllum* bed, which shows both a change of sediments along the same horizon and contemporaneous erosion of the clay with the deposition of the conglomerate. A part of this sandstone and conglomerate on the south side of Elm creek, five miles south of Byrd's store, seems to be of a higher horizon, thus making its overlapping of the underlying eroded strata even greater. North of Elm creek to the bayou this sandstone is much thinner, being represented by only five to ten feet of massive sandstone. Southwest of Byrd's store, on the south side of the bayou, the Trickham bed is as follows:

- b. Sandstone, slightly cross-bedded and shaly.... 5 feet.
- a. Blue shaly clay, with five feet of yellowish
argillaceous sand at the top..... 75 to 100 feet.

Farther to the north, in this bed, the top sandstone and conglomerate practically end.

From Jim Ned creek to the north there are two localities with considerable sandstone at and near the base. The first extends from Jim Ned creek three or four miles north; the strata are ten to fifteen feet thick, and all rather soft sandstone and very near the base of the bed. The second development is from the bayou near Byrd's store to the north; this latter sandstone is finely exposed in Red river (Paint creek) at Byrd's store, and good exposures may also be seen one-half of a mile south of Byrd's store. Some of it is highly calcareous, and east of the store it is interstratified with clay. The underlying clay, one-half mile south of the store, is twenty-five to thirty feet thick, and the top clay, north and northwest of the store, is fifty to seventy-five feet thick.

The following are fossils collected from this bed: *Lophophyllum proliferum*, *Archaeocidaris* sp.?, *Athyris subtilita*, *Athyris* sp.?, *Chonetes* sp.?, *Chonetes granulifera*, *Productus nebrascensis*, *P. Flemingi*?, *P. pertenuis*, *P. cora*, *P. semireticulatus*, *P. costatus*?, *Discina convexa*, *Discina nitida*, *Hemipronites crassus*, *Rhynchonella* sp.?, *R. uta*, *Retzia mormoni*, *Syntrielasma hemiplicata*, *Spirifer texana*, *S. cameratus*, *S. plano-convexa*, *S. lineatus*, *Spiriferina kentuckiensis*, *Pleurotomaria sphaerulata*, *P. brazoensis*, *P. tabulata*, *P. sp.*?, *Eumomphalus rugosus*, *Bellerophon carbonarius*, *B. nodocarinatus*, *B. percarinatus*, *B. crassus*, *Macrocheilus primigenius*, *Polypheopsis nitidula*?, *Macrocheilus texanus*, *Conocardium obliquum*, *Nucula*

ventricosa, *Nuculana bellistriata*, *Pinna peracuta*, *Allorisma subcuneata*, *A. sp.?*, *Goniatite sp.?*, *Goniatite gonilobus?*, *Nautilus sp.?*, *Orthoceras rushensis*, *O. annulato-costatum*, *Conularia crustula*, *Phillipsia sp.?*, *Petalodus destructor*. (This last determined by E. D. Cope.)

2. *Bellerophon* Bed

This name has been given to the disconnected outcropping remnants of limestone which overlie the Trickham bed. The name has not been used because of the abundance or even prominence of *Bellerophon* forms in the bed, but because it is the lowest horizon where the large *Bellerophon crassus* has been found, and because this form could usually be found at most localities in this bed, and it does not occur in any of the near overlying beds.

The bed is usually five to ten feet thick and has a very narrow outcrop. There are about six localities along the top of the Trickham bed where limestone strata exist, which seem to be referable to the same horizon and therefore are considered to be the same bed.

From the north side of the Brady mountains to two miles southwest of Trickham, the bed is continuous and unbroken. Five miles north of Trickham, along the west side of Mukewater creek, this bed occurs for two to three miles. West and southwest of Bangs small hills or points are capped with strata referred to this bed. North of Jim Ned creek and northwest of Thrifty the bed is feebly represented for a mile or two. One and a half miles south of the mouth of Elm creek is a small remnant and west of Byrd's store, on the south side of Pecan bayou, is another outcrop.

It may be possible that all these were never connected in the same bed, but their topographical position and the resemblance of their fossil forms and characters of rocks, make it highly probable that they are remnants of a once continuous deposit; that original change of sediment and a greater development at different places, and contemporaneous erosion with the last stages of deposit, and the further subsequent erosion of connecting parts, has left the bed as we see it in these disconnected outcrops.

From Brady mountains to the southwest of Trickham this bed is from four to fifteen feet thick, but varies considerably in thickness at places. It is best exposed along the Colorado river and north of the river to opposite Trickham. Throughout this extent it forms the capping rock of the main escarpment of that locality. At the southeast side of Park's mountain this bed is over 100 feet above the river bed; its westward dip is fully thirty feet per mile, so that a little over three miles up the river, or two miles below Chaffin coal mine, it passes down into the river. Its outcrop is very prominent all along, and is from five to twelve feet thick. The rock is massive, hard, and forms bluffs where it gets down near the river, but is much broken and crumbled further to the east on the higher and longer exposed outcrops. Along the east side of Park's mountain it is four to ten feet thick, has some thin partings of clay, and varies from a hard blue, to a friable yellowish, white argillaceous rock. Five miles northeast of Rockwood it is twelve feet thick and massive. Two miles southwest of Trickham it is ten feet thick, and varies from a sandy argillaceous friable rock to a blue, hard, and massive rock.

The limestone along the west side of Mukewater creek, four to five miles north or a little west of north from Trickham, is a crumbling white limestone only three or four feet thick, and continues but two or three miles.

The points one mile west and two to three miles southwest of Bangs, capped with five to fifteen feet of limestone, are the only remnant there referable to this bed. These remnants vary from a hard to a soft yellowish and white nodular weathering rock. Some chert occurs in the limestone three miles southwest of Bangs, and west of Bangs on the north side of the railroad it contains some *Campophyllum torquium* fossils. These isolated points seem to have no connection with any of the strata to the west, and it is probable that to the west the bed was eroded before the higher Cisco beds were deposited.

Near or a little above the top of the main face of the escarpment, running north on the north side of Jim Ned creek, northwest of Thrifty, this bed is represented for two or three miles by one to five feet of concretionary structured white limestone, or at places a sandy pink limestone. One and a half miles south of the mouth of Elm creek and one and a half miles west of the Brownwood-Belle Plain road there are eight to ten feet of light gray limestone, much of which is sandy and rich in Bellerophons. This small area is about a mile long, east and west, and about one-half mile wide, and seems to graduate into sandstone strata to the west and south. The outcrop southwest of Byrd's store, south of the mouth of Paint creek, is only two to three feet thick, mostly hard and of a dull gray color, but at places it is a white crumbling rock, highly arenaceous, and even graduating into sandstone. The Bellerophon fossils are common in the bed at this locality.

The following are the fossils collected from this bed: *Fusulina cylindrica*, *Syntrielasma hemiplicata*, *Spirifer plano convexa*, *Pleurotomaria tubulata*, *Bellerophon crassus*.

3. Speck Mountain Clay Bed

This bed of sandy clay is usually about twenty-five feet thick, and has an outcrop of about one-fourth of a mile wide. Its thickness slightly increases to the north. From the Brady mountains to the river its outcrop is obscurely marked, but along the river, on either side, just south of Parks mountain, it is usually shown in full section of twenty to twenty-five feet in thickness.

One of its best exposures is along Home creek and at the base of Speck mountain, where it is exposed in freshly eroded sections, and shows to be mostly bluish sandy clay, but purplish or slightly red at places, and contains a little sandstone. North of the railroad for a short distance it is overlaid by a sandstone bed. North of Jim Ned creek it contains some Carbonaceous shaly clay, and at some places a few inches of coal, and five to ten feet of sandstone occur near the center of the bed three to four miles north of the creek. Southwest of Byrd's store, the bed has the following section:

- | | |
|--|----------|
| c. Red clay, slightly sandy..... | 15 feet. |
| b. Calcareous shaly sandstone..... | 2 feet. |
| a. Light yellow highly sandy clay..... | 15 feet. |

Fossils: *Lophophyllum proliferum*, *Zeacrinus* sp.?, *Stenopora carbonaria*, *Athyris* sp.?, *Chonetes granulifera*, *Spirifer cameratus*.

4. Speck Mountain Limestone Bed

This bed is very thin, but as it continues all or nearly all the way across the field and is usually a prominent part of the stratification,

it has been classed as a distinct bed. From its good development on top and to the west of Speck mountain, it has been named the Speck mountain limestone.

Owing to the level nature of the ground, the bed is not well shown south of the river except very near it, but the indications are that the greatest thickness is to the south. Along and near the river, on either side, it is clearly exposed in one massive, dark, rough weathering limestone three to five feet thick, but where it dips down to near the river it seems to have been eroded before or during the deposition of the next higher bed (Parks mountain sandstone and conglomerate), so that along the river valley and river bed this sandstone occupied the natural position of the Speck mountain limestone. Towards the east end of Parks mountain it is overlapped by the Parks Mountain sandstone and conglomerate, which overlap continues about two miles to the north. Four miles north-east of Rockwood it is composed of five feet of hard massive white limestone. Both southwest and northwest of Trickham it consists of two to four feet of white barren rather friable limestone, but slightly thins to the north and becomes of a darker color. At the railroad, nearly five miles west of Bangs, it is three to four feet thick, massive, hard and tough, and has many *Fusulina* fossils. For about two miles north of the railroad it is overlapped by a sandstone bed, but from near the head of Sandy creek to the Jim Ned creek it has a continuous outcrop of dark brown weathering, hard and rather brittle limestone. Two miles north of Jim Ned creek it is about three feet thick, white and crumbling. Two miles further north it changes again to a hard blue or brown limestone. Southwest of Byrd's store, on the south side of Pecan bayou, it is three feet thick, hard, and weathers to a smooth surface and dark gray color.

5. Lohn Bed

This clay bed is so named because of its good development near Lohn, a postoffice eight or nine miles from Waldrip, on the Waldrip and Brady road. The bed as a clay bed is clearly distinguishable on either side of Brady creek six miles west of Brady, but no fresh outcrops are exposed. From Cow Gap in the Brady mountains, past Lohn and to the Colorado river it is generally clearly marked, but varies considerably in thickness and width of outcrop. Near Cow Gap it is very thin; at Lohn Postoffice it is fifty to seventy-five feet thick, and near the river it is twenty to forty feet thick. This is the bed that contains the Chaffin coal. From the river northward for two or three miles, it seems to be cut off by an irregular sandstone and conglomerate deposit.

One and a half miles east of Rockwood a well section of the top part of the bed is as follows:

- | | | |
|----|--|---------------------|
| c. | Bluish shaly clay, with yellowish colored bands through it | 6 feet. |
| b. | Shale, with innumerable plant impressions..... | $\frac{1}{4}$ foot. |
| a. | Blue clay..... | 12 feet. |

On the south side of Home creek the bed consists of thirty feet of red clay, the top containing siderite nodules at one or two horizons, below which are two to three feet of calcareous sandstone, and this in turn is underlaid by alternating thin strata of friable limestone and calcareous clay, which are mostly rich in fossils, especially *Fusulina*. Southwest of Trickham the bed is about thirty feet thick

along its outcrop, but four miles north of Trickham it is seventy-five feet thick, mostly a bluish shaly clay, toward the top of which, where longer exposed, it is less shaly and of a yellowish or purple color. Farther north to the railroad it seems to be thin, and can be traced mainly by its position between the underlying and overlying limestone beds.

From the railroad four to five miles north, the thick sandstone bed along the Brown-Coleman county line seems, in its basal part, to belong to this horizon, and in its upper part to belong above this bed. This sandstone is sixty or seventy feet thick at the best exposures, but is very local in its development, as shown on the map. It contains but a little conglomerate. In Mud creek, just west of Graveyard mountain, twenty to thirty feet of this sandstone outcrops in the bank of the creek, and at that point is plainly in the Lohn bed.

About two miles north, or a little west of north, from the above point, Mr. R. M. Low drilled a well in this bed and through some overlying strata, and the section of the Lohn bed, as he remembered it, was as follows:

- b. Coal, probably some shale..... 3 feet.
- a. Red clay 40 feet.

North of Jim Ned creek, about one and a half miles east of Indian mountain the bed consists of thirty feet of bluish and purple clays which are highly fossiliferous. Three miles south of East and West Mountain the bed is about as at above place. Southwest of Byrd's store it consists of thirty feet of reddish clay.

Fossils: *Fusulina cylindrica*, *Lophophyllum proliferum*, *Archaeocidaris* sp.?, *Fenestella* sp.?, *Stenopora carbonaria*, *Synocladia biserialis*, *Athyris* sp.?, *Athyris subtilita*, *Chonetes granulifera*, *Productus punctatus*, *P. pertenuis*, *P. nebrascensis*, *P. longispinus*, *P. semireticulatus*, *Hemipronites crassus*, *Rhynchonella uta*, *R.* sp.?, *Retzia mormoni*, *Spirifer cameratus*, *S. rockymontani* sp.?, *S. planoconvexa*, *S. lineatus*, *Spiriferina kentuckiensis*, *Terebratula bovidens*, *Euomphalus rugosus*, *Conularia crustula*, *Phillipsia* sp.?

6. Parks Mountain Bed

This bed of sandstone and conglomerate has been especially described because of its irregular position and relation to the coal beds. As shown on the map, it is of small extent and covers the higher points north of the Colorado river known as Parks mountain, extending westward almost to Chaffin coal mine, and northwest to within about two miles of Rockwood. It is largely the characteristic Carboniferous conglomerate, especially in the eastern part, and at the best developed places is sixty to seventy feet thick. The Speck mountain limestone and Lohn bed along the river to the east and to the southeast of the Chaffin coal mine, seem to have been irregularly eroded and sandstone of the Parks mountain bed deposited. This sandstone in massive strata, twenty to thirty feet thick, may be seen on the south side of the river, one-fourth mile from the mine, and continuing on down one and a half or two miles. On the north side of the river, one mile east of the mine, near the mouth of Rough creek, there are twenty-five to thirty feet of massive cross-bedded sandstone of the same horizon, but usually ten to twenty-five feet of clay of the Lohn bed overlies the sandstone outcrops. So this conglomerate and sandstone overlaps the Speck mountain limestone and clays and part of the Lohn bed.

7. Chaffin Bed

This bed, the Waldrip bed, and the Saddle creek bed will be more minutely described because of the included coal seams. From Home creek to the South, the Chaffin bed consists of massive limestone, and from Home creek to the north it is composed of limestone, clay and a little sandstone. The limestone of the northern part of the bed differs considerably from that of the southern part.

From a little north of Home creek to the south all the bed is practically of the same character of rock, *i. e.*, hard, brittle, massive, slightly nodular structured, of a bluish white color, and weathering to boulders which break into small sharp-angled pieces.

On Brady creek, about seven miles west of Brady, at the east line of the Fisher & Miller survey, No. 2212, this bed is exposed in its characteristic appearance and is fully twenty feet thick. On either side of the creek it soon passes under the Cretaceous beds, and to the north it again outcrops from under the Cretaceous at Cow Gap of Brady mountains; from there it extends almost due north to the Colorado river, but bends a little westward at Lohn postoffice, passing one-fourth of a mile to the west of it. From Cow Gap to Lohn postoffice the outcrop of the bed is obscure, because the ground is so level; but from the postoffice to the river, or even to the Chaffin coal mine, it forms a slight and continuous escarpment, and has an average thickness of about twenty feet.

At the Chaffin coal mine, about two miles east of Waldrip, this bed is fifteen to twenty feet thick, and two to three hundred yards north of the coal mine it is replaced by massive sandstone. North of the river, near the mouth of Rough creek, the isolated remnants of massive limestone probably belong to this bed, and with that exception it has no outcrop to the north until at a point about one and three-quarters miles southeast of Rockwood, or just east of Mr. Shelton's house, where it outcrops and is eleven feet thick. On to the north to Home creek the outcrop is regular and seems to change but little. The outcrop of the bed is not exposed for one-half of a mile where it belongs, on the west side of Home creek, just southwest and northwest of Mr. Sanderson's house, and east of Mr. Keith's. But where it crosses Home creek, at the south line of the Skirlock survey, it is six to seven feet thick and characteristic. It there contains some *Spirifer cameratus*, *Fusulina cylindrica*, *Athyris subtilita*, and Crinoids.

The tongue-like projection of the bed on the east side of the creek is very prominent from where it crosses the creek back down the east side to opposite, or one and one-fourth miles west of Speck mountain. From this latter point the outcrop turns northward, and the bed divides into an upper and a lower limestone, with a central stratum of clay. The upper limestone, toward the north, soon becomes and remains one massive brownish weathering, two to three foot stratum and has many *Fusulina cylindrica* fossils all along to the northern part of the field. The lower limestone stratum passes into a crumbling white limestone, one to five feet thick, and varies but little further to the north. The parting clay is mostly a reddish weathering clay, and is very thin just north of Home creek, but soon thickens to twenty-five feet and remains quite regularly that thickness to the north. These strata outcrop along the east side of the Cleveland survey, and the southeast corner of the Martinez and the Mary Anne Fisk surveys to the Gulf, Colorado and Santa Fe Railroad.

North of the railroad, almost all of the way to Jim Ned creek, the lower limestone is covered by sandstone. The upper limestone,

however, has a continuous outcrop, passing on the east side of Antelope hills or through the west side of the Moses Little survey, the east side of the Samuel Mixon survey, thence down the west side of Mud creek to Jim Ned creek, which it crosses just below the Coleman-Comanche road. Mr. Low's well, west of Mud creek, on the northeast corner of the Samuel Sprague survey, has the following section of this bed:

c. Hard brown limestone.....	3 feet.
b. Red clay	25 feet.
a. White limestone	4 to 5 feet.

This section practically holds good for the bed from west of Trickham to a little north of Jim Ned creek. The lower limestone, being friable, appears less prominent than the upper, which is hard and usually conspicuous along its outcrop.

The bed to the north of Jim Ned creek outcrops at the base of Indian mountain on its south side; along the Thrifty-Cisco road at the crossing of the Coleman-Comanche road; at the east side of East and West mountain; thence nearly due north to the bayou, which it crosses four miles west of Byrd's Store.

On the south side of Indian mountain the bed has the following section:

c. Hard dove-colored limestone, with <i>Fusulina</i> fossils; it breaks down from its outcrop in slab-like pieces	1 to 2 feet.
b. Clay, mostly red, contains some siderite nodules	25 to 50 feet.
a. White, and at places pink, limestone.....	½ to 3 feet.

On the south side of the bayou the bed has the following section:

Hard brown limestone, with abundant <i>Fusulina</i> fossils	3 feet.
Clay, mostly red.....	25 to 50 feet.
Yellowish fossiliferous limestone nodules, with a purer and more uniform layer of limestone at the top	3 feet.

From one-half mile east of East and West mountain to two and a half miles west of Byrd's Store, there are, at the base of the central clay, five to ten feet of sandstone, which has an outcrop of fully one-half mile in width.

Fossils: *Fusulina cylindrica*, *Lophophyllum proliferum*, *Archaeocidaris* sp.?, *Stenopora carbonaria*, *Athyris subtilita*, *Chonetes granulifera*, *Productus nebrascensis*, *P. cora*, *Rhynchonella uta*, *Retzia mormoni*, *Syntrielasma hemiplicata*, *Spirifer cameratus*, *S. lineatus*, *Belterophon crassus*, *Pinna peracuta*, *Allorisma subcuneata*.

8. Waldrip Bed

This bed consists principally of blue clays, but has local sandstone deposits of considerable thickness and three well-marked strata of limestone which extend across most of the field. It also contains some shaly clay, carbonaceous shale, and the coal bed that has been worked at Waldrip, Bull creek, Rockwood, Home creek, and on Jim Ned creek at the Silver Moon mine. The thickness of the bed varies from 100 to over 200 feet, and the width of outcrop varies from one to five miles. Its width along Brady creek and north to the Colorado

river is four to five miles. The eastern edge is about seven miles west of Brady, and north of Brady mountains extends nearly due north from one mile west of Cow Gap to the Colorado river, one and a half miles east of Waldrip; and the upper or west edge extends to within about one mile of Saddle creek, which creek from its mouth to two or three miles south has cut down into the upper part of the bed. From the Colorado river the bed narrows slightly towards the north. It extends about one and a half miles on either side of Rockwood. Northwards to the railroad, it extends through the central part of the following surveys: James S. Martin, William Skirlock, Pleasant Young, Cleveland, Martinez, and Mary Anne Fisk.

From the railroad to Jim Ned creek the bed is about one and a half miles wide, and bounded on the west by an escarpment that runs down the west side of Mud creek; most of the face of the escarpment, however, belongs to this bed. North of Jim Ned creek to the bayou the west limit is approximately marked by the escarpment of the Coon mountains. The following typical section (Rockwood section) was made between Rockwood and Bull creek:

11. Clay	50 feet.
No. 3. Dark blue, gray, or brown, hard, brittle limestone, which contains abundant <i>Fusulina</i> fossils.....	1 foot.
9. Sandy clay, mostly light red in color.....	10 feet.
8. White massive sandstone.....	5 feet.
7. Shaly clay, pink to blue in color.....	15 feet.
No. 2. Hard, massive limestone, weathers to a dark gray color	2 feet.
5. Blue clay	30 feet.
No. 1. White rotten impure limestone.....	1½ feet.
3. Blue clay, with a little shaly sandstone near the top and some siderite nodules in central part.....	75 feet.
a. Coal	2 feet.
2. Blue clay	50 feet.
1. Sandstone	10 feet.

For convenience, the limestone strata of this section have been designated by the numbers 1, 2, and 3, beginning at the lowest.

The narrowness of the outcrop along Brady creek does not admit of good exposures of the strata, but the following were observed: At the base of the bed are ten to fifteen feet of rather soft white sandstone overlaid by clay. On the east side of Survey No. 2586 are two to three feet of hard limestone full of *Fusulina* fossils, and probably is the first or second limestone; overlying this are alternating strata of red clay and hard crystalline limestone of pink, yellowish, and brownish colors. A marked variation of the limestone strata on Brady creek from that farther north is that on Brady creek they are harder, more crystalline, and have more of the pink, yellowish, and brownish color.

So far as can be seen, the Rockwood section holds good from the Brady mountains to the river, except little local variations, such as the sandstone stratum of five to six feet thickness between limestones Nos. 1 and 2, five to six miles south of Waldrip, and the usual absence of the basal sandstone.

The Rockwood section, with minor changes, gives the character of the bed throughout, so frequent reference will be made to it for comparison. The sandstones and a few conglomerates are almost all confined to the basal part of the bed. These deposits are distributed and developed as follows:

That on Brady creek has already been mentioned. Three miles southeast of Waldrip are four to five feet of conglomerate with an outcrop of about a mile in length. The next deposit begins about two miles east of Waldrip, or just north of the Chaffin coal mine, and extends north and northeast to a point one mile east of Rockwood. This sandstone, at the river, is fully twenty feet thick, and seems to be continuous over the named distance at the base of the Waldrip beds, and to have been deposited on the eroded Chaffin limestone. Southeast of Rockwood it laps back on the Parks Mountain sandstone and conglomerate, and east of the mouth of Bull creek there is some evidence that this extends upwards and cuts off the coal bed along a limited area.

The next deposit of sandstone is about three miles northeast of Rockwood, and is about two miles in length and four to six feet thick. In the northeast corner of the Skirlock survey and southwest corner of the Pleasant Young survey, this horizon contains some sandstone, and across the south part of the Cleveland survey is another local bed twenty-five to thirty feet thick, much of which is conglomerate.

South of the Gulf, Colorado and Santa Fe Railroad, for three to four miles, there is another deposit, usually five to ten feet thick. North of the railroad to Jim Ned creek, and even farther north, some clay underlies the sandstone deposits, but they are approximately at the base of the Waldrip bed. Between the railroad and the Antelope Knobs are ten to twenty feet of sandstone and conglomerate underlain by ten to fifteen feet of clay. Brushy and Graveyard mountains are capped with eight to ten feet of massive conglomerate referable to this horizon. From one mile west of Graveyard mountain to the north there is an almost continuous sandstone deposit, which is ten to fifteen feet thick, to the Jim Ned creek, but north of the creek it thickens till northwest of Indian mountain its outcrop is fully one mile wide, and from there gradually thins and narrows till at East and West mountain it is practically lacking; but a mile north of the mountain it commences again and gradually thickens to the north, till two miles north of the bayou it is twenty to thirty feet thick or more, and has an outcrop of a mile in width. All these deposits are practically at the base of the Waldrip bed and represent the general character of the deposits at the beginning of the time that this bed was laid down.

The next stage of deposits is in the following order: clay, coal, clay, and shaly sandstone which are represented in the Rockwood section by the figures 2 and 3 and the letter "a." These deposits are the principal parts of the bed and are continuous throughout with a thickness of 100 to 150 feet. The clay (1) underlying the coal is usually twenty-five to fifty feet thick. The coal (a) varies from twelve to thirty inches in thickness, and the overlying clay (2) from 50 to 100 feet. The clays are blue in color, and near the coal are quite free from sand, but towards the top they are more or less sandy, and at places have shaly sandstone or in a few places sandstone of considerable thickness, as occurs about two and a half miles north of Home creek. The central or upper part of the clay stratum (2) at nearly all the localities contains numerous small siderite nodules, which are well shown two and a half miles southwest of Rockwood, on the north side of Home creek, in the central part of the Cleveland survey, near the Santa Anna-Trickham road at its crossing of the bed, along the escarpment west of Mud creek, etc. The upper part of the bed is somewhat more variable, especially in its limestone.

Along Brady creek there are more than three limestone strata men-

tioned, which seem to belong to this bed; at any rate the limestone strata thicken to the south and thin to the north. Stratum No. 1 extends but a few miles north of Rockwood; stratum No. 2 thins to the north from Home creek, till three miles south of the railroad it is two to three inches thick and largely composed of Echinodermata and Spirifer fossils; two miles north of the railroad it is represented by a thin parting of a mass of Echinodermata and Spirifer fossils; stratum No. 2 is continuous to and beyond the bayou.

Nos. 1, 2, and 3 may be traced from near the mouth of Saddle creek to near Rockwood. No. 2 is in the bed of the river at the mouth of Saddle creek, and No. 3 outcrops three or four hundred yards southeast of the mouth of the creek. Nos. 1 and 2 outcrop along the river bank just west of Waldrip, and No. 1 outcrops about three-eighths of a mile southeast of Waldrip postoffice, and may be traced three or four miles almost due south. At Waldrip and Rockwood, No. 1 is easily recognized because of numerous netted furoid or stick-like pieces of limestone at the base of the stratum.

From the Colorado river north No. 3 can be easily distinguished from the others by its containing many Fusulina fossils, and by its weathering to a dark blue or brownish color. The following are some of the places of the outcrop of this third stratum of limestone: At the top of the escarpment southwest of Rockwood; near the top of the escarpment formed by the Saddle creek bed from Home creek to the railroad; the first outcrop of limestone just west of Squire Malone's house; near and at the top of the escarpment west of Mud creek; and the first limestone below the capping sandstone in the east escarpment of Coon mountains.

The clays between these limestones are more or less sandy, and at places contain some sandstone, and are quite regular in thickness throughout.

Fossils: *Fusulina cylindrica*, *Lophophyllum proliferum*, *Campophyllum torquium*, *Synocladia biserialis*, *Chonetes granulifera*, *Productus nebrascensis*, *P. pertenuis*, *P. punctatus?*, *P. cora*, *Aviculopecten occidentalis*, *Hemipronites crassus*, *Rhynchonella* sp., *Spirifer cameratus*, *S. plano-convexa*, *Spiriferina kentuckiensis*, *Allorisma subcuneata*.

9. Saddle Creek Bed

This limestone bed is usually six or seven feet thick, but varies from five to twelve feet or more. As it is the first hard bed of rock of any thickness that overlies the thick clays of the Waldrip bed, it is the capping rock of an almost continuous prominent escarpment. The bed is mostly composed of massive strata, but usually contains some thin strata as well. Most of the rock is of a light gray color, and contains numerous thin streaks of crystalline calcite and equally as many small irregular streaks of white amorphous limestone, like the mass of the rock except in color. The calcite streaks weather to a brownish color, so that the appearance of the weathered surface of the rock is a ground of light gray thickly set with specks and streaks of white and brown. These characteristics are not possessed by the rock of any bed near this one, and whenever this bed is exposed they are prominent, so it is easily distinguished. At places, however, these features only mark part of the bed, as east of Santa Anna the lower part is at places composed of rock weathering to a brown color, and much of the remainder is simply a light gray rock.

This bed in Brady creek, and about three miles east of the McCulloch-Concho county line, is five to six feet thick. From one to two miles south of the mouth of Saddle creek it is finely exposed on either

side of the creek. On the north side of the river, from north of the mouth of Saddle creek to northwest of Waldrip, it still remains near the river. From Bull creek to Mud creek the map clearly shows its outcrop. From just north of Mud creek to the bayou, except in the valley of Jim Ned creek, it is overlapped by the Coon Mountain sandstone.

Fossils: *Athyris subtilita*, *Productus nebrascensis*, *P. longispinus*, *Platyceras nebrascensis*.

10. Camp Creek Bed

This bed, of forty to fifty feet thickness, consists mostly of red and yellowish sandy clay, but contains some thin layers of limestone at places, and also a little sandstone. South of the river the bed is difficult to locate, except for short distances, but from the north side of the river to six miles northeast of Santa Anna it is usually distinct in its outcrop. About three miles northwest of Rockwood it lies at the base of a prominent escarpment, and has the following section:

g. Yellow sandy clay	15 feet
f. Yellowish sandy limestone	½ foot
e. Yellowish sandy clay	10 feet
d. Yellowish brown limestone	1½ feet
c. Red clay	20 feet
b. Brown limestone, weathers into flaggy pieces.....	1½ feet
a. Shaly, sandy, purple and yellowish clay.....	20 feet

Along Home creek, especially on the north side, the bed is well exposed and consists of fifty to sixty feet of red sandy clay and some friable yellow limestone, which at places, as at and near the head of Dry creek, contains *Campophyllum torquium* fossils. From northeast of Santa Anna it is mostly overlapped by the Coon Mountain sandstone.

11. Coon Mountain Bed

This bed is composed of sandstone and conglomerate. From a few miles south of the Colorado river to the north of the railroad it is continuous, but varies in thickness from almost nothing to twenty-five feet. North of the railroad it thickens regularly till at Coon mountain it is probably over seventy-five feet thick and spreads out over three miles wide, overlapping the underlying beds down to the limestone stratum number 3 of the Waldrip bed. On Bull creek the bed consists of about eight feet of massive nodular structured sandstone. Its variability is well shown on Home creek and along the railroad. On Home creek, in some localities, it is from one to twenty feet thick, and mostly a soft crumbling sandstone. North of the railroad local variations of thickness run from three to twenty-five feet, and some of the sandstone is calcareous. Along Jim Ned creek the bed is thirty to forty feet thick, with firmer sandstone in places, and some of the bed is conglomerate. Along the bayou, especially on the south side, the most eastern or overlapping part of the bed seems to be thicker than farther to the west, where it enters regularly into the stratigraphy, and the overlapping part is more conglomeratic.

13. Bed No. 18.

This is mostly a hard, rather brittle, rough-weathering, gray limestone, containing yellowish or light colored chert nodules. It is about

twenty feet thick at the south part, and gradually thins to the north. Although this bed continues south of the Colorado river and north of Jim Ned creek, its traceable outcrop lies principally between those streams. Along the Colorado river it is fifteen to twenty feet thick, hard, massive, mostly gray colored, and contains many chert nodules. On Bull creek it outcrops at and just east of the Stockwether ranch, and is there fully fifteen feet thick, hard, massive, and gray-colored. North of Bull creek for several miles it caps a prominent escarpment along Home creek; the bed is eight to ten feet thick, and caps a twenty-five to seventy-five feet high escarpment which runs north for four or five miles. It continues to thin toward the north, till at and north of Jim Ned creek it is so thin, and the included limestone strata of associated beds lie so near it, that it is difficult to identify the horizon farther to the north.

13. Bed No. 13.

This bed consists of forty to seventy-five feet of clay, most of which has a reddish color. At some places thin limestone and sandstone strata are distributed through it. It is pretty clearly marked from the Brady mountains to Jim Ned creek, and has an average width of about three-fourths of a mile. Its best exposures are on the north side of Colorado river opposite the mouth of Elm creek, four miles northwest of Rockwood, and on the north side of Home creek, about seven miles south of Santa Anna.

14. Camp Colorado Bed

This consists mostly of hard, rather brittle, bluish-gray limestone, weathering with rough surfaces and often much fractured. It varies in thickness from ten to twenty-five feet, and thins northward and seemingly southward from the Colorado river. Most of the bed, by its containing many black or nearly black chert nodules, is made distinct from the Stockwether bed, in which the chert is of a yellowish color; and it is distinguished from the near overlying beds, because those beds do not contain chert nodules. It outcrops in Brady creek about two miles east of the McCulloch-Concho county line, and is there about ten feet thick, and contains, especially in its lower part, abundant chert nodules; the mass of the limestone is very hard, crystalline, much fractured, and of a reddish or pink color. Along the Colorado river and Bull creek, where it is best developed, the chert nodules are especially prominent, and in places have weathered out till they almost cover the ground.

It makes a more or less prominent escarpment from the Brady mountains to Jim Ned creek. From Camp Colorado north it is divided by clay strata, and becomes obscure in its outcrop. The outcrop of the bed one mile east of Santa Anna shows but six to eight feet solid limestone. On Watt's creek, south of Camp Colorado, it is ten feet thick, and much of the rock is of a yellowish color and rather soft.

Fossils: *Campophyllum torquium*, *Athyris* sp.?, *Chonetes granulifera*, *Productus costatus*, *Hemipronites crassus*, *Productus longispinus*, *Rhynchonella uta*, *Spiriferina kentuckiensis*, *Terebratula bovidens*, *Phillipsia* sp.?

15. Watt's Creek Bed

This bed, of fifty to seventy-five feet, is composed mostly of sandy bluish and reddish clay, and contains at most localities some thin

strata of limestone and sandstone; the sandstone, however, is mostly confined to the top of the bed. It is pretty well marked from the Brady mountains to the north part of the field, but fresh exposures can only be seen near the river and some of the creeks. On Home creek it consists of ten feet of sandstone at the top, below which is thirty-five or forty feet of clay, with a thin limestone parting near the center. Along Watt's creek it consists of sixty-five feet of clay strata, alternating with several thin layers of limestone, and a sandstone stratum one to five feet thick at the top.

The sandstones of this bed are confined principally to and near Home and Jim Ned creeks.

16. Horse Creek Bed

This bed of limestone is usually but five to fifteen feet thick, mostly massive, hard, and of a light gray color. The thinness of the bed permits it to make a sharply defined escarpment only in some favorable position of erosion, so that it is not especially prominent, and south of the river can not be easily located.

On the north side of the river it is probably fifteen feet thick. Along Home creek and Watt's creek are some of its best exposures, though slightly thinner than farther south. On Watt's creek the bed is fully twelve feet thick, and on the north side of Jim Ned creek is either parted by some clay or a limestone stratum of the underlying clay bed has developed to some prominence.

17. Santa Anna Bed

This bed, of twenty-five to seventy-five feet thickness, is composed of bluish and reddish sandy clay, and has scarcely any good exposures of its strata. It passes directly under the Santa Anna mountains at the town of Santa Anna, and its traceable outcrop nearly all lies north of the Colorado river.

18. Bed No. 18

This is fifteen to twenty-five feet thick at most places, and consists principally of limestone, but occasionally has some interstratified clay, much of which is shaly. Along Bull creek the limestone is mostly massive, some hard strata and some friable. East of Santa Anna branch the upper part of the bed consists of thin layers interstratified with carbonaceous clay shale. Along Jim Ned creek the most prominent part is four to five feet of hard massive gray limestone. The bed has little topographic prominence, and it is mainly in sharply eroded places that its strata may be seen.

19. Santa Anna Branch Bed

This bed has a thickness of 100 to 150 feet, and is composed of bluish clay, gray shaly sandy clay, a little coal at places, and some thin limestone and sandstone strata. It is well defined in its outcrop from the Brady mountains to the northern part of the field. About four miles north of the Colorado river, along Panther creek, the bed has the following section:

- g. Bluish shaly clay. 25 feet.
- f. Brown, hard, tough limestone, which contains a great many Myalina fossils. 10 inches.
- e. Shaly bluish clay, with some clay ironstone nodules. 50 feet.
- d. Shaly sandstone 10 feet.
- c. Clay, containing at the base some carbonaceous black shale and some two or three very thin seams or mere partings of coal. 30 feet.
- b. Yellow, massive, tough limestone containing numbers of *Hemipronites crassus*. 2½ feet.
- a. Clay 30 feet.

At the mouth of Santa Anna branch the bed consists of about 125 feet of bluish sandy clay, which contains a little shaly sandstone and a little carbonaceous shale full of plant impressions. South of Coleman Junction the section is as follows:

- c. Red sandy clay. 40 feet.
- b. Shaly sandstone 4 feet.
- a. Yellowish and pink sandy clay, with some blue sandy clay and also two or three feet of carbonaceous shale at the base of the bed. This shale in places contains an inch or two of coal, as may be seen in the branch east of Colonel Mahoney's house. 75 feet.

On Jim Ned creek, near the center of the Anderson survey, at the base of this bed, there is 1½ to 2 inches of coal outcropping in the center of two or three feet of black carbonaceous clay shale, which, in turn, is included in a bright blue clay.

North of Jim Ned creek the bed is about 125 feet thick, and consists at the top of reddish and blue clay, which, lower down, becomes darker and is a dark blue to gray, and at places a black clay shale.

Fossils: *Hemipronites crassus*, *Polyphemopsis* sp.?

ALBANY DIVISION

The following limestone and clay beds, having an aggregate thickness of about 1,200 feet, make up this division in the Colorado coal field:

- 15. Paint Rock bed.
- 14. Talpa bed.
- 13. Grape creek bed.
- 12. Bed No. 12.
- 11. Bead Mountain bed.
- 10. Valera bed.
- 9. Jagger Bend bed.
- 8. Bed No. 8.
- 7. Elm creek bed.
- 6. Coleman bed.
- 5. Bed No. 5.
- 4. Indian creek bed.
- 3. Hordes creek bed.
- 2. Lost creek bed.
- 1. Coleman Junction bed.

1. Coleman Junction Bed

This bed is about thirty feet thick, and is composed mostly of limestone, but from a few miles north of the Colorado river to the north it is divided by a clay stratum. It is readily traced from the Brady mountains to the north, because it caps a well marked escarpment, which from the Colorado river north is especially high and abrupt, being usually from 50 to over 100 feet high.

Three miles north of the Colorado river the bed has at its top five feet of yellowish friable limestone and the remaining twenty-five feet are light gray or dove colored limestone containing yellow spots. The most of this limestone is tough, and evenly-textured, so that it breaks down into blocks of considerable width. West of the mouth of Santa Anna branch the bed has the following section:

- | | | |
|----|--|---------------|
| c. | Yellowish friable limestone..... | 8 to 10 feet. |
| b. | Clay | 10 feet. |
| a. | Massive, hard, brittle, yellowish brown, slightly
cherty limestone..... | 20 feet. |

The following section was made half a mile south of Coleman Junction:

- | | | |
|----|---|----------------|
| c. | Nodular, or concretionary structured, brown and
yellowish limestone, the layers mostly from
six inches to one foot thick..... | 10 to 20 feet. |
| b. | Clay | 10 feet. |
| a. | Dove colored limestone, splotted with yellow and
red, and containing chert nodules, and at
places ferruginous calcareous sand nodules.... | 25 feet. |

North of Jim Ned creek the following section belongs to this bed, and possibly contains a little of the overlying strata:

- | | | |
|----|--|----------|
| c. | Reddish brown brittle sandy limestone..... | 3 feet. |
| b. | Clay | 10 feet. |
| a. | Reddish brown, friable, sandy, ferruginous limestone,
containing a large number of large Bellerophon, some
Hemipronites, Pinna, and Crinoids | 15 feet. |

The following fossils were found in this bed: *Athyris* sp.?, *Aviculopecten occidentalis*, *Productus cora*, *P. semireticulatus*, *Bellerophon crassus*, *Myalina* sp.?, *Pleurophorus* sp.?, *Allorisma subcuneata*, *Pinna peracuta*.

2. Lost Creek Bed

This bed consists of from twenty-five to fifty feet of red sandy clay. It can not be located south of the river, and its best exposures are along the north side of the Colorado river and along Lost, Horde, and Jim Ned creeks. It is but about twenty-five feet thick along the Colorado river, but thickens toward the north, till west of the mouth of Santa Anna branch it is fifty feet thick, all sandy and nearly all reddish colored. Along the railroad west of Coleman Junction, it is about forty feet thick, all more or less sandy and mostly of bluish or yellowish color. From the railroad further north the bed seems to thin.

3. *Hordes Creek Bed*

This bed of limestone varies from ten to twenty-five feet in thickness, and from the Colorado river northward it regularly thins. Two miles north of the Colorado river it has the following section:

e. Alternating layers of sandstone, clay, and thin impure limestone	10 feet.
d. Limestone, with a 3-inch layer of chert at the top..	1 foot.
c. Clay	5 feet.
b. Dove-colored crumbling limestone.....	4 feet.
a. Yellowish limestone, containing <i>Bellerophon crassus</i>	6 to 10 feet.

Along Redbank creek the upper part of the bed is made up of from five to six feet of yellowish friable limestone, and the lower part of two to four feet of gray to brownish gray hard and slightly sandy limestone. West of Coleman Junction the upper part consists of from one to three feet of nodular weathering limestone, and the lower part of from four to five feet of dark gray or brownish hard, massive limestone.

4. *Indian Creek Bed*

This bed of clay is from seventy-five to over one hundred feet thick, the thicker part being toward the north. The clay is more or less sandy throughout, at many places slightly shaly and at some places carbonaceous. The bed is quite clearly marked from the Brady mountains to the northern part of the field. Along the north side of the Colorado river it is fully seventy-five feet thick, and consists of a shaly bluish clay, with purplish and yellowish clay at places. Three to four miles south of the railroad it is fully one hundred feet thick, and made up of bluish clay, slightly shaly and carbonaceous at places, and more or less sandy throughout. The shaly and carbonaceous nature increases northward till on Indian creek, near the top of the bed, as seen near Mr. Gordon's, there is fully six feet of black shale containing four or five seams of coal, which are from mere partings to one and a half inches thick.

5. *Bed No. 5*

This bed of limestone with some marly clay varies from twenty-five to about sixty feet in thickness. The thickest exposures seen are along the Colorado river. From the Brady mountains to the river the outcrop of this bed approximately follows the McCulloch-Concho county line, and from the river to the eastern part of Coleman City the bed forms a distinct and prominent escarpment. On the north side of the Colorado river it has the following development: The upper part consists of twenty-five feet of friable white or light gray limestone, the crumbled fragments of which are quite hard; *Bellerophon crassus*, *Productus semi-reticulatus*, and a few *Pinna peracula* are the common fossil forms. Below this stratum are ten feet of massive dove-colored limestone, containing many yellow splotches. *Bellerophon crassus* is a common fossil in this stratum, and highly calcareous chert nodules are also common.

The basal part of the bed consists of twenty feet of thin rotten limestone layers, interstratified with marly clay. Four miles south of the railroad the bed is about thirty feet thick, and is as follows:

The upper part consists of from four to five feet of friable grayish limestone, containing a great many large *Athyris* and some *Productus semireticulatus*. The lower part consists of twenty to twenty-five feet of hard massive gray limestone, containing yellowish spots and weathering in small nodular-like pieces and some large similar shaped masses or boulders. On Indian creek the upper five feet of the bed is a hard massive limestone, below which are about twenty feet of marly clay and rotten limestone, which represents the transition of the limestone of the south to the clay of the northern part of the field.

6. Coleman Bed

The greater part of the town of Coleman is built on the outcrop of this bed, which outcrops along the Colorado river, at the mouth of Mustang creek, or just west of the Concho-McCulloch county line. This bed, mostly clay, is from fifty to over one hundred feet thick, and very well marked from the Brady mountains to the northern part of the field. From the Colorado river north it forms the basal part of a continuous high escarpment. Along the Colorado river to the south the bed is largely interstratified with thin beds of limestone, and much of the clay is marly and yellowish in color. Three miles north of the Colorado river the bed has the following development:

- | | |
|--|----------|
| d. Marly yellowish clay, interstratified with thin beds of limestone | 10 feet. |
| c. Clay | 15 feet. |
| b. Limestone | 1 foot. |
| a. Clay | 25 feet. |

Farther north the bed loses its limestone and becomes more sandy, shaly, and darker in color. North of Coleman well sections show it to be principally black or dark gray sandy clay shale, with many white specks scattered through the material. On Indian creek there is some black carbonaceous shale in which are occasional partings of coal, but none are more than from one to one and a half inches thick.

7. Elm Creek Bed

This bed of limestone varies from twenty-five to one hundred and fifty feet in thickness. The thickest exposures seen are along the Colorado river, at and below the mouth of Elm creek, and the thinnest are at the northern part of the field. The limestone being hard and of considerable thickness throughout and regularly underlaid by a thick clay bed, a high escarpment is formed, which runs approximately north and south immediately west of Coleman, and is pretty clearly defined from the Brady mountains to the northern part of the field. Along the Colorado river it is about one hundred and fifty feet thick, and consists mostly of bluish-gray limestone, with some yellowish, friable, dark shaly, and highly fossiliferous limestone. Most of the strata are from one to five feet thick, generally rough and somewhat nodular, but a few layers, as some of those at the mouth of Elm creek, are quite smooth and regularly textured, and would do moderately well for building stone, though rather brittle.

Between the various strata there are usually partings of soft or easily weathered, unevenly textured limestone, and at some places marly clay; these assist in causing the strata to break down and crumble more rapidly, so except along the river the hillsides do not often present bluffy outcrops, but present sharply rolling surfaces.

About three miles north of the Colorado river the basal part of the bed has the following section:

- d. White crumbling limestone 10 feet.
- c. Yellowish limestone, containing some red spots, weathers to subangular fragments and larger like-shaped pieces.. 4 feet.
- b. White or light gray limestone, weathers to subangular pieces and contains many *Bellerophon crassus*..... 25 feet.
- a. Yellow weathering limestone: freshly broken pieces are brown in color, it breaks down from its outcrop in large masses of irregular shape

The bed thins regularly to the north, without any special change in character, except where it is a transition from the limestone to marl, clay or shaly strata.

On Indian creek the bed is as follows:

- d. Hard white limestone 16 feet.
- c. Soft limestone 4 feet.
- b. Shaly black clay 6 feet.
- a. Yellow limestone 2½ feet.

The principal fossils collected in this bed are: *Syringopora* sp.?, *Athyris* sp.?, *Aviculopecten* sp.?, *Productus semireticulatus*, *Euomphalus* sp.?, *Bellerophon crassus*, *Murchisoni terebra*?, *M. trinodolineatus* (W. F. Cummins), *Platyceras* sp.?, *Myalina subquadrata*, *Pleurophorus* sp.?, *Allorisma subcuneata*, *Pinna peracuta*.

8. Bed No. 8

This bed of clay is from fifty to seventy-five feet thick in the northern part of the field and thins rapidly towards the south, till at the Colorado river it is almost lacking. From the river, four to five miles north, along the west side of Elm creek, it may be traced by a slight escarpment and a few fresh outcrops of clay. At the head of Panther creek it becomes of considerable prominence, and has the following section:

- c. Reddish clay with some bluish clay..... 30 feet.
- b. Bright yellow clay 2 feet.
- a. Clay 5 feet.

Three or four miles farther north, or about two miles south of the railroad, it has the following section:

- c. Clay 25 feet
- b. Hard bright yellow limestone 2 feet.
- a. Clay 15 feet.

West and northwest of Coleman the bed is from sixty to seventy-five feet thick, and remains very near that thickness to the northern part of the field.

9. Jagger Bend Bed

This bed is mostly limestone, and includes the outcropping strata in Jagger Bend of the Colorado river, and northward by Valera to the

north part of the field at Bluff creek. The level of the country south of the river makes only an approximate location of the bed possible.

Along the Colorado river it is 75 feet thick or more, and thins northward, till in the northern part of the field twenty-five feet would cover its total thickness. As shown in Jagger Bend, it consists of alternating beds of flaggy, smooth limestone, carbonaceous shaly limestone, and carbonaceous clay. Some of the limestone, though rather brittle, would do moderately well for building purposes. The strata vary in thickness from mere partings to four feet. Along the river the bed contains an abundance of *Syringopora*, which occur in some places in large masses, as in the original place of growth, but at others it has been torn from its place of growth, broken to pieces, and deposited with other sediment, which mixture makes up considerable of the shaly or flaggy limestone.

South of Home creek the bed consists of from one to two feet of bright yellow limestone at the base, and above that twenty-five to thirty feet of light gray limestone interstratified with some thin clay. In the north part of the field the carbonaceous nature does not show much, because the strata have been long exposed without much erosion. The fossils collected from this bed are: *Syringopora* sp.?, *Alkyris* sp.?, *Productus semi-reticulatus*, *Pleurotomaria* sp.?, *Pleurophorus* sp.?, *Allorisma subcuneata*.

10. Valera Bed

This bed of clay practically begins on the northside of the Colorado river near the mouth of Grape creek, and is barely traceable to its crossing of Elm creek, where it begins to thicken northwards, and at the railroad is about twenty-five feet thick. Along Horde and Bluff creeks it is about forty feet thick.

11. Bead Mountain Bed

This bed of limestone outcrops along the river at Trap crossing and in Grape creek northeast of that crossing and outcrops around Bead mountain and to the north, as shown on the map. It is composed largely of dark colored, hard, brittle, slightly shaly limestone, alternating with softer light gray limestone.

Along the river it is fully fifty feet thick, but its upper horizon being indefinite, its extent can only be approximated, and like the other limestone beds it thins to the north, till in the northern part of the field six to ten feet includes its continued limestone.

12. Bed No. 12

This clay bed practically begins two miles southwest of Bead mountain and rapidly thickens towards the north, till in the northern part of the field it is fully seventy-five feet thick and has a three-foot stratum of limestone near its middle. The clay is more or less sandy and rather variable in color from yellowish to bluish and reddish.

13. Grape Creek Bed

This bed, with a thickness of from 100 to 150 feet, or probably more, is composed mostly of light gray rather friable limestone, but in the southern and northern parts of the field it contains more or less clay. The average and usual width of outcrop is about three and one-half miles. The upper outcrop or limit of the bed extends up the Concho

river to the mouth of Duck creek, about two and a half miles west of the southeast corner of Runnels county. Along the railroad the bed extends from one-fourth mile west of Bead mountain to within three miles of Talpa.

Along Brady creek the outcrop shows it to be at that place chiefly clay, and the limestone to be thin and somewhat regularly distributed through the bed. But northward to the river the limestone increases, till along the Concho river and on the south side of the Colorado river most of the bed is a light gray or dove-colored friable limestone, and the clay is thin interstratified material which is not thick enough to be of any prominence. On the north side of the Colorado river nearly all the bed is limestone; the lower part a friable yellowish weathering limestone, the middle a harder bluish limestone, the upper mostly a hard, light blue or gray friable limestone. *Bellerophon crassus*, *Pinna peracuta*, *Nautilus*, and *Syringopora* are the most common fossil forms.

From four or five miles south of the railroad to the north, the middle and upper portions of the bed include well marked clay horizons, which along the railroad are very thin, but thicken to twenty or twenty-five feet in the northern part of the field, and the bed as a whole has there about the following section:

f. Clay	25 feet.
e. Limestone, with some clay layers.....	75 feet.
d. Clay	25 feet.
c. Limestone containing many <i>Bellerophon crassus</i> fossils....	20 feet.
b. Marly material	8 feet.
a. Hard limestone	2 feet.

The following is a list of the fossils found in this bed: *Syringopora* sp.?, *Productus semireticulatus*, *P. pertenuis*, *Pleurotomaria* sp.?, *Bellerophon crassus*, *Murchisonia terebra*?, *Platyceras* sp.?, *Nautilus* sp.?, *Myalina* sp.?, *M. subquadrata*, *Pleurophorus* sp.?, *Allorisma subcuneata*, *Pinna peracuta*.

14. Talpa Bed

This bed is about two hundred to three hundred feet thick, has an outcrop of four to six miles in width, and is nearly all composed of limestone strata, which are from a few inches to four feet thick, and mostly hard, massive, and rather unevenly textured. It is especially marked throughout by its containing many *Productus semireticulatus*, large *Euomphalus*, and *Pleurotomaria*, and its uniform lithologic character. Part of the bed is exposed in Brady creek, southeast of Eden, from which place it extends almost due north to the Concho river. Talpa, Glen Cove, and Novice are situated near the center of the outcrop. Along the Concho and Colorado rivers, the base is distinguished from the underlying bed by being composed of harder, bluer, and more massive strata, and by containing the large *Euomphalus*, *Pleurotomaria*, and *Productus semireticulatus*. Throughout the bed there is little else than hard, massive gray or bluish limestone layers, one to four feet thick, with some thin marly layers. On the Colorado river, near the middle of the bed, there is some shaly carbonaceous limestone, but the rest of the bed there is more evenly textured and has smooth bedding planes. South of Talpa, considerable of the rock is yellowish on weathered surfaces.

At the northern part of the field the base of this bed as exposed along Rough creek, east of Novice, is mostly limestone, but has some clays. Some of the limestone is shaly, or weathers into thin sharp-edged

pieces, but most of it is massive and breaks down from its outcrop in blocks, or crumbles into small pieces. Its color is mostly blue, but some of it becomes yellowish on weathering.

Some of the bed, especially the yellowish nodular part, is very fossiliferous in the distinctive forms of this bed as well as in many other forms. The central and upper part of the bed is more regularly composed of limestone in layers from six inches to three feet thick.

The fossils found in the bed are: *Syringopora* sp.?, *Spirifer planoconvexa*, *Hemipronites crassus*, *Productus semireticulatus*, *P. pertenuis*, *Euomphalus* sp.?, *Pleuromaria* sp.?, *Bellerophon carbonarius*, *B. crassus*, *Murchisonia* sp.?, *Platyceras* sp.?, *Nautilus* sp.?, *Myalina* sp.?, *M. subquadrata*, *Pleurophorus* sp.?, *Allorisma subcuneata*, *Pinna peracuta*.

15. Paint Rock Bed

This bed is about one hundred and fifty feet thick, and is largely composed of shaly, slightly carbonaceous limestone, a large part of which while not really shaly, is slightly so, and in weathering readily crumbles into thin flake-like pieces. There is a considerable part of the bed, however, that in places shows little or no shaly nature.

The characteristic features are its dark colored shaly rock and the *Platyceras* and *Productus pertenuis* fossils found in it. The outcrop along and on either side of the Eden-Paint Rock road, from the Brady mountains to Paint Rock, shows numerous beds of dark colored shaly limestone, and good exposures of the same character of rock may be seen near the mouth of Kickapoo creek and along Hog creek south and southeast of Paint Rock.

Along Pony creek, one to two miles from its mouth, there is a fine development of carbonaceous calcareous clay shale, in strata from one to fifteen feet thick, interstratified with shaly limestone strata one to two feet thick. The limestone is rich in fossils, including the characteristic forms of this bed.

Among the exposures of the typical rock of this bed, the one along Mustang creek from its mouth to within one and one-half miles of Norwood, is one of the best. This distance along the creek shows the total thickness of the bed, or fully one hundred and fifty feet of shaly limestone, interstratified with thin layers of carbonaceous, argillaceous, lime shale, which is very soft, and weathers almost as readily as clay. Near the top of the bed some of the limestone is evenly textured, has smooth bedding planes, and is of a light blue or gray color. Nearly every stratum throughout the bed along this creek is more or less shaly, and in weathering breaks up into thin shale-like pieces.

In the north part of the field, as shown along the South Fork of Jim Ned creek, west and northwest of Novice, the shaly nature is not prominent, but some strata are slightly shaly, and the characteristic fossils are abundant enough to pretty well locate the limits of the bed. It forms the uppermost bed which has been referred to the Albany division, and is overlaid by yellowish limestone and red clay, the limestones usually containing great numbers of *Pleurophorus*, *Aviculopecten*, *Meekella striato-costata*, and *Myalina*.

Some of the fossils collected from this bed are as follows: *Athyris subtilita*, *Hemipronites crassus*, *Aviculopecten occidentalis*, *Productus semireticulatus*, *P. pertenuis*, *Euomphalus* sp.?, *E. rugosus*, *Pleurotomaria* sp.?, *Bellerophon crassus*, *B. sp.*?, *Murchisonia* sp.?, *Platyceras* sp.?, *Orthoceras* sp.?, *Myalina subquadrata*, *Pleurophorus* sp.?, *Allorisma subcuneata*, *Pinna peracuta*.

ECONOMIC GEOLOGY

COAL

The coal of this field is confined to the Canyon, Cisco, and Albany divisions, the greater part of it being in the Cisco division. The seams in the Canyon and Albany divisions are too thin to work and of small extent. There are only two seams in the Cisco division that contain anything like workable coal. The thin seams are numerous and local, and are from mere partings to five or six inches thick. Some of the outcrops of these thin seams are as follows:

Canyon Division:

Brownwood bed; on Clear creek, three miles from its mouth.

Cisco Division:

Trickham bed; two to three miles north of Thrifty, and four miles south of Byrd's Store.

Speck Mountain clay bed; at the William Adams place, two miles south of East and West mountain.

Santa Anna bed; on Jim Ned creek on the Anderson survey.

Santa Anna branch bed; along Santa Anna branch, east of Colonel Mahoney's house; along Panther creek three to four miles from its mouth; along the Colorado river at Horseshoe Bend.

Albany Division:

Indian Creek bed; four miles north of Coleman, or the "Gordon Coal."

Coleman bed; about four miles north of Coleman.

At a number of places these thin seams have been prospected and always found too thin to pay for working. From their limited extent, unfavorable conditions for accumulation of coal, and unfavorable existing outcrops, it is practically useless to expend labor in working them.

There are, however, two seams in the Cisco division that are worthy of more careful study. The lower of these two seams is in the Lohn bed, or just below the Chaffin limestone, and has been worked at the Chaffin mine east of Waldrip; the upper seam is the one worked at Waldrip; on Bull creek, on Home creek, and on Jim Ned creek at the Silver Moon mine.

The position of this latter seam in the Waldrip bed is shown in the Rockwood section, plate IV, and the positions of both seams are shown in sections Nos. 4 and 5 of the Cisco division.

Continuity of the Two Seams.—Both beds show some irregularities in extent, probably due to breaks in the belt of the original plant accumulation, or erosion of the bed while the vegetation was accumulating, or a combination of both. These breaks of the coal bed are small and not frequent in the upper seam, but are marked characteristics of the lower or Chaffin seam.

THE CHAFFIN SEAM

At the Chaffin mine this coal is immediately below the Chaffin limestone. As shown on the map, and described under the head of the "Chaffin Limestone Bed," this limestone, with a few breaks, extends across this field from Brady creek to and beyond Pecan bayou, and so, by locating it, the horizon of the Chaffin coal is closely

determined. But as a matter of fact this coal has nowhere been seen in the outcrop of the Lohn clays except at the Chaffin coal mine, and the outcrop of this thin clay bed generally indicates the absence rather than a probability of coal.

East of Rockwood, wells sunk through the Chaffin limestone into the clay where the coal should be, show no coal, but a very little carbonaceous shale with plant impressions. On Home creek the clays under this limestone have something of the appearance of clays associated with coal, but the little prospecting below this limestone has revealed no coal.

North of Home creek the Chaffin limestone divides into two beds, as previously described.

In the lower part of the Waldrip bed, on the northeast corner of the Samuel Sprague survey, Mr. R. M. Low has recently drilled a well about 160 feet deep. He gave me the following section from memory:

i. Soil	4 feet.
h. Sandstone	8 feet.
g. Blue clay	40 feet.
f. Red clay, with some siliceous pebbles.....	30 feet.
e. Hard brown limestone.....	3 feet.
d. Red clay	25 feet.
c. White limestone	4 to 5 feet.
b. Coal (probably part shale).....	3 feet.
a. Red clay	40 feet.

"a" and "b" belong to the Lohn bed; "c," "d," and "e" belong to the Chaffin limestone bed, and the higher strata are the lower part of the Waldrip bed, or that part under the Bull creek coal seam.

The position of this coal just under the Chaffin limestone being the same as the position of that at the Chaffin mine, it could not well be regarded as other than the same coal, though the bed is probably not now continuous throughout. As this well was drilled for water, and the quality or even quantity of the coal is more or less conjecture, the value of the seam is yet to be determined.

At and near the Silver Moon mine two shafts have been sunk below the upper or Bull creek coal seam, with a view of determining whether other workable coal seams lay below, but in each case (two times) the prospecting was stopped at the limestone stratum "c," which is the second limestone below the upper coal seam, as the strata exist along Mud and Jim Ned creeks. No further evidence of this lower coal seam was obtained to the north, and the outcrop of the Lohn bed would indicate the absence rather than the presence of coal.

Sections Nos. 4 and 5 across the Cisco division were made to include the Chaffin mine and the Low well, and it is probable that those two places, with limited extent to the west of them, include the only places where this coal seam exists in this field. Between the Chaffin mine and Rockwood, the coal seems to have been eroded and sandstones and conglomerates deposited, and as the Chaffin mine is at the eastern outcrop of the coal bed, the most probable extent of the coal is to the southwest from the mine.

THE UPPER OR BULL CREEK SYSTEM

This seam* is most probably the same as the coal seam No. 7 of

*See Second Annual Report Geological Survey of Texas, p. 373.

See First Report of Progress Geological Survey of Texas, 1888, p. 49.

the general sections made by Prof. W. F. Cummins. This coal seam has been found at numerous places throughout the field along the outcrop of the Waldrip bed, which, as shown in the Rockwood section, contains this coal. The coal mines that have been or are now worked and the outcrop of this coal bed are shown on the map.

The numerous and distributed localities across the field near the outcrop of the coal seam, where the coal has been found, prove conclusively that the bed from the line connecting its outcrops, extends in almost an unbroken bed or seam back to the west, but varies much in thickness at different places. At some places, however, within this area, the coal has been found lacking, but in such cases localities near by on either side prove the existence of the seam, so that the places where the coal bed belongs and is not found are decidedly exceptions and not the rule. The seam contains frequent places where the coal is wedged out for a foot or two, and some cases of failure in finding coal in drilling for it can easily be explained by the occurrence of the wedged out points and "horsebacks." Where shafts have been put down and no coal found, sandstones and conglomerates or highly sandy clays passed through indicated rapid current action that probably cut away the coal vegetation at the time of its accumulation.

THE CHAFFIN COAL

The coal at the Chaffin mine is twenty inches thick,* and probably of a better quality than the Bull creek coal, though we were not able to get specimens from the mine for analysis, as it had been neglected and was filled with water and mud.

THE BULL CREEK COAL SEAM

The several places where this coal seam has been found on and to the south of Brady creek, it is reported to be about a foot thick; in the north part of the field the evidence is that it is no better, or even not so good. At the Silver Moon mine the average of several measurements of the coal is as follows:

e. Coal (very variable).....	1 to 3 inches.
d. Slate or hard clay.....	10 inches.
c. Coal (somewhat variable in thickness).....	6 inches.
b. Slate or hard clay.....	5 inches.
a. Coal	8 inches.

Only the two lower seams are worked, the analyses of which are as follows:

	Coal Seam "c."	Coal Seam "a."
Water	2.26	2.46
Volatile matter	39.75	37.31
Fixed carbon	44.87	42.89
Ash	13.12	17.34
†Total.....	100.00	100.00
Sulphur	2.94	8.89

*Geological Survey of Texas, 1889, p. 159.

†Analyses by L. E. Dickson.

The thinness of this coal, its being separated by slate that must be removed, and the high per cent of sulphur and ash, are all objectionable elements that make this part of the coal field undesirable for working.

East of the Santa Anna, on the Mary Anne Fisk survey, a Corsicana coal prospecting company, in the winter of 1891, sunk a coal prospecting drill 305 feet. No section of the strata passed through could be obtained, but from the geological elevation where the work began (just below limestone No. 3 of the Rockwood section) it is most probable that their work extended into the Lohn bed, and consequently pretty well determined the coal probabilities of both the upper (Bull creek) and lower (Chaffin) seams. This and several other prospecting shafts near by contained a little coal at the horizon of the Bull creek seam, but entirely too little to work.

Along Home creek, about at the south line of the William Skirlock survey, several shafts have been put down to the Bull creek coal, and it is reported to be from twenty-four to thirty inches thick and of very good quality. The greatest amount of prospecting has been done in the vicinity of Waldrup and Bull creek, and the coal found to vary from one foot to about thirty inches in thickness, but in nearly all the shafts it is fully two feet thick. Outcrops along Bull creek show the coal to be two feet or more in thickness.

The only mine now being operated is that of the Star and Crescent company, about one and a quarter miles southwest of Rockwood. In September the tunnel from the main entry was forty to fifty feet long, and from a general average of the coal seams along this face the following section was made:

g. Coal	1 ½ inches.
f. Shale (clay)	3 inches.
e. Coal	4 inches.
d. Earthy coal	1 inch.
c. Coal	3 inches.
b. Earthy coal	½ inch.
a. Coal	16 inches.

Seam "g" is not worked, but the rest of the coal (twenty-four and a half inches) is all mined together.

The following analyses were made of the different parts of this coal, the specimens all being taken from one block representing the total thickness and an average specimen.

	No. 1.	No. 2.	No. 3.	No. 4.
Water	4.71	3.98	2.67	2.63
Volatile matter	39.26	37.36	38.79	39.43
Fixed carbon	46.24	40.58	46.12	43.49
Ash	9.79	18.08	12.42	14.45
*Total	100.00	100.00	100.00	100.00
Sulphur	2.22	5.06	4.17	2.90

*Analyses by L. E. Dickson.

	No. 5, or "b" of section.	No. 6, or "d" of section.
Water	2.29	2.17
Volatile matter	23.49	19.95
Fixed carbon	32.06	26.13
Ash	42.16	51.75
Total	100.00	100.00
Sulphur	3.29	0.99

By taking the per cent of the coal seam worked, that each analysis represents, and making an average of the full seam, we have the twenty-four and one-half inches of coal represented by the following analysis:

Water	3.23 per cent.
Volatile matter	37.54 per cent.
Fixed carbon	42.80 per cent.
Ash	16.40 per cent.
Total	100.00 per cent.
Sulphur	3.67 per cent.

The percentages of sulphur and ash are high, and the per cent of water is slightly more than an average, so it is to the position of the coal more than its amount and quality that its development depends. The increasing population of the poorly timbered country to the west demand fuel, and with increasing demand the feasibility of working thin and inferior coal seams will become greater. The roofing in all the mines is found good and usually is a hardened clay. At the Chaffin mine the roof is the Chaffin limestone.

It is probable, that from known thicknesses of the Bull creek coal at different localities, that an area extending from Home creek to a few miles south of Waldrip includes the best part of this coal seam in the Colorado coal field, and that the mine now in operation by Star and Crescent company one and one-fourth miles southwest of Rockwood is a fair average of what the field may be expected to show. The dip of the coal seams is about forty feet per mile north 60 degrees to 70 degrees west.

The Chaffin and Bull creek coals have by several persons been regarded as the same seam. The local nature of the Chaffin coal, the somewhat irregularly associated stratigraphy, and the similarity of the two seams make it of some difficulty to decide their positions and relations. But, as has been shown, the Chaffin limestone is by no means a local bed, but extends clear across the field, and from Brady creek to the north of Home creek the bed is quite regular and from eight to twenty feet thick, all of the same massive, splintery weathering, bluish white or gray limestone, and, where not covered by the Cretaceous beds, it is continuously traceable, except between the Colorado river and a point about one mile south of Rockwood. Then it is evident that if the outcrop of this bed is so regular, its extent to the west under the overlying beds would also be regular, at least for the short distance between the Chaffin mine and those near Waldrip (the Harris and Williamson mines). But over the coal at these latter places there is no such limestone bed, and the same is true with the Bull creek coal farther to the north. As shown in the Rockwood section, page 434, the first two limestone strata

above the Bull creek coal seam are very thin, and, as discussed under the "Waldrip beds," they are distinct in character of material. Both limestone strata (No. 1 and No. 2) may be seen outcropping on the east river bank opposite Waldrip Postoffice, and have about the same appearance and relative vertical distance apart as they have southwest of Rockwood, so they, too, are uniform and can not be confounded with the Chaffin limestone. Stratum No. 1 outcrops about one-fourth of a mile east of Waldrip Postoffice, and the clay stratum "3," with its characteristic ironstone nodules, is also finely exposed from one-half to three-fourths of a mile east of the post-office, and as this horizon of ironstone nodules is in the middle part of stratum "3," the Bull creek coal seam is not far below it, and would outcrop at about a mile east of Waldrip, or half a mile or more west of the Chaffin coal mine.

OIL AND GAS

A majority of the deeper wells in the Canyon, and a large per cent of those in the Cisco division, give off some natural gas. Some of them afford such quantities of gas that when it is lighted it furnishes a constant flame for several hours, this being especially the case when the gas is first struck, or when the water is pumped out of the gas well.

The Albany and Strawn divisions also have some weak gas wells, but wells affording gas are not common in these divisions. In the Cisco and Canyon divisions some oil has also been obtained from a few wells.

In 1878, Mr. Martin Meinsinger sunk a well at Brownwood for water, and at a shallow depth struck a sandstone which gave a slight flow of light oil. He says the flow is now fourteen to sixteen gallons per day. The oil is sold for lubricating purposes, and is said to be of excellent quality. Mr. L. L. Shields drilled a well at Trickham to a depth of 220 feet, and at a depth of 100 feet salt artesian water was reached which brought up some oil. Near Milburn a sipe of oil has been obtained, and at several other places in the Canyon division very small sipes of oil have been struck.

The occurrence of gas and oil, especially that at Brownwood, caused the Colorado and Sunset oil prospecting companies to be formed, which, in 1890, put down two wells at Brownwood.

The Sunset Oil Company sunk a well (the Lone Star well) to a depth of 1,938 feet. The first 1,500 feet was through alternating beds of sandstone, clays, and shaly clays, below which the shaly nature rapidly increased, and toward the bottom of the well hard white limestone was passed through. At 512 feet salt artesian water was struck in sandstone, at 1,600 feet a little oil was obtained in limestone rock, and at 1,935 feet another sipe of oil was obtained from limestone.

The Colorado company sunk a well (Well No. 2) within about one-fourth of a mile of the above, to a depth of 1,643 feet. The first 1,500 feet was through alternating sandstone, clay, and shaly clay strata, below which was more pure shale and hard white limestone. Salt artesian water was obtained in this well, and quite a flow of gas from sandstone was struck at 1,500 feet, and at 1,561 feet a sipe of oil was reached. The gas was utilized for a short time for heating a boiler used at the oil well works.

There can be but little doubt but that the lower parts of those

wells are in the Bend division, for beds of the Strawn division contain almost no limestone or true shale, and the shales and limestones in the lower part of those wells closely resemble or are identical with the outcropping shales and limestones of the Bend division; and further, the beds of the Strawn lie unconformably on the Bend division, so that the latter division might be reached at irregular depths.

ORIGIN OF OIL AND CONDITIONS OF ACCUMULATION

The best authorities unhesitatingly affirm that oil is derived from organic matter, and that shale beds are its most common source. The great accumulations of oil, however, are not found in the rock from which it originated, but in an overlying porous stratum which furnishes a collecting reservoir for the accumulation of oil. From ages to ages the oil rises or by some distilling process is passed to the overlying strata. This overlying porous or reservoir bed must be overlaid by some impervious material so as not to allow the oil to continue upwards to the surface and waste away. It is obvious that if this series of beds, i. e., at the base oil producing beds, overlaid by porous or reservoir beds, and this in turn overlaid by impervious material, were highly inclined so as to leave one edge of the beds outcropping, the oil would slowly pass from the oil producing bed into the porous bed and upwards through this to the outcrop and waste away; while if the beds of the above named order were thrown into folds the oil would pass from the basal or synclines to the upper or anticlines and there, everywhere overlaid by impervious strata, the oil with its tendency to continue upwards could go no further and would accumulate. Some such structure of the strata for hemming the oil in its natural directions of movement is necessary for the accumulations of economical value.

Some oil fields are situated in monoclinical structure of the strata, and the beds are practically horizontal, but there the above hemming conditions are equally true.

As elsewhere shown, the Strawn, Canyon, Cisco, and Albany divisions are laid down unconformably on the Bend division. The Bend strata dip to the north quite rapidly along its contact with the higher divisions; but most likely further to the north, away from the older rocks and under the higher divisions, its dip rapidly decreases till it lies in almost level or slightly folded strata.

The upper part of the Bend division consists of carbonaceous shales, seemingly such as are needed as the source of oil.

The overlying Canyon, Strawn, and Cisco divisions have porous sandstone beds well adapted to hold oil, and these sandstones are overlaid by impervious clays. These sandstone and clay beds dip quite regularly and on an average about fifty feet to the mile to the northwest, so that the oil could move upwards along these inclines and waste away where the porous or oil gathering strata outcrop. The most rapidly dipping strata would allow the most rapid waste, or no accumulation of oil, while the strata that dip but little or are practically level would accumulate some gas and oil.

The Strawn division, near its basal part, dips over 100 feet per mile, and the dip decreases quite regularly upward to the upper part of the Canyon and the lower part of the Cisco divisions, and the Albany division seems to dip slightly more than the basal part of the Cisco division. The Albany division is nearly all hard limestone and impervious clay, so its strata are not well adapted to form reservoirs. The comparative shallowness of the covering of the Bend

shale by the Strawn strata and the high inclination of the latter make its conditions very unfavorable for oil.

The particular places of some of the most nearly horizontal strata in this field are as follows:

Along the Colorado river at the Mitchell and old Military road crossings, or from the mouth of Home creek to Cow creek; a second locality is along the Colorado river from a little west of the mouth of the Colorado river to below the Jagers bend of the river; a third locality is at and a few miles to the north of Brownwood; and a fourth, a very small area along Jim Ned creek about four miles east of Thrifty.

While these localities probably represent the best conditions of the strata in this field, they can not, with our present knowledge of them, be claimed to be good; and none of them, except that at the mouth of the Concho river, shows any special outward signs of oil below. There a large part of the limestone and included shaly limestone or clay is slightly bituminous, some of which will burn* without loss of volume.

Irregularities of original bedding may make some local places favorable for the accumulation of small quantities of gas and oil. The Meinsinger well at Brownwood most probably is situated in some such locally favored bedding.

It might be supposed that the Bend division, away from its outcrop, at places has the proper anticlines or flexures of bedding for the accumulation of oil, but such a place would be difficult to locate, since the strata are deeply buried there; and besides the Bend limestone is too dense to make good reservoirs, and, so far as known, the shale nearly all lies at the top of the division and its oil would pass into the higher divisions.

With these conditions it seems very improbable that oil or gas in economic quantities can be expected to be found in this field, but some closer work is needed to fully determine the question.

IRON ORE

The occurrence of numerous nodules of iron in some localities has led persons to think that larger quantities existed farther back in the hills, or deeper in the ground, and in a few cases some money and labor have been expended in digging for iron. There are two geological horizons that carry enough iron to make the localities along their outcrop noticeable.

These horizons are the basal part of the Trinity conglomerate west of Bangs, and southeast of Brownwood on either side of Pecan bayou, and the second horizon is the central part of the Waldrup bed of the Cisco division of the Carboniferous. In both horizons, iron nodules occur scattered through the bed through a vertical distance of from five to six feet, and as the beds are worn down the hard iron nodules, resisting weathering longer, are left scattered over the ground, even thicker than they occur along any plane in the bed, in too small quantities to work.

CLAYS

There are two classes of clays in this district; one composing the regular strata of the beds, and the other Quaternary deposits, or accumulations of clays worn from the outcropping clay beds, and deposited in valleys at the foot of escarpments, etc. These later

*See First Annual Report, Geological Survey of Texas, p. 216.

deposits are more or less mixed with other materials, especially where other than clay strata are near by, sand nearly always forms a large per cent. These are the deposits that are used in making brick, as they contain the desired proportions of sand and clay to make good brick. This class of deposit is abundant in the Coal Measures, and good brick making material may be found in any of the divisions, but especially in the Strawn and Cisco divisions.

The strata throughout the divisions afford clays with varying proportion of the elements, especially sand, lime, and iron. The lime, however, usually forms but a small per cent. Iron is usually contained in a high per cent, especially in the clays above the central part of the Cisco division.

The following analyses represent the greater part of the clay of the Carboniferous below the middle part of the Cisco division:

No. 1 Canyon division, Brownwood bed, one and one-half miles northeast of Milburn.

No. 2, Cisco division, Waldrip bed, clay above the coal seam at the Silver Moon mine.*

	No. 1.	No. 2.
Water	1.70	1.79
Loss on ignition (water and carbonic acid).....	7.09	7.07
Silica	57.60	55.57
Ferric oxide	6.14	7.35
Alumina	19.34	22.04
Lime	1.23	0.35
Magnesia	2.01	1.35
Potash	2.02	1.04
Soda	2.73	3.46
Total	99.86	100.02

The high per cent of the fluxing elements of iron, lime, magnesia, potash, and soda in these clays shows they are not fire clays, nor clays that can be used for the finer grades of manufacture. But as they represent the general character of the clay beds, and not particular deposits, better clays may be expected to be found as soon as the deposits can be more closely examined.

BUILDING STONE

This district is abundantly supplied with good stone for ordinary buildings. In both the Carboniferous and Cretaceous systems there are sandstones and limestones of excellent quality for building purposes.

The sandstones are mostly confined to the lower divisions of the Carboniferous, while the best limestones are mostly those of the Caprina bed of the Cretaceous.

WEATHERING AND DURABILITY OF BUILDING STONES

The lasting qualities of a stone vary greatly according to the climate in which it is placed. If there is a great variation of heat and cold, the expansion and contraction due to these changes of temperature have a tendency to lessen the coherency between the grains; especially is this the case if the rock is composed of grains or particles of different minerals of different expansive coefficients. If the stone is porous and has an argillaceous cement, either of which

*Analyses by L. E. Dickson.

will cause it to absorb water readily, because of the enormous expansive power of freezing water, frosts will loosen outer thin coats and more or less weaken the stone to greater depths. Limestones or sandstones with calcareous cement are slightly soluble; especially is this the case in the acidulated atmosphere of cities, the outer coats of the rock are decomposed, washed or blown away, and fresh surfaces exposed for renewed disintegration. This action may be slow, but after long periods of time becomes important.

In selecting a quarrying place much can be determined by observing the weathering properties of the different layers as shown in their outcrops. The most durable ones make the most prominent outcrops, while the layers least fitted for withstanding weathering have become decomposed and worn farther back into the main rock bed.

BUILDING STONES OF THE CARBONIFEROUS BEDS

STRAWN DIVISION

As already stated, this division contains by far the most stone good for building purposes in the Colorado Coal Field. Sandstone beds and clay beds are quite equally divided and well distributed throughout this division, as shown on the map. Nearly every sandstone bed contains good building stone, and the following description of the sandstone applies almost equally well to all the beds:

The sandstone has little color, or is of a very light gray and changes but slightly upon exposure, which shows that it contains little iron. Each layer of the rock is usually massive and has no outward appearance of any but a general and regular commingling of its constituent grains, but it usually can be split or broken along planes parallel to its bedding surfaces easier than in other directions. This property is, however, rarely enough marked to make the strata distinctly flaggy. The grains composing the rock are rather fine, angular, mostly white quartz, some few red siliceous grains, and a little mica. The comparative uniform size of the grains and regular compactness of the rock make it one of even texture, homogeneous structure, and regular weathering. The rock contains but little cement, and its tenacity is largely due to the pressure to which it has been subjected. The small amount of cement material is usually siliceous, though calcareous and argillaceous material occur in some of the beds. Those containing the calcareous cement are usually the hardest, because the siliceous material present is so little that it rarely ever makes the rock very hard. On an average the stone is hard enough for any ordinary buildings, and soft enough to dress easily. After the rock is taken from the quarry and exposed to the air it hardens very rapidly. The cause of this hardening has been explained by Newberry as follows: * "The rock when taken from the quarry contains moisture or quarry water, which water holds in solution small particles of siliceous, calcareous, and clayey matter, which, as the water is drawn to the surface of the rock and evaporated, deposits those cementing materials in the outer crust of the rock. For this reason a rock should be dressed to its final shape when first taken from the quarry, for this 'quarry water' once having carried and deposited its cements to form the outer crust there is no more to be thus placed when that crust is broken away by redressing or dressing after the seasoning of the rock."

The above general characteristics apply quite definitely to most of the sandstone that is adapted to building purposes. The strata that contain too much clay for good stone will usually be readily recog-

*Stones for Building and Decoration, G. P. Merrill, p. 364.

nized by its readily decomposing along its outcrop. Some of the rock is of coarser grains and more loosely bound together, such as most of the Brown creek bed (10) or that west of Big Valley. Ferruginous and conglomeritic strata become somewhat more prominent in the upper beds of the Strawn division, and the relative proportion of good building stone slightly decreases, but is still very abundant in every bed.

Some of the beds have very thick massive layers. Stones of uniform structure ten feet thick or more and of most any desired length might be obtained along Burnt branch southwest of Red Bluff; along the Colorado river below Shadwick's mill; in James' bend of Colorado river, or Fox Ford, and along Pompey, Blanket, and Rough creeks, and other localities. The stone along Antelope creek east of Red Bluff and near the mouth of Elliott creek occurs usually in thin smooth flaggy layers and of good quality. The stone for building the court house at Goldthwaite was quarried on Nabor's creek, where the strata are composed of smooth layers one to four feet thick.

On Pompey creek, at the old "wire" road crossing, some quarrying has been done. The layers are from one to three feet thick, and the stone is of a reddish color, but not of uniform color throughout the bed, and even along the same layers the color varies slightly. In other characteristics the rock is regular.

On China creek, about two miles from its mouth, some sandstone layers three feet thick, of a light color and uniform texture, have been worked. Near the mouth of Brown creek the Brown creek bed has been worked to some extent. Most of the strata are rather soft for substantial constructions, but some are quite hard, especially those that contain calcareous cement.

The Ricker bed, on the south side of Pecan bayou, about four miles from Brownwood, has been quarried considerably for building in Brownwood. The stone is of the light colored variety characteristic of this division.

There are numerous other places where stone has been quarried for local demands.

CANYON DIVISION

LIMESTONES.—While there is an abundance of limestone in this division, its irregular texture almost wholly unfits it for building purposes.

SANDSTONE.—Sandstone beds are not common in this division, and are mostly unfit for building stones because of their friableness, gritty and conglomeritic nature, but good building sandstone occurs at a number of places and in almost every community.

Just southwest of Brownwood a thin bed has been extensively worked. Its outcrop in the low lands requires the removal of a considerable amount of material to work the layers back from the outcrop.

About two miles west of Brady, on the west side of Post Oak creek, considerable quarrying has been done in a ten-foot stratum of sandstone, which contains about four feet of workable rock. It outcrops at the top of an escarpment and requires but little work in removing the material to obtain the rock. It contains a little iron, so that on exposure of the newly quarried slightly gray sandstone it changes to a slightly yellowish color.

CONGLOMERATE.—Some of the Rochelle conglomerate is so firmly cemented by a siliceous and ferruginous cement that it is susceptible of polishing, and might be used for some ornamental purposes. The siliceous pebbles are brown, white, pink, yellowish, red, and some almost black. The cement is a reddish color, and almost as hard as

the siliceous pebbles, so that in dressing the pebbles break as readily as the cementing material.

CISCO DIVISION

LIMESTONE.—The limestones of this division are of very much the same character as those of the Canyon division, and therefore not suitable for building purposes. Some localities, however, contain moderately fair stone that may be used for interior construction. There is a slight increase of regularity of structure and toughness of the rock towards the upper part of the division.

SANDSTONES.—The sandstones are mostly friable, gritty, and conglomeritic, and useless as building stones, but some good rock occurs, especially from the railroad north in the lower half of the division.

ALBANY DIVISION

Sandstones are practically wanting in this division.

LIMESTONES.—This division is largely composed of limestones, the greater part of which are unfit for building stone, but there is an abundance of rock moderately good for ordinary construction. The limestones best adapted for building purposes are those layers with smooth bedding planes, six inches to three feet thick, which outcrop in abundance along the Colorado river at the mouth of Elm creek, in Jagger bend, and along Mustang creek below Norwood. The rock is hard and rather brittle, so that in dressing it breaks in unexpected directions. This defect, however, is almost absent in some of the strata. The stone contains a little carbonaceous matter, giving it a gray color, is of uniform compact or close texture, and of very high compressive strength.

CRETACEOUS BUILDING STONES

SANDSTONES.—The only Cretaceous sandstones that can be used for building purposes are a few local deposits of the Trinity conglomerate, and the only place yet worked is at the head of Devil's branch, about seven miles southeast of Brownwood. At that place the Trinity conglomerate has the following section:

f. Soft calcareous sandstone	—feet.
e. Red sandstone	2 feet.
d. Red sandstone	1 foot.
c. Red sandstone	1½ feet.
b. Red sandstone	3 feet.
a. Conglomerate	20 feet.

"b," "c," "d," and "e" include the workable layers. The stone is red colored, composed of white and some red siliceous and quartz grains, and has a calcareous cement, a high compressive strength, and massive structure. Some few quartz pebbles occur in it, and concretions and argillaceous pockets occasionally occur, so that some extra stone must be worked to obtain perfect pieces. Blocks two to three feet square are about as large as can be obtained. This stone is now being used in Brownwood to trim some of the finest buildings and makes a very showy and beautiful stone. Other deposits of this same material may be found in this conglomerate bed along the bayou, but in most of the similar deposits the rock is too soft for building purposes.

LIMESTONE.—The Cretaceous limestones of this field that are suited for building stones, are almost wholly confined to the Caprina bed, *i. e.*, the strata capping Santa Anna mountains, Brady mountains, and the Cretaceous area north of Talpa. These strata have a beautiful white color, are amorphous, have a good compressive strength, uniform texture, and are easily dressed. The strata are thick enough to obtain stones from three to four feet thick. This bed is being worked at Santa Anna, and shipped to distant points.

ROAD MAKING MATERIAL

There are several classes of rock in this field that are adapted to macadamizing roads. Among the most important are the Carboniferous conglomerates, cherts, and limestones.

LIMESTONES.—These are hard, somewhat brittle, and durable for limestone, and the beds are so abundant and well distributed through all the divisions above or west of the Strawn division, that at any locality in those higher divisions this rock would be very close to any road where it needed to be used.

CHERT.—There are a number of the limestone beds which have been mentioned above which contain considerable chert, some of which is almost pure flint. This makes an excellent macadamizing material, but usually is not abundant enough to be economically obtained, and could only supplement other rock material, or the limestone with which it occurs.

CONGLOMERATE.—Beds of conglomerate are plentiful in the upper part of the Strawn and lower part of the Cisco division, and in the Canyon and Albany divisions there are some such deposits. This conglomerate is composed of small siliceous pebbles and quartz grit; it is usually friable and can be broken easily into its small component parts. The extreme hardness of the pebbles and grit make the material of the greatest durability; it will so impact as to make a firm road, and will be so porous as to quickly drain after rains.

The almost ideal roads at the crossings of the conglomerate beds show clearly how desirable this material is for road dressing.

PAVING MATERIAL

The Cretaceous beds and the Carboniferous sandstones are too soft for good paving material, and most of the carboniferous limestones, because of their uneven texture and structure, are unfit for pavements, but in the upper part of the Cisco and through the Albany divisions, especially such strata as those occurring at the mouth of Elm creek, along Jagger Bend of the Colorado river, and south of Norwood along Mustang creek, because of their hardness, toughness, uniform texture and structure, are moderately well suited for pavements.

GRINDSTONES

The rock adapted to the manufacture of grindstones is nearly all within the Strawn division. No systematic manufacturing has been established, but a large per cent of the grindstones in use throughout the localities of this division are such as have been cut out of the sandstones from the various beds. The quality varies from poor to excellent, and there is usually a considerable range of fineness of grit, so that with care excellent material for manufacturing good stones can be found. The properties that make so much of this sandstone adapted to the manufacture of grindstones are that the rock is com-

posed of small angular quartz grains, consolidated mainly by pressure, or has little cement material, so that as the stone is worn away it does not polish, but always presents a surface of grains with sharp projecting and cutting edges.

LIME MANUFACTURE

Most all the limestone beds of the Carboniferous furnish good rock for the manufacture of lime for mortars, and some may be adapted for making higher grades of cement, but at present no analyses or practical tests are at command for determining these properties.

The Caprina limestone of the Cretaceous is very pure and makes an excellent lime, and in other parts of the State is being extensively used for this purpose.