DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

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GEOLOGIC ATLAS

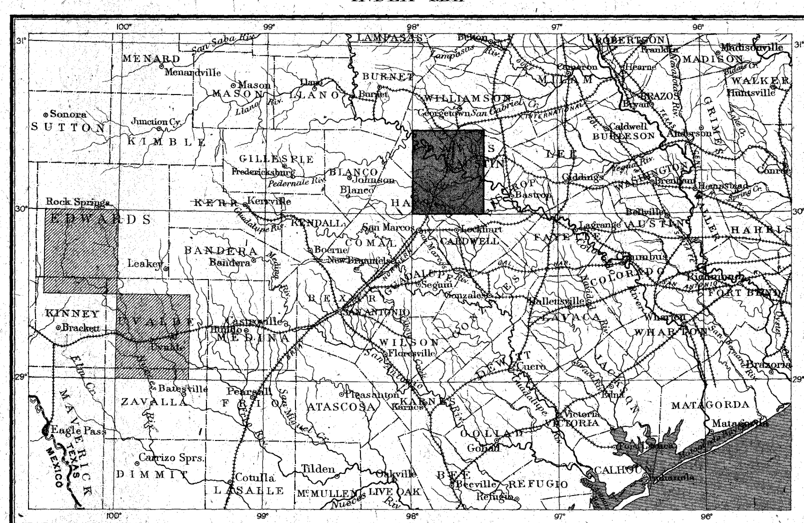
OF THE

UNITED STATES

AUSTIN FOLIO

TEXAS

INDEX MAP



SCALE: 40 MILES - 1 INCH

AREA OF THE AUSTIN FOLIO

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LIST OF SHEETS

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ILLUSTRATIONS

FOLIO 76 | LIBRARY EDITION | AUSTIN

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS S. J. KÜBEL, CHIEF ENGRAVER

1902

UNIVERSITY

EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea-level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

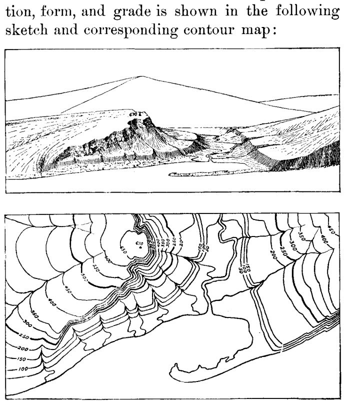


Fig. 1.—Ideal sketch and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand-bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The vertical space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If the stream flows the year round the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree, i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known, and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks*. These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks*.

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it either consolidates in cracks or fissures crossing the bedding planes, thus forming dikes, or else spreads out between the strata in large bodies, called sills or laccoliths. Such rocks are called *intrusive*. Within their rock enclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive*. Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over it, the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in successive layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be discovered by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbance of the beds has been so great that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then *fossils*, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color or colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations.

PERIOD.	SYMBOL.	COLOR.
Pleistocene	P	Any colors.
Neocene { Pliocene / Miocene }	N	Buffs.
Eocene (including Oligocene)	E	Olive-browns.
Cretaceous	K	Olive-greens.
Juratrias { Jurassic / Triassic }	J	Blue-greens.
Carboniferous (including Permian)	C	Blues.
Devonian	D	Blue-purples.
Silurian (including Ordovician)	S	Red-purples.
Cambrian	€	Pinks.
Algonkian	A	Orange-browns.
Archean	Æ	Any colors.

Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations of the Pleistocene render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the metamorphic rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any particular colored pattern and its letter-symbol on the map the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet by fainter color-patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

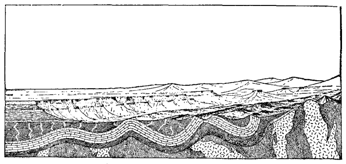


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

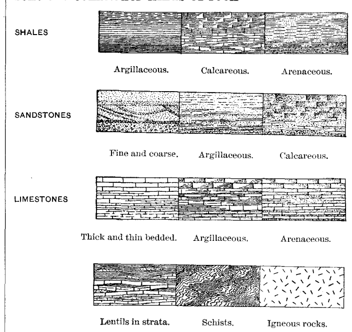


Fig. 3.—Symbols used to represent different kinds of rock.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section.

The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. But these sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones.

On the right of the sketch the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has swelled upward from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger strata thus rest upon an eroded surface of older strata the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets, marking a time interval between two periods of rock formation, is another unconformity.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections in the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profiles of the surface in the section correspond to the actual slopes of the ground along the section line, and the depth of any mineral-producing or water-bearing stratum which appears in the section may be measured from the surface by using the scale of the map.

Columnar-section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. The diagrams and verbal statements form a summary of the facts relating to the character of the rocks, to the thicknesses of the formations, and to the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be indicated graphically or by the word "unconformity," printed in the columnar section.

Each formation shown in the columnar section is accompanied by its name, a description of its character, and its letter-symbol as used in the maps and their legends.

CHARLES D. WALCOTT,
Director.

Revised June, 1897.

DESCRIPTION OF THE AUSTIN QUADRANGLE.

By Robert T. Hill and T. Wayland Vaughan.

GEOGRAPHY.

Geographic position and relations.—The Austin quadrangle embraces one-quarter of a square degree of the earth's surface, and contains 1029.84 square miles. It is bounded by parallels 30° and 30° 30′ N., and meridians 97° 30′ and 98° W. The adjacent quadrangles that have been topographically mapped are the Bastrop on the east, Georgetown on the north, and Blanco on the west. To the northeast is the Taylor quadrangle, to the northwest the Burnet, and to the southeast the Flatonia. The Austin quadrangle lies southeast of the center of the State, at the interior border of the Coastal Plain and at the junction of the Central, East Central, Southern, and Great Plains provinces of the Texas region. (See fig. 1.) It embraces the greater portion of Travis County and parts of Williamson, Hays, Bastrop, and Caldwell counties.

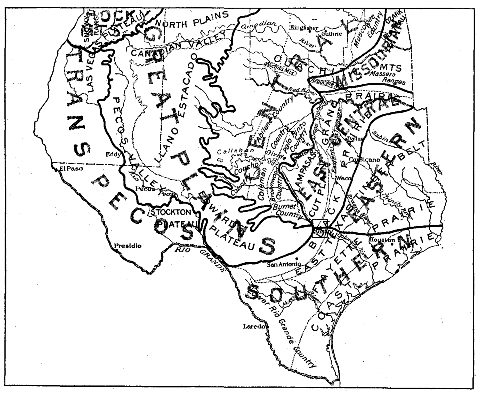


Fig. 1.—Provinces and minor subdivisions of the Texas region.

TOPOGRAPHY.

GENERAL FEATURES.

In general the topography of the quadrangle is varied and picturesque, consisting of a diversified landscape of rugged hills, rolling plains, and level areas, broken by frequent streams and presenting a pleasing alternation of timber and prairie. The highest altitudes of the quadrangle are found along the western margin, the greatest upland altitude being 1200 feet, at the extreme northwest corner, and the least about 600 feet, along the eastern margin. The valley depressions as measured along the Colorado vary from 600 feet at the northwestern edge of the quadrangle to 375 feet where the Colorado leaves the eastern border.

RELATION BETWEEN FORMATION AND RELIEF.

Nowhere is there a more intimate relation between topography and stratigraphy than in the Texas region, and the Austin quadrangle is a very fine illustration of this relation. In fact, nearly all the natural features, especially those closely related to human activities, such as topography, soil, flora, and the occurrence of structural material and underground water, are determined or influenced by the geologic formations. Each of the geographic subdivisions is the superficial expression of some of the geologic formations to be described later, and is coincident in extent with the outcrop of these formations as shown on the geologic map.

TWO TYPES OF TOPOGRAPHY.

Notwithstanding the partial destruction of original surfaces by erosion, causing the present diversified relief, it is evident that the general configuration of the area is that of a greatly dissected plain, which, leading from the Cordilleran region to the sea, has been termed the Regional Coastward Slope. This broader feature is sharply divisible, within the area of the quadrangle, into two types of country—a higher district in the western third which is a part of the physiographic province of the Texas region known as the Edwards Plateau, and a lower district to the east which physiographically belongs to the interior margin of the great Atlantic Coastal Plain. (For a detailed description of the physiography of the Texas region see Topographic folio No. 3, U. S. Geological Survey, 1900.)

EDWARDS PLATEAU.

Balcones scarp.—A noteworthy topographic feature of the quadrangle is a high escarpment along the border between the Edwards Plateau and the Rio Grande Plain. It runs northeast and southwest from the vicinity of McNeil to near Driftwood post-office (Blanco quadrangle), passing by the eastern foot of Mount Bonnel and Oatmanville, and separates the two major provinces mentioned. This escarpment is called the Balcones, and in its extension southwestward to the Rio Grande is a structural feature known as a fault scarp. It rises from 100 to 300 feet above the lower country of the Coastal Plain, and properly belongs to the Edwards Plateau. Its front is not a vertical cliff, as one might infer from a too literal interpretation of the word scarp, but rather an indented line of sloping hills leading up from a lower plain to a plateau summit, as seen along the eastern front of the ridge northwest of Austin.

The country west of the Balcones scarp line, which is locally known as "the mountains," consists of bold hills, many rising 500 feet above the drainage valleys, and some of them so symmetrical in contour and stratification that they appear as if they had been turned in a lathe. The summits of the highest of these hills, which are usually flat topped and composed of a single geologic formation—the Edwards limestone—have a nearly constant topographic level. These hills are the remnants of a vast dissected plateau or cut plain, and stretch across Texas from the Brazos to the Rio Grande. In the Austin quadrangle the remnants of this plateau stand at altitudes of from 1100 feet along the western border to about 975 feet at the edge of the escarpment, having a slope of about 20 feet to the mile as measured along a westward line from the Lone Tree triangulation station. In places, such as the area termed the Jollyville Plateau on the map, considerable remnants of the old plateau exist. These are covered with a dense thicket of live-oak and post-oak brush and timber. The slopes of the hills are terraced or benched by the outcrops of the subhorizontal strata. Streams, especially the Colorado, have cut deep valleys into this plateau. (See fig. 2.) These valleys, immediately adjacent to their courses, are bordered by steep bluffs of banded yellow or white limestones of great beauty, crowned above by terraced stratification slopes leading to the summits. The terraces of these hills are often covered with a growth of juniper and Texas laurel (*Sophora*), while the high summits are usually covered with a dense growth of scrub oak and live oak. That portion of the Edwards Plateau which is north of the Colorado has been termed the Lampasas Cut Plain.

A vast dissected plateau.

COASTAL PLAIN.

The area of that part of the quadrangle which is situated to the east of the Balcones scarp, although presenting within itself several diverse features, constitutes a portion of the great physiographic feature known as the Atlantic Coastal Plain. This portion of the plain represents its older, higher, and more eroded interior margin, and in general, except along the southeastern margin and western border, is largely a region of undulating upland prairie, mostly of the type which is known in Texas as rolling prairie land and which has been called the Black Prairie. The highest points of this plain rarely rise over 750 feet above the sea. This feature is subdivisible, in the Austin quadrangle, into several distinct northeast-southwest belts of country, which may be enumerated, in the order of their sequence from west to east, as follows: Bear Creek country, Manchaca belt, White Rock country, Taylor Prairie, Littig Prairie, and Lytton Springs country. Besides the above there are exceptional minor features within the area of the Coastal Plain which will be described as alluvial plains and terraces and volcanic hills.

Bear Creek country.—Immediately adjacent to the foot of the Balcones fault and extending approximately eastward toward the International and Great Northern Railway is a narrow plain of brush-covered country which ranges in altitude from 700 to 900 feet. This country corresponds with the outcrop of the geologic formations elsewhere described as the Edwards and Georgetown limestones, shown on the map east of the Balcones fault. Owing to the stony character of the surface, the shallowness of the soil, and the thick growth of brush, the region has been locally termed "hard scrabble." This plain is cut in places by steep creek gorges, while its surface is usually broken by projecting limestone ledges and covered with a thick growth of post oak and live oak. In some places the surface is covered with vast numbers of oxidized residual flints, which are suggestive of alluvial deposits, but which are the residua of the flint-bearing layers of the underlying Edwards limestone. The hard scrabble belt as a whole is a downfallen fault block. While not well adapted to agriculture, this portion of the country is utilized for grazing purposes, and contains an occasional small area of tillable land.

Manchaca belt.—Immediately east of the Bear Creek belt is another narrow strip of exceptional country, underlain by the Del Rio, Buda, and Eagle Ford formations. (See Historical Geology sheet.) This consists of alternations of wooded hills and prairies. Along its eastern margin are spots of forest, growing upon the Eagle Ford and Buda formations, the former bearing mostly hackberry and the latter live oak, as seen in the Sixth Ward of the city of Austin and along the eastern bank of Shoal Creek. West of these areas are small spots of prairie land, with black soil, underlain by the greenish-yellow subsoils of the Del Rio clay and covered with a thin growth of mesquite bushes. The surfaces of these small areas are also marked by hogwallows. The various features of this belt are complicated, owing to the excessive faulting along their area of occurrence. North of the Colorado the belt narrows to less than half a mile in width, or even is absent in places. A unique feature of the Manchaca belt are the cliffs of Buda limestone seen along the creek valleys.

White rock country.—A broad belt of country extending north and south through the center of the quadrangle, marked by the outcrop of the Austin chalk, may be known as the White Rock country. The formation is especially well exposed in Fiskville, Austin, South Austin, Manchaca Springs, and Mountain City. This belt is a district of gently rolling, hilly land like the English downs, and is characterized by glaring white outcrops of the Austin chalk on the slopes and in the bluffs of the creeks. Graceful clumps of live oak and sometimes groves of juniper are found. The residual soil of this belt, which is usually thin, is black and calcareous.

Taylor Prairie.—Immediately east of the White Rock belt is the main district of the Black Prairie lands of the country underlain by the Taylor and Webberville formations. This is an area of rolling prairie land, consisting of a deep mantle of black waxy soil which is exceedingly fertile. The western portion is called the Taylor Prairie. Manor and Creedmoor are situated on its eastern edge; Pflugerville and Manchaca Springs are near its western edge.

Littig Prairie.—In the extreme eastern part of the quadrangle, to the east of Manor and Creedmoor, and extending to Texas Hill, there is an area marked by a rather sterile, sandy, clay soil and covered by a growth of chaparral, large opuntias, and mesquite. This country, known as the Littig Prairie, is underlain by the Webberville formation, so far as can be determined, thinly veneered by Pleistocene surficial deposits.

Lytton Springs country.—The area covered by this division lies in the southeast corner of the quadrangle and extends from one and one-half miles northwest of Lytton Springs to near Elysium. This area consists of rather low, gently rounded hills having an altitude of from 400 to 650 feet above the sea. The soil is sandy and subject to rapid erosion. The timber consists mostly of post oak and other trees, such as characterize the southern extension of the East Texas timber belt, of which it is a part.

Alluvial plains and terraces.—Extending along the margins of the Colorado and the larger creeks are wide valleys of alluvial bottom land, subject to overflow; above these there is usually a series of more or less connected terraces, now standing above the line of overflow; and still higher, upon some of the divides, there are areas of gravelly soil. All of these deposits are composed of alluvial material which has been brought down by the streams.

The Colorado, being the oldest and most deeply incised stream, has more extensive bottom lands and more numerous higher terraces. The latter are

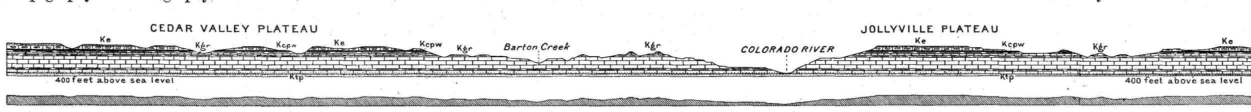


Fig. 2.—Northeast-southwest section crossing the Colorado River 8 miles west of Austin, showing the dissection of the Edwards Plateau by the Colorado River and its tributaries, and the benches formed by the harder beds. Horizontal scale, 1 inch = 1¼ miles; vertical scale, 1 inch = 2250 feet. Natural profile is shown in shaded drawing below section.

somewhat similar in character of soil and vegetation, being usually composed of red loam and gravel derived from the central provinces of the State and covered by a growth of post-oak timber. The bottoms and terraces of the larger creeks are usually composed of calcareous soils and débris derived from the Cretaceous formations of the adjacent Edwards Plateau.

The old terraces may be divided into two classes: (1) high gravel terraces, which rise from 100 to 200 feet above the level of the streams, and which are now largely of a stony nature; (2) wide, flat terraces elevated only from 40 to 50 feet above the streams, usually of good soil and devoted to agriculture. These terraces, which have their greatest development within the Coastal Plain east of the Balcones scarp line, increase in area down the stream and in places attain a width of 5 miles or more.

Westward, in the Edwards Plateau country, the terraces narrow in width and are reduced in number, although they continue to be a marked feature in the canyon of the Colorado.

Onion Creek basin.—Along Onion Creek, extending from a little above Buda to Pilot Knob, is a wide, flat constructional valley plain standing about 100 feet above the present streamway, terminating in a deep gorge through the Pilot Knob hills. The surface of the plain is very level, its elevation rising from about 500 feet at Pilot Knob to a little over 700 feet at Buda. This plain appears once to have been an old lake basin, which has been drained by the canyon later cut through the northern side of the Pilot Knob dome.

Upland gravel plains.—There are several high divides and small upland plateaus within the Coastal Plain area which are covered with old gravel deposits. These are so distributed as to indicate that nearly all of the area of the Coastal Plain in the Austin quadrangle was once veneered with alluvial débris from the Edwards Plateau. One of these peculiar gravel deposits is in the vicinity of St. Elmo post-office, and hence has been named the St. Elmo Plateau. Its surface is level and the soil consists of black, waxy, calcareous clay containing gravel. It is mostly open prairie, except a few mesquite trees. The elevation of this plateau is from 550 to 700 feet. Another high divide that reaches across from the rolling black prairies and into the sandy Lytton Springs area is Mustang Ridge, which stretches from the confluence of Mahard and Cedar creeks, in the southeast section of the quadrangle, in a westerly direction to the International and Great Northern Railroad about 2 miles south of Buda. This ridge is covered with gravel, which in the areas of the Taylor and Webberville formations is embedded in calcareous clay; in the Eocene area, in loose sands or loamy clays. The vegetation consists mostly of mesquite, or the land may be prairie in the Black Prairie region. In the Eocene area post-oak timber may be abundant. The summit of the ridge is very nearly level, the elevation being from 650 to 800 feet. Bald Knob, a conspicuous hill west of Manor, is also capped with this material.

Volcanic hills.—An exceptional feature of the country is the small group of volcanic hills known as Pilot Knob, about 7 miles southeast of Austin. These occupy an area of about 3 square miles and consist of three low summits rising to a height of about 100 feet above the adjacent prairie. They are covered by a peculiar species of grass, which is apparently limited to their surface, growing on a black soil from which protrude many fragments of hard, basaltic rock.

At various other places in the region, as shown on the geologic map, there are small outcrops of this material, constituting exceptional features within their areas.

DRAINAGE.

The waters of the Austin quadrangle reach the sea principally through the Colorado River, although a few streams on the northern edge lead to the Brazos, and some on the southern edge to the San Marcos. The Colorado drains over nine-tenths of the total area.

The streams, except in time of flood, are not copious; in fact, they present peculiarities of flow which may be classified as perennial, interrupted, and intermittent. The Colorado is perennial or constant in flow, although variable in volume, being subject to great floods. Other streams, like Barton and Onion creeks, are interrupted, presenting alternate stretches of running water and dry bottom. Still others, such as the secondary streams of the eastern margin, are intermittent, having no water except in time of rainfall.

The streamways have certain distinctive characters in each of the two greater topographic divisions. In the Edwards Plateau they are usually encased in deep and narrow canyons, like those of the Colorado and Barton Creek west of Austin. In the Coastal Plain the valleys are usually broad and terraced by older alluvial plains leading up to the rounded divides described under a separate head.

Sinuous canyon of the Colorado.

It is interesting to note that the courses of the larger streams are sinuous in all the topographic divisions. Thus the Colorado River flows in great sweeping curves, sometimes almost joining, in both the country above the Balcones escarpment and in the plains country southeast of Austin. The meanders are as thoroughly established in the canyon part of the Colorado as in the prairie country in the eastern portion of the quadrangle.

The Colorado, a great through-flowing river (i. e., one that rises beyond the province and runs through it), crosses the quadrangle from northwest to southeast. It rises in the breaks of the Llano Estacado and empties into the Gulf of Mexico. It meanders across the quadrangle in great oxbows, and occupies a deep valley some 500 feet below the present summit level of the Edwards Plateau and 250 feet below the summit levels of the Coastal Plain. This stream, the most important drainage channel of the region, gathers little perennial water from the area, although it receives water from many intermittent streams in time of rainfall, from a few gravity springs in the northwestern portion of the quadrangle, and from some fissure springs between the foot of Mount Bonnel and the city of Austin.

The principal secondary streams are Barton and Onion creeks, which rise along the western border of the quadrangle south of the Colorado and enter the latter stream to the eastward.

Barton Creek Canyon.

Barton Creek is peculiar in that it runs closely parallel to the Colorado River and has incised deep canyons into the Edwards Plateau, almost equal to those of the Colorado itself. Furthermore, this stream, except in time of flood, is eccentric in the intermittent character of its drainage. Within the Edwards Plateau its bed is at first a dry arroyo for several miles, which is succeeded by 6 or 7 miles of running water derived from gravity springs; then follows a dry stream bed for 5 or 6 miles, to within a mile of its mouth, where magnificent artesian springs (Barton Springs) arise from fissures within its bed and supply a beautiful and constant stream which empties into the Colorado. Barton Creek is also notable for the relatively small amount of country drained by it laterally.

Onion Creek Valley.

Onion Creek rises in the Blanco quadrangle, west of the Austin quadrangle, and flows nearly the entire distance across the latter, emptying into the Colorado River near the eastern margin. It is somewhat different in physiographic character from Barton Creek in that it is apparently not so deeply incised and receives the floods of many laterals, such as Bear, Slaughter, and Williamson creeks, thereby draining a very large area of the quadrangle. Its headwater portion is normally a long dry arroyo, with occasional pools rising in the hills of the Edwards Plateau of Blanco County. As it enters the Austin quadrangle it shows some long and beautiful pools of permanent water derived from gravity springs. Crossing the Bear Creek country it is a dry and stony arroyo inclosed in a rocky canyon. From Buda to the Pilot Knob uplift it occupies a more modern valley within the higher and older alluvial plain elsewhere described as the Onion Creek Basin. On reaching the western side of the Pilot Knob uplift it enters a steep-walled canyon cut directly across the uplift for a distance of about 3 miles. After passing the latter obstacle it continues its way through the Taylor Prairie and the Colorado bottom to the Colorado River.

In the extreme southwest corner of the quadrangle is found a small section of the Blanco River, a tributary of the San Marcos, which enters and leaves the quadrangle from the south. The portion of this stream here shown is embedded in a steep and almost impassable vertical canyon nearly 300 feet deep.

The secondary streams in the eastern half of the quadrangle, such as Cottonwood, Wilbarger, Gilleland, Walnut, Cedar, and Mahard, are usually dry arroyos which have an occasional pool of standing water and are incased in valleys with rounded clay or gravel slopes.

Antecedent and consequent streams.

These stream courses show peculiar and interesting adaptation to the geologic structure and changes of level, elsewhere discussed in this paper. In technical terms the Colorado River is antecedent to the Edwards Plateau and consequent to the Coastal Plain. Barton Creek and the Blanco relative to the plateau are also antecedent and inherited, but of later origin than the Colorado. Onion Creek and the numerous smaller tributaries are still newer consequent streams which have adjusted themselves to the regional slope and to the deepening of the Colorado Valley as the land was elevated. Many of the streams which we have called consequent are really antecedent in the western part of the quadrangle and, in their lower courses, especially as they enter the old alluvial plains of the Colorado, are controlled by the flood plains of the larger river. Such is the case with Barton Creek in South Austin and Onion Creek near its mouth, each of which, on reaching the alluvial bottom of the old river, changes its course down the valley and runs parallel with the Colorado for some distance.

Some of these streams in portions of their courses have also adapted themselves to structural features, following the joints and fissures of the Balcones fault zone. Such is the case with that portion of the stretch of the Colorado between the foot of Mount Bonnel and the city dam. Barton Creek just above the springs, Onion Creek west of Buda, near the western margin of the quadrangle, and Shoal Creek in the city of Austin show similar adaptation to fault lines.

CULTURE.

The Austin quadrangle has a comparatively dense population, but nine-tenths of its inhabitants are found on the Coastal Plain, east of the Balcones scarp, the Edwards Plateau country to the west being but sparsely populated.

The densest rural population is found in the White Rock and Taylor prairies and the Colorado bottoms, nearly the entire areas of which are devoted to the cultivation of cotton, with some minor crops. The few people inhabiting the Edwards Plateau are engaged in raising cattle and cutting cedar timber from the hills to supply the city of Austin with fuel. Occasionally farmers cultivate small areas of alluvial soil in the valleys of this district.

There are a number of towns. Austin, the capital of the State, occupies both banks of the Colorado near the center of the quadrangle. It is a city of 30,000 inhabitants and contains many handsome public buildings, including the capitol and university. Manor, about 12 miles northeast of Austin, is a prosperous rural village of about 5000 inhabitants. McNeil, Manchaca, and Buda are small towns along the line of the International and Great Northern Railroad. The other towns on the map, such as Oak Hill, Watters, Pflugerville, Sprinkle, Bluff Springs, New Sweden, and Fiskville, are small villages with one or more stores and a few houses.

The principal railways are the International and Great Northern, running approximately north and south across the quadrangle; the Houston and Texas Central, extending from Austin eastward; and the Austin and Northwestern Branch of the Houston and Texas Central Railroad, running northward nearly to the northern edge of the quadrangle, when it turns westward toward Burnet.

Highways radiate from Austin in all directions. They may be classified under three heads: county roads of the first order, which lead from Austin to the neighboring county seats; lanes leading from the main highways to small communities or farms; and country roads, originally made by wood cutters, which meander through the region of the Edwards Plateau. Many of the first-class highways are macadamized in places, and commendable interest has been taken by the people of Travis County in their improvement. Three substantial bridges span the Colorado, the westernmost of which is devoted solely to railway traffic, and the others, at Austin and Montopolis, to vehicles.

It is interesting to note on the map how the courses of the principal railways and highways are governed by the geologic structure.

FOREST AND WOODLAND.

In the Austin quadrangle there is a diversified flora, which, like other features, varies with the underlying geologic formations. The highest summits of the Edwards Plateau, where patches of the Edwards limestone are preserved, are covered with a thick growth of post-oak, live-oak, and scrub-oak timber. The numerous slopes of this region were formerly covered with a dense growth of juniper, locally called cedar, which for nearly fifty years has furnished the principal domestic fuel of Austin. In the region of the Coastal Plain the Bear Creek belt is forested with post oak similar to that capping the high summits of the Edwards Plateau. The Del Rio soils of the Manchaca belt sustain a growth of mesquite trees, while the outcrops of the Buda formation are generally covered with live oak. The principal arborescent growth of the Eagle Ford formation consists of hackberry trees. The White Rock belt presents an open, park-like aspect, with here and there a clump or "motte" of gigantic live oaks, while upon the rocky slopes, as in South Austin, a thick growth of juniper may also occur.

The Manor belt is usually devoid of arborescent growth, except occasionally a mesquite bush. The Taylor Prairie is occupied by a peculiar flora of chaparral, consisting of tall mesquite bushes between which are large clusters of the Mexican nopal, a species of cactus belonging to the genus *Opuntia*. The western margin of the upland Atlantic timber belt, consisting of a growth of post-oak and black-jack trees, mantles the Littig country. In the bottoms of the Colorado and alluvial valleys of the other creeks grow stately pecans, as well as other large trees.

GENERAL GEOLOGY.

The geology of this quadrangle is comparatively simple. It is an area of evenly bedded rocks which, in common with all the strata of the Regional Coastward Slope, have been uplifted without serious deformation except faulting. It presents typical examples of the geologic structure of the eastern margin of the Edwards Plateau and the interior margin of the Coastal Plain, as seen between the Brazos and the Rio Grande and as shown in the Nueces and Uvalde folios (folios 42 and 64).

Classification.—The rocks found within this quadrangle are of three kinds—sedimentary, surficial, and igneous. The sedimentary rocks occupy the greater portion of the area and the surficial rocks are of considerable extent, whereas the igneous rocks are of only occasional occurrence. The sedimentary rocks were deposited in the sea and subsequently elevated so as to form a land surface. They now consist of evenly bedded horizontal limestones with occasional beds of clay, and constitute the foundation of the country. The surficial rocks consist of material derived from the marine sedimentary rocks and the igneous rocks, brought down from the northwest by streams and deposited as a veneer over the uplands, as terraces along the streams, and in occasional temporary lake basins. They are fluviatile or lacustrine sediments. The igneous rocks consists of solidified molten rock in fissures and necks and associated lava and volcanic ash.

SEDIMENTARY ROCKS.

CRETACEOUS PERIOD.

All of the marine sedimentary rocks of this quadrangle except the Lytton formation belong to the Cretaceous system. These rocks also are most important from the standpoint of economic geology, since they yield the richest soils, furnish the best material for road and building purposes, and determine the distribution of the greater portion of the underground water.

These rocks are classified into two greater categories, termed "series," each divisible into a number of units termed "formations," which in turn may sometimes be divided into beds and layers. For convenience two or more formations of the series, especially in cases where they are not readily separable, are collectively discussed as subordinate parts of the series under the term "division" (or "group"), as shown in the following table:

Cretaceous rocks of the Austin quadrangle.

Series.	Division. (Group.)	Formation.
Gulf series. (Upper Cretaceous.)	Montana.	Webberville formation. Taylor marl.
	Colorado.	Austin chalk. Eagle Ford formation.
	Dakota.	(Missing.)
Comanche series. (Lower Cretaceous.)	Washita.	Buda limestone. Del Rio clay. Georgetown limestone.
	Fredericksburg.	Edwards limestone. Comanche Peak limestone. Walnut clay.
	Trinity.	Glen Rose formation. Travis Peak formation.

One of the most complete sequences of the rocks of the Cretaceous period to be found in our country is revealed in the outcrops of the Austin quadrangle, especially in the section along the valley of the Colorado. Hence these rocks will be described in detail.

The Cretaceous formations succeed one another to the eastward in more or less regular belts, the outcrops of the oldest formations being found along the western margin of the quadrangle and successively newer ones being encountered to the eastward. The continuity of this sequence is broken, however, at the Balcones fault line, as is further explained under the heading "Geologic structure."

COMANCHE SERIES.

This series is composed largely of limestones, although there are arenaceous beds at its base and many beds of marly clay interspersed through it. One formation of the series, the Del Rio, is composed almost entirely of clay.

The rocks of the Comanche series are limited in outcrop to the western half of the quadrangle, occupying all of the country of the Edwards Plateau, the Bear Creek belt, and most of the Manchaca belt. The eastern border of their outcrop passes near Round Rock, beyond the north border of the quadrangle, through Austin, to the east of Davis Hill, and to the west of Mountain City, as shown by the boundary between the Buda and Eagle Ford formations on the geologic map.

TRINITY DIVISION.

Travis Peak formation.—These beds are especially well exposed on both slopes of the valley of Colorado River between the mouths of Sycamore and Cypress creeks, in Burnet and Travis counties. They were so named because they are well exposed in the vicinity of Travis Peak post-office. (See First Ann. Rept. Geol. Surv. Texas, 1890, p. 118.)

While these beds are arenaceous in composition and porous in texture, like the basement beds of the Comanche in general, they differ considerably from the allied beds to the northward. They consist in part of conglomerate, composed of rounded pebbles of Silurian and Carboniferous limestones, granite, Llano schists, quartz derived from the adjacent Paleozoic rocks, beds of finely cross-bedded pack sand, white siliceous shell breccia resembling the Florida coquina, and some clay. The base is formed usually of conglomerate, and is succeeded by coarse, angular, cross-bedded sand, which becomes more finely triturated until it reaches the condition known in Texas as "pack sand"—i. e., a very fine-grained, loosely consolidated sand, cemented by carbonate of lime.

Basal conglomerate of the lower Cretaceous.

The sands show occasional patches of red and greenish-white clays, whose tints resemble very much the characteristic colors of the Potomac beds of the Atlantic coast, and they sometimes contain lignite and fossil bones. The sandstone contains grains of silica varying in size from that of a pea to that of microscopic particles, and small subangular fragments of clay in the cement of lime. Only the upper 80 feet of the formation are exposed in the quadrangle. A complete section down to the Paleozoic rocks, as exposed in the Colorado bluff west of the quadrangle, is presented on Columnar Section sheet 2.

Fossils occur in these beds as low down as the contact conglomerates, but they are neither plentiful nor well preserved. The upper or coquina-like beds are full of casts and molds, among which are *Ammonites justinæ* and undetermined species of *Cucullæa*, *Trigonia*, *Pholadomya*, and *Cyrena*. In these beds also appears the first of the several oyster agglomerates of the Comanche series. This is composed of a solidified mass of large oyster shells, forming a stratum 7 or 8 feet in thickness, which outcrops just below the junction of Post Oak and Cow creeks.

Lowest oyster-shell bed.

Accompanying the oyster breccia there is epsom salts, or magnesium sulphate. The oyster-shell bed effloresces into a powdered earthy substance accompanied by the epsom salts. Magnesium and pyritiferous layers occur in other horizons higher in the division, and are no doubt in part the cause of the mineral character of some of the artesian waters, especially those of wells which are not drilled into the basement sands below these layers.

At the top of the sandy beds in the Colorado section a yellow, arenaceous, fossiliferous limestone appears. This marks the first or lowest appearance of the peculiar fossils *Monopleura* (*Caprotina*) and *Requienia*, and indicates the beginning of the conditions which finally produced the Glen Rose formation.

The Travis Peak formation records a subsidence of the land during its deposition. As the waters deepened the deposits changed from coarser to finer material, becoming more comminuted and calcareous at the top of the beds, until the sand grains are so fine as to be almost imperceptible to the eye, the whole mass becoming chalky and "magnesian" in appearance.

The following section, by Mr. J. A. Taff (Third Ann. Rept. Geol. Surv. Texas, 1892, p. 295) will give an idea of the sequence and composition of the formation as exposed in the valley of the Colorado between Travis Peak post-office and Smithwick Mill, Burnet County. (See Columnar Section sheet 2.)

Hickory Creek section of the Travis Peak formation, beginning at the top of the divide between Hickory and Cow creeks and continuing to the Colorado River level at the mouth of Hickory Creek, Burnet County.

	Feet.
13. Bands of conglomeratic and calcareous sandstone, alternating with beds of arenaceous limestone, the arenaceous limestone predominating	40
12. Marly magnesian limestone	40
11. Calcareous sand at base, grading upward to a siliceous limestone at the top, barren of fossils	55
10. Yellow calcareous sand, stratified	15
9. Conglomerate similar in character to No. 2, with the exception that the pebbles are smaller and more worn, grading into sand below and into calcareous sand above	25
8. Red sand, unconsolidated	3
7. Friable yellow sand	5
6. Cross-bedded shell breccia, containing many small rounded grains and pebbles of quartz, flint, and granite sand. Fossils: *Trigonia* and small bivalves, and *Ammonites justinæ*	7
5. Ostrea beds, magnesian lime cement, fossils en masse	3
4. Brecciated grit, composed of worn fragments of oyster shells and shells of other Mollusca, with sand and fine pebbles, stratified in false beds	5
3. Bands of friable bluish shale and calcareous sand, stratified. Fragments of oyster shells are common in the calcareous sandstone	15
2. Basal conglomerate of pebbles of limestone, quartz, chert, granite, and schist, well rounded in a cement of ferruginous yellow and red gritty sand. Some of the pebbles at the base are from 4 to 6 inches in diameter. They decrease in size, however, upward from the base, until a false-bedded calcareous shell grit appears at the top	50
Total thickness of Travis Peak beds	263
1. Laminated, flaggy, Carboniferous sandstones and friable light-blue clay of the Carboniferous (Coal Measures) formation, from the Colorado River level upward to the base of the Cretaceous conglomerate, the laminated sandstones containing prints of ferns, nearly	100
Total thickness of section	363

Glen Rose formation.—The Travis Peak formation grades upward into the Glen Rose without any abrupt change in the character of the sediments, as can be seen in the high bluff of Cow Creek immediately below Mr. Hensel's house at Travis Peak post-office, in the western part of Travis County.

The basal beds of the Comanche series have been described as being predominantly of an arenaceous character. The Glen Rose formation may be distinguished as being essentially calcareous. Each of these subdivisions, however, is accompanied by material similar to that of the other as an accessory. Thus the calcareous Glen Rose formation is slightly arenaceous at its base, the arenaceous material consisting of siliceous grains so triturated that they are reduced to an almost impalpable powder. This siliceous matter gradually diminishes in quantity upward, and the lime and clay proportionately increase.

The Glen Rose formation outcrops on the slopes of all the numerous hills of the Edwards Plateau and forms the bluffs of Mount Bonnel and the canyon of the Colorado. (See fig. 9.) The rocks consist of beds of white and yellow limestone alternating with softer beds of limestone or clay. The thickness is from 500 to 700 feet. In the northwestern part of the quadrangle, near the western boundary, the formation is thinner than at Austin, thickening southeastward.

The lowest beds of the Glen Rose formation are marked by the appearance of strata of homogeneous texture, such as "magnesian" marls and hard layers in which the fossil *Requienia* occurs. The term magnesian has long been applied to certain yellow strata in these beds. The writers can not state positively whether these strata are or are not magnesian in composition. The name "Caprotina Horizon No. 1" has also been applied to these beds, because in the earlier geologic literature the fossils now called *Requienia* were termed *Caprotina*.

In nearly all complete sections the Glen Rose formation shows three marked subdivisions. The lower and upper thirds are composed of thin-bedded alternating marl and flags, usually weathering into terraced slopes; the middle third is made up of thicker and more massive beds, which weather into bluffs. Some of the beds near the base of the thicker layers are chalky in texture and carry many peculiar fossils, especially noteworthy being a foraminifer, *Orbitulina texana*, besides many casts of large mollusks. The lower portion of the formation carries much fine arenaceous material in addition to the calcareous material, and its indurated and unindurated beds do not occur in such uniform alternations as do those of the upper third. For instance, there will be 10 or 12 feet of soft, friable material and then a thin layer (less than a foot) of indurated stone. In weathering this results in wide terraces with steep slopes.

The yellow "magnesian" strata also increase in thickness in ascending series, and become very conspicuous in the middle portion, often being from 5 to 15 feet in thickness, as seen in the bluffs of Mount Bonnel near Austin. These limestones are soft and of a cream or brownish-yellow color, and alternate with strata of marls similarly constituted, and are sometimes accompanied by pockets or nodules of calcite, aragonite, strontianite, celestite, and epsomite.

Conspicuous yellow limestone layers.

The upper third of the formation, as seen at the top of Mount Bonnel, presents alternations of friable marls and hard limestone strata. The limestone strata usually average less than a foot in thickness. These alternations occur with great regularity and persistence. Clay is the chief accessory of the calcareous beds. The marls are soft and laminated and are composed largely of minute shell fragments, giving the beds a distinctly granular, oolitic character. They have little clay and imbibe moisture very freely.

While possessing no great agricultural possibilities, the basal or alternating beds are capable of producing valuable building material. Some of these have rich "magnesian" buff-yellow colors, while some of the white unlaminated limestones suitable for carving resemble the Caen stone of France, which is imported into this country. Some of the beds may also be valuable for the manufacture of hydraulic cements, although at present they are not utilized. The formation also contains undeveloped beds of epsom salts, strontianite, and other materials.

Limestone suitable for carving.

The alternations of horizontal beds of soft marls and hard limestones above described produce the bench-and-terrace topography of the slopes of many of the canyons and along the margin of the Edwards Plateau from the East Fork of the Nueces to the Colorado, where the streams have cut downward through the Edwards limestone. The beautiful bluffs of the Colorado as seen from Mount Bonnel westward to the Burnet County line are of this character.

The accompanying detailed section of the entire thickness of the beds of the bluff on the south side of the Colorado in the vicinity of Lohmann Ford, Travis County, is typical. (See Columnar Section sheet 2.) It coincides almost exactly with Mr. Taff's Sandy Creek section on the opposite side of the river. (Third Ann. Rept. Geol. Surv. Texas, 1892, pp. 298–299.)

Section from top of high hill south of Round Mountain and east of road from Bee Caves to Lohmann Ford on the Colorado River.

	Feet.
Comanche Peak limestone:	
40. Limestone, breaking easily; firm slabs at top	5
Walnut clay:	
39. Yellow calcareous clays with large *Exogyra texana;* forms a shelf	10
Glen Rose formation:	
38. Shaly limestone; not very fossiliferous	10
37. Alternating hard and soft strata of limestone; some thin slabs about base; not fossiliferous	15
36. Alternating hard and soft yellowish limestone; not very fossiliferous	35
35. Shaly limestone, fossiliferous; contains a few individuals of *Cardium mediale* and a few other species	4
34. White limestone; breaks easily	15
33. Marly material, forming a terrace	10
32. Alternations of soft argillaceous or marly limestone with harder thin layers of purer limestone (4 hard and 3 soft layers)	30
31. Slope and shelf; fossils at top	15
30. Hard, nodular limestone; contains *Nerinea* fragments	5
29. Slope and shelf	14
28. Thin, hard ledge	1
27. Slope, very gentle—rather a shelf	15
26. Bed of *Monopleura* in hard, yellowish limestone—thin, a foot or two.	
25. Hard, perforated limestone	2
24. Alternating thin, hard layers and soft, thick layers; the thin layers 6 inches to 1 foot, the soft 3 to 4 feet	20
23. Soft, chalky, argillaceous stuff, only a few feet.	
22. Ledge of hard, yellowish, perforated limestone, 2 feet; hard ledges of limestone, 8 feet	10
21. Small, hard ledge, 1 or 2 feet.	
20. Soft, argillaceous limestone, marly; forms a slope	10
19. Shelf above, ledge below, rises	10
18. Soft, chalky, argillaceous limestone with *Exogyra texana* at base, with harder layers that form shelves—11 hard ledges. Twenty feet from the top of these beds the hard ledge is honeycombed by solution, and is arenaceous. In the lower 20 feet numerous fossils occur: *Tylostoma pedernalis, Cardium mediale, "Goniolina,"* etc.; also horizon of *E. texana*. Thickness of series	60
17. Hard ledges of honeycombed (perforated) limestone. The limestone, hard, yellowish, contains many poorly preserved calcitized fossil shells, largely the remains of nerineas	30
16. Hard ledge of limestone; many *Cardium mediale*	5
15. Soft, argillaceous, chalky limestone	5
14. Ledges, 6 inches to 1 foot thick, with soft, shaly layers between	20
13. Soft limestone	20
12. Hard ledge	2
11. Soft, chalky, argillaceous layer	10
10. Ledge of hard, brownish or yellowish limestone, containing embedded sand grains	5
9. Soft, chalky, argillaceous limestone, with an occasional hard ledge. Hard ledge 2 feet thick 15 feet above base. In the upper part of this marly bed fossils are very abundant. *Cardium mediale, Tylostoma pedernalis,* many echinoderms, *Pseudodiadema texana, Nerinea, Ostrea,* etc	35
8. Ledge of hard, yellowish limestone	5
7. Slope, underlain by soft, chalky limestone	25
6. Arenaceous ledge, a few feet.	
5. Soft ledge with many *Monopleura*, a few feet.	
Travis Peak formation:	
4. Rather hard ledge, with poorly preserved fossils; appear to be oysters	2
3. Soft, chalky limestone	20
2. Ledge of yellowish limestone, 2 feet, and 40 feet of the section covered by river alluvium	42
1. Yellowish calcareous sandstone at river level, thickness not obtainable.	

Totals of above section.

Comanche Peak and Walnut formations (in part)	15
Glen Rose formation (entire) about	455
Travis Peak formation (in part)	64
Total of section, about	534

FREDERICKSBURG DIVISION.

Walnut clay.—At the top of the Glen Rose formation a bed of yellow, calcareous clay always occurs, which is extremely rich in two species of oysters: *Exogyra texana* Roemer and *Gryphæa marcoui* Hill and Vaughan. Its thickness is from 10 to 15 feet. This is an extremely persistent bed both in its lithologic and its paleontologic characters. To it the name Walnut clay has been given. Above these clays is a soft, chalky limestone, the Comanche Peak limestone. These two formations frequently occur near the summits of buttes in the area of the Edwards Plateau and do not occur in the Coastal Plain, except in one small outcrop along the eastern foot of Mount Barker, too small to be shown on the map.

The yellow clays of the Walnut formation most commonly occupy a terrace or bench resting upon a hard stratum of the Glen Rose formation, with a nipple-like hill of the Edwards limestone occurring above. This bench forms a conspicuous feature of the landscape of the Edwards Plateau.

Comanche Peak limestone.—This is a persistent bed of white, chalky limestone, presenting a shattered, reticulated appearance on weathering. It is partly characterized by an abundant fossil fauna containing a large number of *Exogyra texana*, which is especially abundant in its basal portion. It is from 40 to 50 feet thick, thinning toward the Rio Grande. Although it is insignificant as regards thickness, and may be considered the base of the Edwards limestone, it is one of the most persistent paleontologic horizons of the Texas Cretaceous sections. In the Austin quadrangle this formation occurs only within the area of the Edwards Plateau, usually as a chalky slope immediately below the cap rock of Edwards limestone and above the bench occupied by the Walnut formation. A typical exposure of this formation may be seen on the top of Mount Barker, northwest of Austin, and its section is shown on Columnar Section sheet 2.

Persistent bed of white, chalky limestone.

Edwards limestone.—The Comanche Peak limestone is the base of a thick group of limestones consisting of the Comanche Peak and Edwards formations. The upper formation contains a large number of flint nodules with vast quantities of *Rudistes* and aberrant *Chamidæ*, and was called by Shumard the Caprina limestone.

This formation is the most conspicuous and extensive in the Texan-Mexican region. It is composed mostly of limestone strata, but there are some marly layers. It shows slight variation in color, composition, texture, and mode of weathering. In general the beds are whitish, although layers of buff, cream, yellow, or dull gray are frequent. These colors depend much upon weathering. In composition many of the beds are as nearly pure carbonate of lime as can be found in nature, but some have small admixtures of silica, epsomite, chloride of sodium, and perhaps other salts as yet undetermined. Occasional bands of soft brownish-yellow stone are intercalated with the limestone. These bands are popularly called "magnesian," and are composed largely of exceedingly fine-grained siliceous material, like tripoli. As these beds often contain flints, the silex may be of organic origin. Clay is absent except as a minor constituent in the few marly layers. Iron is sparingly present as pyrites, and is revealed by the red color of the clay that weathers out of a few beds. Exceedingly fine siliceous particles occur, especially southward from Comanche County—but no sand grain, pebble, bowlder, lignite, or other undoubted piece of land-derived débris has ever been found.

Beds of pure carbonate of lime.

The limestones vary in degree of induration from hard, ringing, durable strata to soft, pulverulent chalk that crumbles in the fingers and resembles very much the prepared article of commerce. Some of the beds are coarsely crystalline, with calcitized fossils, and are susceptible of high polish. The beds also vary in texture. Some of them are porous and pervious, while others are close grained and impervious. Some are homogeneous throughout; others have hard and soft spots, the latter dissolving by the percolation of underground water and constituting what is popularly termed "honeycombed" rocks. The harder spots in some cases seem to be in process of induration, suggesting a step in the formation of flints. The holes in the honeycombed layers often represent what were once spots containing soluble salts of iron and other accessory minerals.

The formation can usually be distinguished by the immense quantity of flint nodules embedded in and between the limestones and scattered over the surface everywhere. These are of many shapes; some are fusiform, like elongated roots; others are knotty, like warty potatoes; others are parts of extensive sheets or very flat lenses. They vary in size from that of a hen's egg to a foot or more in diameter. They also vary greatly in color. On fresh fracture some are almost jet black; others are light blue, gray, or opalescent; still others are delicate pink in color. There is some, but not conclusive, evidence that each particular kind of flint occupies a definite horizon.

Great quantities of flints.

In most cases the Edwards limestone may also readily be distinguished by the peculiar aberrant mollusks of the genera *Monopleura*, *Requienia*, and *Radiolites*—bivalve fossils which have cornucopiate form, suggesting a resemblance in shape to the horns of cows, goats, and sheep.

The formation is stratified into a succession of massive beds accompanied by very few flaggy and marly layers. Some of the strata are harder than others and project beyond the softer layers in the profile of the hills as overhanging shelves; others are soft and erode very rapidly. In the Austin quadrangle the Edwards limestone is almost inseparable from the underlying Comanche Peak, since both are composed chiefly of carbonate of lime. The Comanche Peak strata are less consolidated, and, as they are somewhat argillaceous, possess a more marly texture than the Edwards limestone, which is usually a firm, white, ringing limestone of great hardness and durability; so that the Edwards weathers into cliffs, while the Comanche Peak is wrought into lower slopes; but in most cases reliance must be placed on paleontologic determinations to distinguish the two formations.

Neither is the Edwards limestone always sharply defined from the overlying Georgetown, except by paleontologic criteria. It is true that the Georgetown limestone is somewhat more arenaceous, but the differences are so slight that their detection requires the trained eye of the geologist.

The Edwards limestone, being more purely calcareous than any other of the Comanche series, probably corresponds to the deepest submergence of the Comanche epoch. It is true that in the Glen Rose formation occasional thin beds of chalk occur, and that some of these are composed almost entirely of foraminifera, but such chalks usually contain a considerable percentage of clay, recognized as an offshore deposit.

Evidence of deep submergence.

Topographically the Edwards limestone is one of the most important formations in Texas. In fact, it is the determining factor in the topography of the whole of the Edwards Plateau. Its hardness being superior to that of the overlying and underlying beds, its consequent resistance to erosion has preserved it as the capstone of the innumerable buttes and mesas of this portion of the State and of the extensive Edwards Plateau and Grand Prairie regions. Not only are most of the buttes and mesas capped by it, but these are accompanied by scarps overlooking the lower-lying valley prairies which follow the stream. The walls of the canyons which many of the streams have cut are also composed largely of the Edwards limestone, especially the portions of those crossing the Bear Creek belt. The cliffs of the Colorado between Austin and Bee Creek form a conspicuous exposure of this limestone. To its hardness is also largely due the topography of the limestone mountains of Mexico.

It shows many types of weathering. Some of the strata make bold cliffs nearly 50 feet in height, the faces of which, although apparently of homogeneous texture, weather into small open caverns. This weathering sometimes brings out a thinly laminated structure associated with white efflorescence. The bottoms of caverns of this character are filled with a layer of white, pulverulent earth. The residual products of other massive ledges weathering into caverns are vermilion-colored clays, in which are beautiful fossils composed entirely of crystallized calcite.

The hard limestones weather into vertical, square-cut bluffs, while the soft and more homogeneous beds of marly or chalky texture form slopes. Where these hard and soft beds occur in alternation there is a corresponding alternation of scarps and slopes in the topographic profile.

Series of alternate cliffs and slopes.

Where the Edwards formation makes extensive stretches of level country, such as that of the Bear Creek country between Manchaca and Oak Hill and that upon the summit of the plateau, and where the surface stratum is of homogeneous texture, it weathers into innumerable little ridges, crests, and drainage lines, illustrating in miniature the processes of erosion and mountain carving. These minutely eroded limestone surfaces are technically known as "karrenfelder," and are formed by the solvent effect of rain water upon the sun-heated limestone surfaces. The crevices in these level areas of Edwards limestone country are usually grass covered, with occasional patches of scrub oak. The surface is very rocky, the karrenfelder protruding in jagged points through the rich but scanty soils. Sometimes residual flints occur in such immense quantities over these surfaces that one is apt to mistake them for a water-rolled gravel formation.

The base of the Edwards limestone is found capping many of the high buttes of the Edwards Plateau, as shown on the geologic map, while the upper and greater portion is exposed along the Bear Creek country, east of the Balcones scarp. This is well displayed in the banks on the south side of the Colorado in the western part of Austin, between McDonald's brickyard and the city dam. Owing to faulting, this section is somewhat complicated and is not continuously exposed at any single locality. The details as made out at three localities at Austin are shown in the accompanying sections and figures. It will be noticed that in the lower portion of the Bee Creek section, which is still above the base of the whole of the formation, arenaceous marls and limestones are rather numerous. These play an important part in the artesian conditions from the Colorado southwestward.

The following sections represent the entire thickness of the Edwards limestone exposed on the downthrown side of the fault in the bluffs of the Colorado between Austin and the river level at the mouth of Bee Creek. (See Columnar Section sheet 2.)

The base of the beds is concealed in the Coastal Plain, lying probably less than 100 feet below No. 1 of section C, but can be seen on the upthrown side of the fault, capping the remnants of the plateau.

Section of bluff on Barton Creek about 1 mile above Barton Spring, Travis County.

	Ft.	In.
Georgetown limestone:*		
5. Grayish limestone, irregular fracture, with *Alectryonia carinata* and *Gryphæa washitaensis*	1	0
4. Yellow or reddish calcareous shale	4	4
3. Alternating layers of hard and soft limestone with *Alectryonia carinata, Gryphæa washitaensis, Exogyra americana*, etc	18	0
2. Hard, grayish limestone	33	0
1. Soft, chalky limestone, with a saline taste	13	0
Total thickness of Georgetown limestone	69	4
Edwards limestone:		
49. Nodular limestone full of requienias (first requienia bed)	3	0
48. Nodular limestone; nodules as large as one's head	2	0
47. Hard, chalky limestone	3	0
46. Thinly laminated limestone (the so-called "lithographic flags")	8	9
45. White, sublaminated, chalky limestone. The lower part of Nos. 45 and 46 contain many fossils — *Exogyra texana, Pholadomya knowltoni*, etc	8	5
44. Nodular limestone, no requienias	1	0
43.† Nodular limestone with many requienias (second requienia bed)	3	9
e. Laminated limestone	1	0
d. A series of hard limestone ledges (eight in number), separated by the thinly laminated layers. There are some flints, about as large as a man's fist, *Radiolites* and *Chondrodonta munsoni*	45	8
c. Flaggy layer with discoidal flints	2	4
(29.) *b*. Hard limestone, forming a shelf along this portion of Barton Creek and its bottom at the bridge below, eroded into deep pot holes. The lower 2 feet of this layer contains very large blue flints, often 1 foot across. Some of them are oval, others flattened out and very irregular in outline. The upper part of bed contains small flints	12	8
a. Limestone ledges, with some flattened flints. All of the flints in this section belong to the blue variety	11	0
Base of *a* is Barton Creek bed.		
Total thickness of strata in bluff	171	11

Section of Deep Eddy Bluff, south of the Colorado River, west of Austin.

	Ft.	In.
43. Nodular limestone with requienias at top (the second requienia bed of the Barton Creek section).		
42. Limestone ledges	5	0
41. Limestone ledges containing requienias. The three layers above described form a slope to the top of the hill (or bluff) above the face proper of the bluff	1	0
40. Ledge of hard limestone, 10 inches above basal sheet flint. The upper part of the ledge contains rather small nodular flints	15	0
39. Limestone weathering out and giving rise to a good deal of red clay, apparently representing the zone of calcitized fossils found in the high bluff above McGill's Ford	6	6
38. Massive, thick ledges of limestone; detail not exposed	23	8
37. Soft, white, arenaceous limestone	2	2
36. Soft, arenaceous limestone	3	10
35. Ledge of limestone, rather soft, emitting odor of petroleum	2	10
34. Chalky limestone, forming little caves, composed of a good many small ledges; discoidal flints at top	4	0
33. Hard limestone, emitting odor of petroleum under blows of hammer. Texture of limestone rather mealy. Nodular flints; occasional discoidal flints in top	2	1
32. Two thin ledges of limestone; layer of sheet flint in top	1	2
31. Ledge of thick, massive limestone	5	0
30. Hard, yellowish limestone	2	0
29. Hard, thick, massive ledge of siliceous limestone, ringing under blows of hammer. At the base there is a layer, about 9 inches thick, of opalescent, pinkish or brownish flint. Apparently the limestone is being converted into flint by replacement, and the process has not yet been completed	6	0
28. Soft, chalky limestone, dissolving and forming small caves	3	0
27. Soft, chalky limestone with very large (may be 1 foot long), irregularly shaped blue flints at top.	2	3
26. White, chalky limestone, apparently siliceous; zone of flint near top. The flints blue, discoidal, and tending to form sheet	6	8
25. Massive ledge of hard, bluish limestone	7	0
24. Very hard limestone	0	6
23. A layer of enormous blue flints, in some places over 1 foot thick	1	0
22. Thick, massive ledge of limestone, rather soft, yellow in color, and slightly arenaceous	5	5
21. Ledge of hard, yellowish limestone with a zone of flints tending to form a sheet at base	1	4
20. Soft, white, slightly arenaceous limestone, composed of thin ledges; upper 2 feet, middle 4 feet, lower 1 foot	7	0
19. Soft, yellowish or whitish limestone with layer of flattish, bluish flints forming a sheet at top. This is really three ledges; upper ledge, with flints at top, 2 feet; middle containing concretions of calcite in lower part, 4 feet; lower ledge exposed at low water, 1 foot	7	0
Total, Deep Eddy section	121	5

* The Georgetown limestone is assumed to be 70 feet thick at Austin. Future study may modify this estimate. The uppermost layers, characterized by *Kingena wacoensis*, are here missing.

† The beds in the Barton Creek section below 43 can not be correlated layer for layer with the Deep Eddy Bluff section; therefore numbers are not used in the description of the former section for beds below the one numbered 43 except the one lettered *b*. which is equivalent to 29 of the section below.

Section of bluff at mouth of Bee Creek.

	Ft.	In.
Limestone slope, detail not exposed	11	0
23. Layer of enormous blue flints	1	0
22. Arenaceous limestone	5	5
21. Hard, yellowish limestone with sheet flint at base.	1	4
20. Yellowish, rather hard limestone, somewhat siliceous; thin band of chalky limestone at top; calcite concretions near base	6	0
19. Sheet flint at top (sheet flint at top of lowest ledge of Deep Eddy Bluff); three ledges of limestone: upper, 1 foot; middle, 2 feet 6 inches; lower (containing calcite concretions), 3 feet	6	6
18. Sandy limestone, with two zones of nodular flints near middle; sheet flint at base; mass of requienias just above the sheet flint	10	0
17. Soft, yellow, calcareous sandstone, a part of the preceding ledge, about	3	0
16. Yellow, cherty limestone, about	0	6
15. Three or four ledges of rather soft, whitish or yellowish limestone; the upper ledge containing a great mass of requienias, the others fewer	8	1
14. Solid, white limestone, granular, not very hard; contains a great many requienias near top	6	11
13. Yellow, arenaceous limestone	4	0
12. Blotched, arenaceous limestone	3	8
11. Soft, yellow, arenaceous limestone	2	0
10. Hard, yellowish, granular limestone, with shell fragments, gray on fresh exposure	1	6
9. Soft, yellow, arenaceous limestone or calcareous sandstone	2	4
8. Ledge of nonindurated, granular limestone, with indurated blotches, which are structureless and flinty looking	1	0
7. Ledge of white, rather soft limestone, with many very irregularly shaped flints in a zone about the middle of the ledge. The flints are mostly small, bluish in color, and do not show concentric banding; about	3	0
6. Ledge of white, rather soft limestone; no flints; a few fragmentary fossils	2	6
5. A soft, arenaceous ledge. The lower 1 foot 10 inches is a subledge. In the upper part (near top) are concretionary bodies that in form resemble flints, but are not flints in texture. These bodies are hard, apparently siliceous, and contain white blotches, some of which appear to be of foraminiferal origin	5	5
4. Hard limestone, whitish or bluish, without flint; not fossiliferous	4	0
3. Arenaceous limestone, has a tendency to lamination, but in the ledge the laminated character is not always evident. The upper part of the ledge by solution becomes porous. The rock has a considerable absorbent power for water, and has a dark (wet) appearance, due to contained water	5	9
2. Thick ledge of white limestone, not very hard, oxidizing yellow from contained iron. Contains a large number of irregularly shaped flint nodules. These may be as much as 1 foot long, but usually are rather small—3 or 4 inches in length. They are bluish in color and have a concentrically grained structure, resembling the graining of pine wood. Their long axes are not		

	Ft.	In.
always parallel to the bedding planes of the limestone, an important exception to the usual position of the flints relative to the stratification of the limestone	5	9
1. Ledge of yellowish or whitish limestone, without flints; in a thin layer, about 6 inches thick, at the top of this ledge there is an enormous number of *Requienia texana*	4	0
Total, Bee Creek section	104	8

The thickness of the Edwards limestone exposed along bluffs of the Colorado between Austin and Bee Creek is as follows:

	Ft.	In
Bluff on Barton Creek, beds 49 to 43	29	11
Deep Eddy Bluff, beds 42 to 24	99	8
Bluff at mouth of Bee Creek, beds 23 to 1	104	8
Grand total	234	3

Total thickness, including the 70 feet or more of the lower part of the formation preserved on the summits of the plateau, about 300

WASHITA DIVISION.

The Washita division, which has its greatest development in Texas to the northward, toward Red River, is represented in the Austin quadrangle by three formations—Georgetown limestone, Del Rio clay, and Buda limestone.

Georgetown limestone.—This formation consists of a group of impure white limestones, regularly banded, and alternating with bands of marly clay. Before exposure they are dull blue in color, but when weathered they are white or yellowish. The lower portion of the section as exposed at Austin contains thicker and more massive beds than the upper. At the base there is a hard, gray, massive limestone, about 27 feet thick, which is succeeded by chalky, argillaceous limestones that become nodular upon weathering. The thickness of the formation is from 65 to 70 feet. Intervening between the top of the undoubted Edwards limestone and the base of the Georgetown limestone is a bed of very soft, granular, chalky limestone about 13 feet thick, having a saline taste, which may be classed with either the Edwards or the Georgetown.

The Georgetown formation is paleontologically characterized by *Epiaster elegans, Ammonites* (*Schlœnbachia*) *leonensis, Gryphæa washitaensis, Exogyra americana*, and *Kingena wacoensis*. These fossils occur throughout in definite zones and associations, and some of the strata are composed almost entirely of them. Above the more massive lower layers is an agglomerate of *Gryphæa washitaensis*. Associated with this is found an oyster, *Alectryonia carinata*, a familiar European form, which occurs only at this horizon in the Austin section. At the top is a stratum of massive limestone less than 3 feet thick, consisting of a homogeneous calcareous matrix thickly studded with *Kingena wacoensis*.

These beds do not occupy very extensive areas, but occur from place to place in the Bear Creek belt intervening between the International and Great Northern Railroad and the eastern margin of the Edwards limestone. They are best shown in the cut of the International and Great Northern Railroad at the west end of Pecan street in the city of Austin (see Columnar Section sheet 2) and on the slopes of the hills near Taylor's limekiln.

Del Rio clay.—This is a peculiar greenish-blue laminated clay which weathers dull brown or yellow and forms a very black soil. It is from 80 to 100 feet thick at Austin, where it has its typical occurrence in Shoal Creek, shown on Columnar Section sheet 2, and at Fish Pond bluff near the mouth of Barton Creek. It outcrops immediately beneath the Buda limestone and rests upon the Georgetown limestone, the uppermost band of which is characterized by the occurrence of *Kingena wacoensis*. It is an especially important feature of the geologic column, making a break in the monotonous sequence of limestone beds, and possesses lithologic and paleontologic characters which render it easily recognizable. It can always be identified by means of a peculiar fossil, *Exogyra arietina*, a little oyster shown on Illustration sheet 2, figs. 35 and 36. This occurs in the greatest abundance, weathering out by the thousand in a state of perfect preservation. Attached to these shells, especially on the umbonal region, are small cubes of iron pyrites. Upon decomposition this coats the shells with thin layers of brown iron oxide, and converts the lime into numerous crystals of fibrous selenite, which are intercalated in the seams adjacent to the shell horizons. In places the shells are cemented into thin layers of indurated argillaceous limestone, making persistent bands in the middle of the clay beds.

Laminated clay containing great abundance of a peculiar oyster shell.

Above the zone of *Exogyra arietina* the clay is somewhat barren of fossils, except near its summit, where it becomes slightly arenaceous and contains impure limestone slabs bearing other fossils, some of which also occur in the upper layers of the Georgetown limestone. Among these fossils is a gryphæate oyster, *Gryphæa mucronata* Gabb.

Buda limestone.—This formation (the Shoal Creek limestone of previous writings) overlies the Del Rio clay, and though very thin, being only 45 feet thick, is a very conspicuous and easily distinguished formation. It occurs in ledges, which, when exposed in vertical bluffs, always have a rough, nodular appearance, and are not evenly bedded. When they form surface exposures the country is usually extremely rough and the limestone is full of cavities.

Its outcrop oxidizes to a slightly darker color than the limestones already described. On fracture it is light yellow, with blotches or spots of pale pink, as if it had been subjected to fire. In places it is very hard, but in general is of varying texture, usually lumpy; in some spots it is efflorescent and decays into a soft, pulverulent material having a slightly saline taste. The minute red and pink blotches are peculiar to this limestone and have given to it the local name of "burnt limestone." Microscopic study has revealed the fact that the rock is made up largely of foraminifera, filled and coated with a mineral which in all probability is glauconite. Exteriorly the limestone presents no appearance indicating that it contains foraminiferal remains, but, so far as examined, it is more largely composed of them than any other rock of the whole series. In one thin section *Rotalia, Textularia, Globigerina*, and fragments of three or four other genera of foraminifera have been recognized.

Red spotted limestone.

In the Austin section the Buda limestone rests without apparent gradation upon the Del Rio clay, indicating a rapid physical change in sedimentation. It is abruptly overlain by the thin laminated bituminous clays of the Eagle Ford formation. The outcrop of this formation is proportionately very limited, being better displayed at Austin than at any other locality. It can be found in the bluffs of the Manchaca belt near the streams, such as Bear Creek at Manchaca, and Onion Creek at Buda. Characteristic exposures are seen in the steep scarps of Shoal Creek in the city of Austin, shown on Columnar Section sheet 2, and in the bluffs on the south side of the river, where Bouldin Creek enters the valley, at the crossing of the International Railroad and the Oatmanville road. It forms precipitous cliffs with toppling projections, owing to its jointed structure.

GULF SERIES.

Strata of the Gulf series underlie all that portion of the Austin quadrangle in the Coastal Plain east of the Manchaca belt, and even include a part of that belt.

The series presents four recognizable formations in the Austin quadrangle—Eagle Ford, Austin, Taylor, and Webberville. The Woodbine (Dakota) formation, which marks the base of the upper Cretaceous in Texas and elsewhere north of the Brazos, is absent in the Austin region.

These formations are the result of one continuous sedimentation and pass one into the other without sharp lines of demarcation. They are composed mostly of indurated strata—marls, marly clays, and glauconitic clays—with one conspicuous chalk formation (Austin chalk) near their base. Owing to the soft nature of these formations the surface occupied by them is usually flat, or gently rolling, and devoid of scarps. The mantle of detritus is also deeper than in the area occupied by the formations of the Comanche series.

COLORADO DIVISION.

Eagle Ford formation.—This formation consists of laminated bituminous clays, shales, and impure limestone flags, usually blue or black when unweathered, but becoming light yellow and white on exposure. Both the shales and the flags are distinguished from the other Cretaceous rocks, especially those immediately above and below them, by their laminated character. The clay shales are often accompanied by mixtures of arenaceous material which make a thin laminated siliceous flagstone, and nearly always contain a great abundance of fish teeth and bones. (See figs. 38 to 41.) From this fact the formation has been called the fish beds. The strata also contain a few remains of mollusks, principally of inoceramus and oysters. Bones of a large saurian were also found in this formation near the Deaf and Dumb Asylum.

Bituminous clay containing fossil teeth and bones.

The formation is rarely over 50 feet thick anywhere in the vicinity of Austin. Geologically it represents the uppermost horizon of the Eagle Ford shales, so extensively developed in northern Texas. The abrupt contact below with the Buda limestone represents an unconformity or a time break in the sedimentation of the Cretaceous period, the only distinct one traceable in the Texas region.

The formation usually occurs in low bluffs capped by the Austin chalk, or as flat areas upon the summits of the escarpments of the Buda limestone. It outcrops along a very narrow belt in spots north and south through the quadrangle, as shown on the map. A typical outcrop may be seen in Shoal Creek just above the Pecan street bridge, Austin, and in the banks of the creek thence to its mouth. (See Columnar Section sheet 2.) Here it rests upon the Buda limestone. It also underlies nearly all the Sixth Ward in the northwest portion of the city. It occurs south of the river along the banks of Bouldin Creek, and is best seen where the railroad twice crosses that creek near the Granbury residence in South Austin, where it produces a small bluff about 25 feet in height. It also outcrops between Manchaca and Buda in the bluffs of Onion Creek, and near Watters station, in the northern part of the quadrangle.

Austin chalk.—Surmounting the Eagle Ford shales, without break in sedimentation, is a white, chalky limestone of coarse texture, occurring in beds of various thickness, separated in places by crumbling marly beds. This chalk is glaring white in color as seen in the streets of Austin and along the San Antonio road southward. Occasionally there are slight blotches of yellow from the oxidation of the little balls of iron pyrite which it contains. Before weathering, and especially when impregnated with ground water, this chalk has a bluish tint. The rock usually weathers in large conchoidal flakes. Under the microscope the chalk exhibits a few calcite crystals, particles of amorphous calcite, and a great number of the shells of foraminifera and other minute organisms. In composition it varies from 85 to 94 per cent of calcium carbonate, the residue consisting of magnesia, silica, and a small percentage of ferric oxide. Although sometimes so much indurated that it can be used for building purposes, it is generally too soft and crumbling for such use. It is principally used as road material, but is a poor one, the road builders preferring the far more durable materials of the lower Cretaceous. The fossils of the Austin chalk are very abundant, consisting of a great number and variety of species, especially inoceramus, oysters, and ammonites. Its thickness is difficult to determine, but averages about 500 feet in other parts of the State. The Manor well shows the thickness in the Colorado section to be about 410 feet.

Glaring white chalk, occurring in the streets of Austin.

The Austin chalk is the most conspicuous of the formations of the county, outcropping along a wide belt extending through the central portion, and constitutes the principal formation upon which the city of Austin is built. Here fine outcrops are exposed in the street cuttings and along the bluffs of Waller Creek. Fairview Park, in South Austin, presents excellent exposures of the Austin chalk, the white roadways being cut through this material, while the drainage has furnished abundant bluffs and canyons. Along the south side of the margin of the valley the Austin chalk forms a picturesque bluff from 2 miles below the Deaf and Dumb Asylum, finally disappearing to the eastward at the Montopolis bridge. (See Columnar Section sheet 2.) Around the perimeter of Pilot Knob the Austin chalk has been altered in places to a firm, white, crystalline rock, almost a marble. On Onion Creek north of Pilot Knob beds of volcanic tuff are interstratified with the chalk. (See fig. 8.)

MONTANA DIVISION.

Taylor marl.—The Austin chalk is overlain by a deposit of calcareous clays, locally known as "joint clays," estimated to be about 540 feet thick in the Colorado River section. When fresh these beds are fine-grained, tough, unctuous, blue clays. They are apparently unlaminated until exposed to weathering, when their laminated character is developed. Their accessory constituent is lime. On atmospheric exposure their color, owing to oxidation of the contained iron, changes to a dull yellow. Because of the rapid disintegration the character of the unaltered clay is seldom seen, except when fresh material is brought up by the well digger or exposed in freshly cut ravines or creeks. At the Blue Bluffs of the Colorado, 6 miles east of Austin (fig. 7), there is a good, fresh, vertical exposure.

At the top, as seen at various places in Travis County east of Austin, the clays grade into the marls of the Webberville formation. Their middle portion apparently contains no well-preserved fossils, but impressions are abundant in places. In the base of the beds *Exogyra ponderosa*, a large, heavy oyster, is abundant.

Unctuous blue clay and marl.

The marls constitute the greater part of the topographic subprovince denominated the Taylor Prairie. The hills are usually gently rounded, but frequently along the streams low bluffs are formed by the clays slipping down. They erode with great ease, enormous gullies being formed by heavy rains in a very short time. After rains the roads throughout this country are indescribably bad, first from the readiness with which deep gullies are formed, and secondly because of the soft and extremely sticky character of the mud.

Webberville formation.—This, the highest formation of the upper Cretaceous within the Austin quadrangle, underlies the eastern margin of the Taylor Prairie in the quadrangle. The marls of the Taylor formation grade upward almost imperceptibly into the clay marls of the Webberville formation, the latter containing greenish grains of glauconite and, in the upper part, impure limestones and blacker clays. These clays do not oxidize into a clear yellow buff, as does the Taylor formation, but are of a greenish-yellow color, caused by the presence of the glauconite. The thickness of this formation can not be determined except by an estimation of the regional dip.

Greenish glauconitic marl.

The beds contain fossils characteristic of the upper division of the upper Cretaceous (the Ripley group of the Atlantic coast, the Montana group of the Rocky Mountain region, and the Corsicana and Eagle Pass formations of northern and southern Texas). The following forms from Webberville have been identified by Mr. T. W. Stanton: *Anomia conradi, Leda protexta, Corbula crassiplica, Drillia ? distans, Sphenodiscus lenticularis*. Three fossil oysters, *Exogyra costata, Gryphæa vesicularis*, and *Alectryonia larva*, are common and characteristic fossils.

Although probably not the very highest layers of the upper Cretaceous system, the Webberville beds are the highest Cretaceous exposures seen along the Colorado River, for below Webberville they are overlain by the basal division of the Eocene Tertiary. Good outcrops of the formation are exposed at only a few localities, although the residual soil occupies an extensive area. Low, vertical bluffs of the formation may be seen just north of the east base near Onion Creek and near the water line of the Colorado between the mouth of Onion Creek and at Webberville. (See Columnar Section sheet 2.)

The topographic expression and the general characters of the soil are about the same as in the case of the Taylor marl. The country is open prairie except where mesquite trees, which may be abundant, occur, and the soils are black and sticky. The lands erode easily and after heavy rains gullies are often produced similar to those described in the discussion of the Taylor marl.

EOCENE PERIOD.

There is but one formation in the Austin quadrangle which may be positively referred to the Eocene period. This is the Lytton formation.

Lytton formation.—This formation, named from Lytton Springs, situated in the southeast corner of the quadrangle, consists of laminated clay, clay and sand, and sandstone, the latter often showing cross bedding. The color before oxidation is bluish, but when subjected to weathering becomes white, yellow, or reddish, depending upon the amount of ferruginous matter contained, the degree of oxidation, and the extent of leaching. Only a few fossils were found in the area covered by this formation within the Austin quadrangle. They were *Venericardia alticostata* Conrad, *Turritella*, and *Calyptræa*. The fauna belongs to the basal division of the Eocene and corresponds to that of the Midway formation of Arkansas and Alabama.

The relations existing between the Lytton and Webberville formations have not been positively determined because actual contacts were not found within the quadrangle. The faunal break is very complete and the abrupt manner in which the Eocene abuts against the Cretaceous suggests an erosion unconformity, such as has been shown to exist along the Frio River in western Texas, in southern Arkansas, in Mississippi, and in Alabama.

Faunal break between the Cretaceous and Eocene.

The area occupied by the Lytton formation lies in the southeastern portion of the quadrangle and is bounded on the northwest by a line extending approximately from near Elysium to a point $1\frac{1}{2}$ miles northwest of Lytton Springs. The thickness of the formation within the quadrangle is about 300 feet.

The topography consists of low hills usually having rather gentle slopes, but occasionally, where there is a capping of sandstone, the hillsides are rather precipitous. The soil is usually sandy, but contains argillaceous and ferruginous material, varying in amount from place to place. The surface is clothed with a growth of hardwood timber, in large part post oak.

SURFICIAL ROCKS.

The Colorado and other streams in the Austin quadrangle in past times have veneered the Cretaceous and Eocene formations in places with vast sheets of old alluvium. These formations may be divided into several categories, the oldest being hypsometrically the highest.

NEOCENE PERIOD.

Uvalde formation.—East of the great Balcones fault the surface, at an altitude of from 640 to 750 feet, is covered with a thick deposit of flint bowlders, usually mixed with a marly matrix of calcareous material derived from the nearby formations. The flints are often large and all show signs of having been rolled. The original extent of this old gravel, as well as the configuration which existed at the time it was deposited, can not be determined with exactness, because only patches of the gravel remain. So abundant are these remnantal areas, however, that the original extent of the deposits in this quadrangle may be approximately restored. The Uvalde alluvial deposit radiates out from the canyons of the Colorado, Barton Creek, and Onion Creek into a fan-shaped area, with its broader edge toward the eastern margin of the quadrangle. It is represented in the hilly district west of the great fault by narrow terraces along the borders of the valleys of the river. The greatest body of the Uvalde formation lies between the Colorado and Williamson Creek, where it constitutes a distinct plateau. Here the gravel sheet is so mixed with the calcareous matrix that it often makes a rich, black soil, which has usually been mistaken for the residium of the underlying Cretaceous formation in situ. As this alluvial gravel sheet is not readily removed, it persists in places as a capping of hills or divides, while the weathering of its edges above the softer underlying formation produces sharp slopes around its margin along the lateral drainage of the Colorado and Onion Creek from 2 miles east of Oatmanville to near the town of Del Valle, on the south side of this river. (See fig. 5.)

The Uvalde gravel also caps the round hills from Onion Creek southward toward the south border of the quadrangle and covers the eastern half of the Mustang ridges. Denudation has resulted in the almost total destruction of the Uvalde Plateau north of the river. The most conspicuous occurrence of this gravel north of the Colorado is at the large butte known as Bald Knob, just east of Manor, which stands about 750 feet above the river and is the highest point in the northeast quarter of Travis County. The summit of this hill is composed of a thick mass of the flint gravels, and it is readily seen that it is but a remnant of a now almost destroyed area, and is the continuation of the St. Elmo Plateau of the south side of the river. The flints of the old plateau now veneer the newer surfaces.

The innumerable flints which so largely compose the Uvalde formation were all derived from the Edwards limestone of the Edwards Plateau west of the Balcones fault line, and it is evident that this great deposit of flint gravel represents the destruction of the Edwards formation, which once existed over the central province in Burnet, Llano, and other counties. When it is considered that there is not one foot of flint to 100 feet of limestone in the Edwards formation, it can be imagined how great must have been the denudation which resulted in the deposition of the flints in the Uvalde formation.

Great deposit of loose flints.

Although the Uvalde formation now occurs as high as 300 feet above the adjacent bottom of the Colorado, it is probable that it was not originally a continuous sheet across the whole eastern half of the county, but may have been deposited in an estuary or group of estuaries and have been represented coastward by finer and finer sediments.

The exact age of the Uvalde formation can not be stated; but that it was laid down after the Balcones faulting began is indicated by the extension of the material up the stream valleys of the Edwards Plateau, and in every condition it seems to correspond with the Lafayette formation, which marks the close of the Pliocene and the initiation of the Pleistocene. (See Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. II, p. 260.)

PLEISTOCENE PERIOD.

Although the Uvalde terrace has been so nearly destroyed that its former continuity can be recognized only with difficulty, the later terraces which mark the slopes of the valley of the Colorado are very plainly recognizable. There are many of these, all of which may be classified into three distinct categories — Asylum terrace, Capitol terrace, and second bottoms.

Asylum terrace.—An old high-level terrace, usually a mile or two back from the river, occurs as the summit of a bench which marks the interior margin of the so-called Colorado bottoms. This terrace in the city of Austin is located north of the State University and forms the sandy post-oak flat on which the State Lunatic Asylum is situated, about 150 feet above the river. It is traceable for many miles toward the east.

The material of this terrace is formed almost exclusively of granitic débris derived from the granite mass of Burnet County, in the shape either of fine quartz sand, the plastic feldspathic material oxidizing into red clay, or of gravel consisting of large angular pieces of quartz. Pieces of the Paleozoic limestone of the Burnet-Llano region and some flint from the Edwards limestone also occur. The material of this old terrace is so recent looking that, were it not for its high position above the river and the progressive series of lower terraces which have been cut out of it, it would be deemed recent.

Terrace gravels of granitic débris.

The Asylum terrace is characterized by a dense growth of black-jack and post oak. West of Shoal Creek, toward the Balcones fault, small patches of it are preserved upon the dissected surfaces. Remnants in Taylor's quarry and along the plateau between Shoal Creek and the International Railroad clearly show that the Asylum terrace once extended up to the fault line.

South of the Colorado the Asylum level has been almost destroyed, but patches of it are preserved here and there, especially on the hill south of Barton Spring on the Oatmanville road and along the river bluff north of Del Valle. In the eastern part of the county the sediments become finer and begin to spread over a large area of upland.

Capitol terrace.—Below the Asylum level there are traces of several other terrace planes bordering the Colorado River, but the next in importance is that upon which the capitol and the residence portion of Austin are built. Tillotson University is also situated upon it. This terrace is very similar in material to the Asylum terrace, being composed chiefly of the débris of the Paleozoic granites of the Llano region. It can be traced eastward down the river. East of Austin the terrace gradually merges into the wide bottom of the Colorado. South of the river this terrace forms the cap of the high bluff or valley wall of the Colorado bottom at the State Asylum for the Deaf and Dumb.

Second bottoms.—The Colorado has carved still other and lower valleys below the level of the Asylum and Capitol terraces and above the present flood plains and east of the mouths of Barton and Shoal creeks, which are filled with rich alluvial soil. Although standing high above the present waters of the river and never overflowed by it, these lower benches are known as the "Bottoms," from the very evident fact that in late geologic time they were the flood plains of the river. These really consist of five or more distinct levels of sedimentation, but the differences of elevation are so slight that they can not be delineated on the map. The second bottom is widely cultivated and its agricultural conditions are very different from those of the upland Cretaceous lands.

Flood-plain deposits.—The flood plains or true bottoms of the stream are rather extensive, and in the region of the Coastal Plain apparently large in proportion to the small stream of water which normally occupies them. That of the Colorado from Austin eastward consists, first, of a wide sand bed, occupied by the stream at low water and during times of ordinary rises, bordered by a higher bench, from 5 to 15 feet above the river, of alluvial land, which is overflowed only in times of extraordinary flood. The stream itself flows in places over its own débris and in other places is cutting into the bed rock.

The accompanying table shows the locality, height, and composition of some of the terraces recognized on both sides of the Colorado River. The altitudes given represent as nearly as possible the original deposition surface of the formation.

Table showing relation of terrace phenomena on the sides of the Colorado Valley near Austin.

South side of river.			North side of river.	
Location.	Composition.	Altitude above sea.	Composition.	Location.
		Feet.		
Hills 3 miles southeast of Manchaca	1	775		
Hills southeast of Creedmoor	1	725		
Hill three miles southwest of Austin	2	675		
Terrell Hill	4	675	1	Plateau southeast of Sprinkle; Bald Knob.
St. Elmo divide	1	650–675		
		635	2	Lunatic Asylum, Austin.
Lytton Springs	1, 2	625		
		615	2	University of Texas.
Onion Creek marl	1	550		
		525	1, 2	State capitol; Tillottson College; terrace east of mouth of Walnut Creek.
East of Seelig's store	1	500	2, 3	Fourth street terrace.
		480	2, 3	Railroad station and city bridge bluff.
Del Valle Bluff, lower part	2	475		
Bottom, South Austin	4	430	2, 3	Minor bottom terraces below Austin.
Stream way, South Austin	4	422	2, 3	Stream way, Austin.

1 = Rolled flints, white limestone, and other débris of Cretaceous formations of the Edwards Plateau.
2 = Largely quartz and feldspar from granite of the Burnet region, with mixture of Paleozoic limestone.
3 = Red Beds débris.
4 = Mixture of the above materials.

Onion Creek marl.—Another Pleistocene formation having considerable extent in the Austin quadrangle is the alluvial deposit which borders the banks of Onion Creek. For this formation we shall use the name Onion Creek marl, although it contains in places some gravel. Both the marl and the gravel are the calcareous débris of the Cretaceous area through which this stream flows. It consists of wide belts of a yellow, calcareous marl, sometimes 40 feet deep, which extends up the valley of Onion Creek from its mouth below Del Valle to west of Buda, where it emerges from the highland. The Onion Creek marl, however, is principally developed above where that creek cuts its canyon through Pilot Knob, and the topography between Pilot Knob and Buda, as well as the distribution of the formation, suggests that at one period in its history this area was a small lake, caused by the obstruction of the Pilot Knob protrusion, through the northern end of which the stream later cut an outletting canyon, thereby lowering its level.

Old lake bed.

IGNEOUS ROCKS.

Basalt.—Eight miles east of south of Austin is a peculiar hill called Pilot Knob. It is composed of black volcanic rock, which, according to the determination of Prof. J. F. Kemp, is a nepheline species of the family of basalts known as limburgite. (Pilot Knob, a marine Cretaceous volcano, by Robert T. Hill, with notes on its petrography by J. F. Kemp: Am. Geologist, November, 1890.) At Pilot Knob this material constitutes the remains of the neck or core of an ancient volcano occupying an area of about 3 square miles, from the center of which rise three stubs or hills of the black columnar basalt, which are encircled by an area composed largely of tuffs and débris. Pilot Knob was evidently the center or focus of an ancient volcanic outbreak, and within a radius of 6 miles of this locality there are many minor accompanying phenomena, such as small dikes and beds of tuff.

Remnants of an extinct volcano.

The only outcrop occurring north of the Colorado River is about $1\frac{3}{4}$ miles east of the Austin post-office, at the point where the Austin and Northwestern Railroad turns northward out of the Colorado Valley. This is a small neck of nepheline-basalt, less than 100 square feet in area. Due south of Austin, on the opposite side of the river, in a ravine which makes down to the river from the east side of Fairview Park, there is another small outcrop of the basaltic rock. One-quarter of a mile from where the International and Great Northern Railroad crosses Williamson Creek, and about three-fourths of a mile west of St. Elmo, a railway cutting exposes a peculiar mass of rotten volcanic tuff capped with Uvalde gravel and filling a dike or fissure in the Austin chalk.

Two miles south of the above locality, on the San Antonio road, about a mile north of St. Edwards College, there are other outcrops of similar material. Along the canyon of Onion Creek north of Pilot Knob there are beautiful exposures of tuffs interstratified with the Austin chalk, containing many casts of fossils made up of this material, which fact has suggested the Cretaceous age of at least a part of the old Pilot Knob eruptions. Up to date no occurrence of this material has been found west of the Balcones fault zone.

GEOLOGIC STRUCTURE.

The geologic structure or arrangement of the rocks in the Austin quadrangle is that of a monocline broken by a zone of faulting, with intrusions of igneous rocks on the downthrown side of the fault. The general inclination of the strata is from north of west to south of east, in conformity with the inclination of the whole of the Regional Coastward Slope between the Rocky Mountains and the Gulf. The rate of dip is different, however, in the two greater provinces represented in the quadrangle, the Edwards Plateau and the Coastal Plain. This change of inclination accompanies the faulting of the Balcones zone, which passes northeast and southwest through the quadrangle and which will presently be described. To the west of the main Balcones fault the dip of the strata is almost parallel to that of the regional slope, or less than 20 feet to the mile, and hence the rocks in that region lie in sheets nearly parallel to the surface. East of the main Balcones fault line the strata have a greater inclination, and they become deeply embedded to the east by increased dip in that direction. The regularity of the dip in this region is broken by numerous minor faults (see figs. 3 and 6), which fact, together with the lack of good exposures along which the dips can be measured, renders it impossible to ascertain with certainty the rate of dip.

From the records of the Manor well the Austin chalk, which outcrops 5½ miles to the westward, at Sprinkle, is reached at a depth of 590 feet below the surface and 690 feet below the altitude of Sprinkle. Hence it is apparent that the strata of the Coastal Plain in this portion of the Austin quadrangle become embedded through fault displacement at the rate of about 130 feet to the mile.

Zone of faulting along the Balcones scarp.

The Balcones fault zone consists of a series of steep faults running north of east and south of west through the quadrangle and principally traceable along the western margin of the Coastal Plain. This zone of faults, as a whole, results in the dropping down of the western margin of the Coastal Plain along the foot of the Balcones scarp. Although the zone is composed of a number of minor faults along its western margin, there is a major fault which is very conspicuous and easily traceable from Watters southward via Spicewood Springs, Amboy, the east foot of Mount Bonnel, Bee Creek, and Oak Hill. This fault results in a downthrow to the eastward, so that the Edwards limestone, which caps the Edwards Plateau to the westward, is found some 500 feet lower on the eastern side of the river in the stretch between the eastern foot of Mount Bonnel and Austin. There are a number of minor faults, which produce little or no effect upon the topography, but which are visible in stratigraphic sections. This minor faulting is well shown in Shoal, Barton, Williamson, and Onion creeks. The details, however, are very complicated, as is shown in fig. 3, which is a carefully prepared representation of a section along the south bank of the Colorado.

Pre-Cretaceous land area.

The Cretaceous rocks of the Comanche and Gulf series, which constitute the larger part of the geologic formations, are old sea muds, composed in part of the débris of preexisting lands and in part of calcareous material extracted from the sea waters by the animals which inhabited them and deposited as their fossil remains. The latter, at least, is the source of much or most of the lime material, which is the predominant component of the Cretaceous rocks. These rocks were laid down in the margins of the Gulf of Mexico as it invaded and conquered a land which had existed in Jurassic time and progressed westward into what is now the Rocky Mountain region of the United States. The preexisting land consisted of a complex of Paleozoic and Archean rocks, such as are now being reexposed by erosion in the Burnet quadrangle. From what is known of the history of the Cretaceous formations lying to the northward, it is probable that this period of subsidence was broken in the middle of Cretaceous time by an episode of elevation, and that hence the epoch consisted of two subsidences instead of one.

Uplift in the middle of the Cretaceous period.

The old Cretaceous sea encroached upon the preexisting Jurassic land until the former land surface had sunk to a depth equaling the thickness of the lower Cretaceous formations, or about 1800 feet. The Dakota formation, which represents the littoral of the second subsidence, is missing in the Austin and other quadrangles south of the Brazos, and it is probable that in this region of the State the sea bottom did not completely emerge during the mid-Cretaceous episode, as was the case to the northward. The change of level, however, is indicated in the Austin quadrangle not only by the absence of the Woodbine and lower part of the Eagle Ford formations, but by the abrupt change of sediments taking place as noted in the contacts between the Buda limestone and the base of the Eagle Ford clays, the former being an offshore marine foraminiferal limestone and the latter a shallow-water clay.

Toward the close of the Cretaceous, regional subsidence was again succeeded by elevation and the oceanic waters again receded from the Rocky Mountain region toward the present coast line of the Gulf. This is indicated in the shallow-water character of the Taylor marl and the Webberville formation, succeeding the Austin chalk. There were emergence and erosion at the end of the Cretaceous. Subsidence was renewed during the Eocene.

The history of the Coastal Plain since the development of the Balcones fault system in Eocene time has been complicated. Our knowledge of this history is only sufficient to suggest the broad and inviting field which the subject offers to the future student. Since Eocene time the plain as a whole has been uplifted some 700 feet above the sea along its interior margin and the sea has receded from the Balcones scarp to its present position.

River terraces in the plateau region.

The portions of the Colorado and other streams within the Edwards Plateau likewise present an interesting Pleistocene history. In the valley of the Colorado (see figs. 4 and 9) there are erosion surfaces which seem to indicate a correspondence with the terrace deposits of the later epochs in the Coastal Plain. Onion and Barton creeks have terraces through the highlands which are evidently of great age and seem to indicate that those streams are more ancient than the other minor drainage. Up both these streams, as well as the Colorado, there is a distinct bench covered with flint débris, which seems to indicate that these streams also took part in bringing down the vast supply of gravel which formed the oldest or Uvalde terrace.

The Austin quadrangle furnishes many data of value for the understanding of the later history of the Coastal Plain and the successive uplifts which it underwent before the final reclamation of all the great eastern and southern provinces of the Texas region from the Gulf of Mexico. These data are recorded in the drainage of the old terraces and in vast deposits of upland gravel.

The ancient Colorado River.

The testimony of the Uvalde formation is harmonious with and corroborative of that of the topography of central Texas as to the former extent of the lower Cretaceous formations over the central region and the vast denudation that must have taken place. There is no doubt that at the time of its deposition the agents of erosion were very active over what is now central Texas and that the Colorado then emptied into the sea close to the present line of the Balcones fault. The Uvalde formation also tells the story that at the time of its deposition the Colorado had not cut down into the Paleozoic and granitic beds of the Central Denuded Region, but was still flowing over a Cretaceous floor, for very little if any of the débris of these earlier formations, which makes so large a part of the later alluvium of the Colorado, is represented in the Uvalde terraces.

Concerning the history of the volcanic phenomena little can be said. There is evidence, as

contain oil in commercial quantity, as has been proved by experiments at Watters.

Three miles northwest of Austin a little very fine-grade paraffine oil was found in a dug well, as reported to the writer by Dr. Edgar Everhardt. Unfortunately no great quantity could be procured. Therefore the indications are that oil does not exist in commercial quantities in the Austin quadrangle.

STRUCTURAL MATERIAL.

Building stone, brick clays, lime, cement, and building sand abound.

Building stones.—These occur in the lower Cretaceous rocks, where there are many layers of white and yellow limestone suitable for various uses. In the upper part of the Edwards formation there are certain flaggy layers which have been used for paving and curbing in Austin and which make a durable stone for fences and house walls. These have been extensively quarried in the western part of Austin and the material enters into the structure of many buildings in that city.

Austin marble.

Another limestone in close proximity to this is known as the Austin marble. This is composed of an agglomerate of calcified fossils, principally *Rudistes* and *Requienia*. The stone in the quarry has a white, chalky color on fresh fracture, but is sometimes varied by cream-yellow and pale-pink colors. It is susceptible of a high polish and makes beautiful marble for interior purposes, having a creamy tint, like the marbles of Portugal, Spain, and North Africa, which produce harmonious effects in decoration. This material is not commercially utilized for marble, although the stone is largely used for rubble work, as may be seen in the government building at Austin. In the lower part of the Edwards formation and in the Glen Rose formation there are layers of a slightly arenaceous, open-textured, buff-colored limestone which is of the class known as Caen stone and of the kind much used throughout the world for carving. Some layers of the Austin chalk, notably that taken from the quarry near Amboy station, are also used for building purposes, but this stone is not very durable.

Many of the Cretaceous limestones are soft in the quarry, where they may be cut with a saw or axe, but grow hard on exposure to the atmosphere.

Brick clays.—Excellent brick clays are found in the alluvial terraces of the Colorado and are extensively used locally and shipped to various

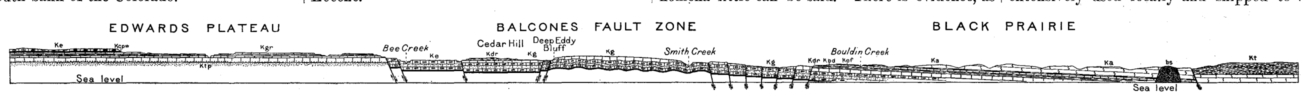


Fig. 3.—Section along the south side of the Colorado River, passing through Austin, showing the details of the Balcones fault zone, and the increase of dip toward the east. Horizontal and vertical scales, 1 inch = 3000 feet.

It is impossible to tell how far eastward this zone of faulting continues, owing to the fact that individual faults can not be traced in the unconsolidated material of soft marl and sandy clay formations in the eastern half of the quadrangle. Along the western margin of the Coastal Plain, in the White Rock, Manchaca, and Bear Creek countries, where the rocks are more consolidated, the faults are plainly visible.

The volcanic necks, such as Pilot Knob and the small plugs in east and south Austin, are forced through the subhorizontal sedimentary rocks. The underground extent of these intrusions has not been determined, but it is probably small.

The interpretation of the structure has an important bearing upon the determination of the depths of underground reservoirs and constitutes an interesting problem for future students of the local geology.

GEOLOGIC HISTORY.

The rocks and configuration of the Austin quadrangle illustrate the geologic history of detailed portions of the Coastal Plain and Plateau of the Great Plains, but until more detailed study is made of the larger provinces as a whole the history can not be fully understood. Hence the remarks upon the history recorded within this quadrangle can be considered only as a partial contribution to a larger subject.

Explanation of the zone of faulting.

As the ocean was withdrawing over the vast area from the Rocky Mountains to the eastern margin of the Austin quadrangle, erosion and uplift were producing changes in the configuration of the Central and Plains provinces of the Texas region. The sea border during Eocene time was approximately along the eastern half of the Austin quadrangle, and during this epoch the older rivers, such as the Colorado, were depositing great loads of land débris on the margin of the sea, laying down a load of sediments whose weight may have caused the development of the great fractures now known as the Balcones fault zone, and initiated the present configuration of the Coastal Plain. This, however, is entirely hypothetical.

Since that epoch the Edwards Plateau has been maintained as a great physiographic feature in the Texas region, but its present summit level, occupied by the hard Edwards limestone, is only a lower remnant of its former surface, at one time most probably largely covered by the upper Cretaceous formations, which have since been removed.

The history of the Rocky Mountain region and the Plains Province, to the latter of which the portion of the Edwards Plateau within the Austin quadrangle belongs, has been a long era of erosion and elevation, during which canyon cutting has been more or less intermittently progressing.

elsewhere shown, that during the Austin epoch of the upper Cretaceous, Pilot Knob was a marine volcano; this is indicated by the apparent contemporaneity of the deposition of its volcanic débris and that of the Austin chalk.

ECONOMIC GEOLOGY.

The Austin quadrangle abounds in many of those mineral resources which add to wealth and commercial development, especially structural material—such as building stone, cement, and lime—and road metal, and contains a diversity of agricultural soils. Metallic minerals are lacking, and mineral fuels in commercial quantities are apparently absent.

OIL.

The Webberville formation, which underlies the eastern edge of the area, is oil bearing, but the quantity and commercial value of the oil have not been determined. This formation, which is the same as that which supplies the Corsicana oil, is not sufficiently embedded to justify the expectation of oil in the Austin quadrangle, but it presents a favorable field for exploitation on the western margin of the adjacent Bastrop quadrangle.

The Eagle Ford shales often yield globules or other small quantities of oil, but as these shales are very thin there is no probability that they

parts of the State. The quality of bricks produced is excellent. Both white brick of the Milwaukee type and red brick are made. The manufacture of tile, drainage pipe, and other articles of this kind has not been attempted.

Lime.—Lime making is an extensive industry, which is carried on at Austin and McNeill, the product being shipped as far east as New Orleans and west to the Pacific coast. This lime, commercially known as Austin lime, is exceedingly white and pure and is made from the Edwards limestone.

Cement material.—The Cretaceous rocks of Travis County abound in materials for making both natural and Portland cement. The flaggy arenaceous limestone of the Eagle Ford formation, when burned in a kiln, produces a natural cement of fair quality, like that which for many years was manufactured at San Antonio. Materials for making artificial Portland cement are unusually abundant, and from them a product equal to the best foreign cements now so extensively imported into Texas can be manufactured. This material includes limestones in a marly or chalky condition, clays, and sands, all of which may be procured in close proximity to one another and to lines of transportation. Hitherto the chief obstacle to the development of a cement industry has been the cost of fuel and the difficulty of obtaining sites and trackage.

Sand.—Quartz sand of excellent quality for building purposes abounds in the alluvial valley of the Colorado.

FLINT.

Flint is found in commerial quantities in the Edwards limestone west of Austin and in the old gravel deposits of the Coastal Plain. Elsewhere material of this kind is extensively used in the arts, for sanding sandpaper, glass making, ball grinding, mixing with potters' clays, and for other purposes, and is imported into the United States from France and England. No use has yet been made of the Texas material.

ROAD METAL.

Road metal of unusually excellent quality and of many varieties may be found in the quadrangle. Limestones and siliceous hydraulic marls for making light macadamized country roads and drives are abundant. The Buda limestone and certain layers of the Edwards and Glen Rose limestones are especially suitable for this purpose.

In the experiments in road building thus far made in the quadrangle soft and unsuitable layers have too often been used. Gravel of any size may be obtained in great quantities in the alluvial material of the Colorado and other bottoms, while large flint gravel of excellent quality for crushing into durable and sharp road metal abounds on the margins of the uplands within the Black Prairie.

The nepheline-basalt of Pilot Knob makes one of the hardest and most durable road metals to be found, but it is hardly probable that the necessities of the country would warrant the present cost of crushing and utilization.

CABINET SPECIMENS AND MINERAL CURIOS.

A small industry has been carried on in mining the beautiful crystals of calcite, aragonite, and strontianite which occur in the recesses of the bluffs of Mount Bonnel. Epsomite is also found in this locality in quantities suggestive of value. Some beds may possibly be capable of supplying strontianite for use in the arts. The abundant fossils, if properly collected, also have commercial value for educational uses.

GLASS SAND.

Some of the sands of the Travis Peak formation are of sufficient purity to suggest their possible use for glass-making purposes. Their outcrop in the western part of the Austin quadrangle is at present too remote from fuel or transportation to give them value.

SOILS.

One of the chief natural products of Travis County is the superb group of agricultural soils which result from the surficial weathering of the rocks. Each formation described in this folio weathers into a peculiar soil which has its own qualities of production, as is attested by the difference of natural growth upon them. The relative merits of these soils can not be discussed here, nor has scientific investigation advanced sufficiently to give a final presentation of them. In general, however, the deep and rich soils are found in the area of outcrop of the Gulf seiles of rocks, while they are shallower in the region of the Edwards Plateau and in the Bear Creek and Manchaca belts.

ARTESIAN WATERS.

The underground waters of the Austin quadrangle are carefully discussed in more extended reports. (See Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. II; and Twenty-first Ann. Rept., Pt. VII.) It may be stated, however, in a general way, that all portions of the quadrangle are underlain by the reservoirs of the Trinity group and that, theoretically, the water from these will rise to the surface at points below 600 feet in altitude.

Owing to the structural conditions previously described, these reservoirs are embedded at different depths in the regions of the Edwards Plateau and the Coastal Plain. In the Edwards Plateau the basement Trinity reservoir, which is the best source of supply, is embedded from 300 feet above sea level along the western border of the quadrangle to about sea level at Mount Bonnel. In the region of the Coastal Plain the basement reservoir is embedded about 1800 feet beneath Austin, or 1200 feet below sea level, and probably 3000 feet, or 2500 feet below sea level, in the longitude of Manor.

There are several reservoirs above the basement Trinity sands which may be struck at shallower depths, but these are impregnated with mineral matter.

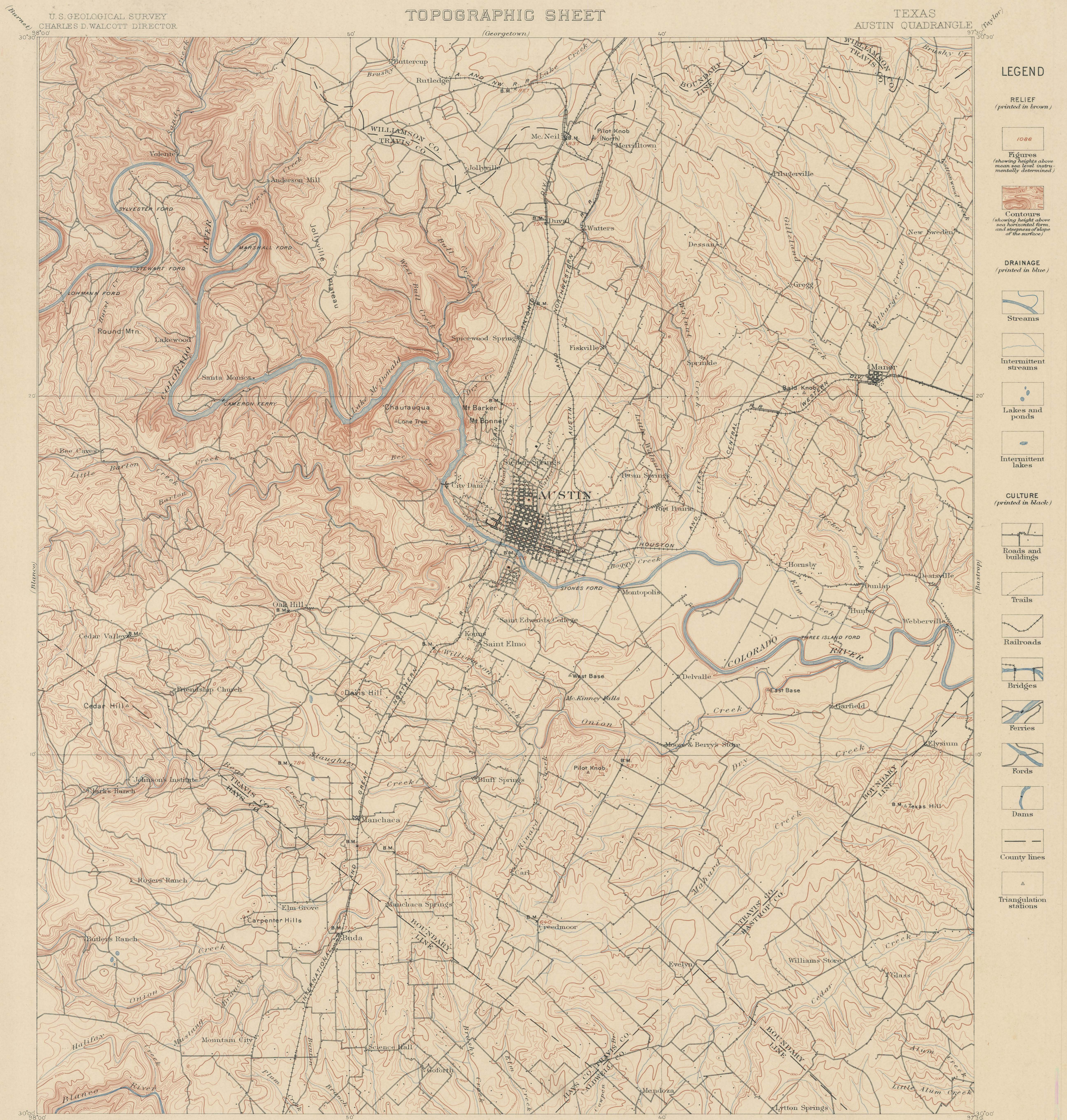
Shallow flowing wells at depths of less than 1000 feet could probably be obtained along the banks of Lake McDonald between Volente and Mount Bonnel, the depth decreasing to the westward.

May, 1900.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

TOPOGRAPHIC SHEET

TEXAS
AUSTIN QUADRANGLE



Henry Gannett, Chief Topographer.
E. M. Douglas, Topographer in charge.
Triangulation by E. M. Douglas.
Topography by T. M. Bannon and W. B. Corse.
Surveyed in 1895-96.

Bannon
Corse
Bannon

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 25 feet.

Datum is mean sea level.

Edition of Oct. 1901.

U.S. GEOLOGICAL SURVEY
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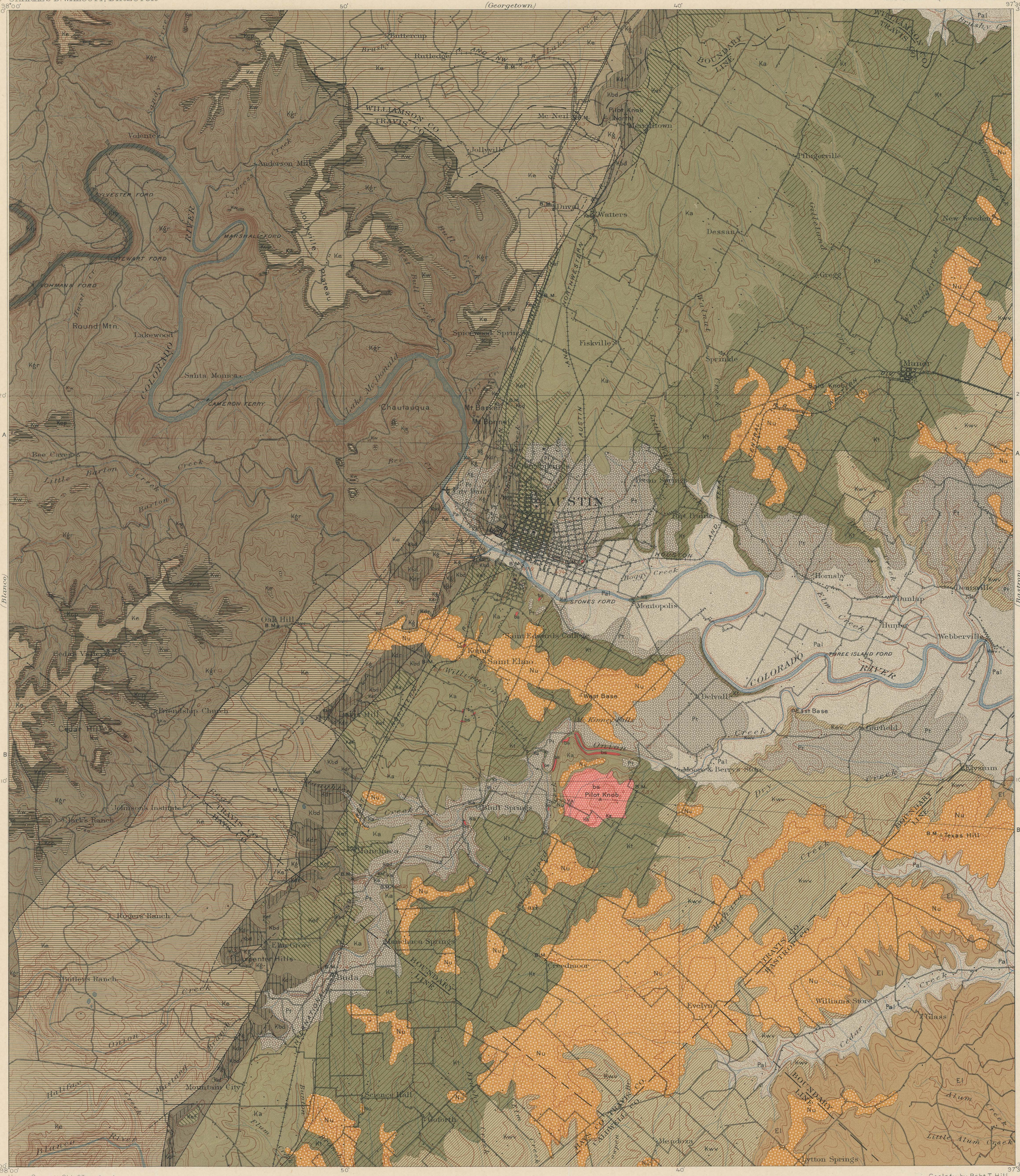
HISTORICAL GEOLOGY SHEET

TEXAS
AUSTIN QUADRANGLE



30°30′ 98°00′ · 50′ · 45′ · 97°30′ 30°30′ · 20′ · 10′ · 30°00′ 98°00′ · 50′ · 40′ · 97°30′ 30°00′

Henry Gannett, Chief Topographer.
E.M. Douglas, Topographer in charge.
Triangulation by E.M. Douglas.
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1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 25 feet.

Datum is mean sea level.

Edition of Nov. 1901.

Geology by Robt. T. Hill
and T. Wayland Vaughan.
Surveyed in 1894 and 95.

LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles.)

PLEISTOCENE

- Pal — Alluvium *(silt of the present river valleys)*
- Pt — Terrace gravels *(gravel and sand, mostly granitic; includes Onion Creek formation of calcareous marl and gravel)*

NEOCENE

- Nu — Uvalde formation *(upland gravels, composed mostly of flint)*

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

EOCENE

- El — Lytton formation *(unconsolidated clay and sand with some harder sandstone beds)*

CRETACEOUS

Gulf series

- Kwv — Webberville formation *(black shaly clay with occasional arenaceous layers)*
- Kt — Taylor marl *(bluish unctious marly clay)*
- Ka — Austin chalk *(white chalk, in part marly)*
- Kef — Eagle Ford formation *(laminated clay and flaggy limestone)*

Comanche series

- Kbd — Buda limestone *(massive limestone)*
- Kdr — Del Rio clay *(unctious greenish clay)*
- Kg — Georgetown limestone *(white limestone with marly beds)*
- Ke — Edwards limestone *(massive white limestone with beds of flint)*
- Kcp — Comanche Peak limestone *(white chalky limestone)*
- Kw — Walnut clay *(yellow clay)*
- Kgr — Glen Rose formation *(white and yellow limestone and marl)*
- Ktp — Travis Peak formation *(conglomerate, sand, and clay)*

IGNEOUS ROCKS

(Areas of Igneous rocks are shown by patterns of triangles and rhombs.)

CRETACEOUS OR LATER

- bs — Basalt *(massive and fragmental)*

Faults

Concealed faults *(extension of known faults beneath recent deposits)*

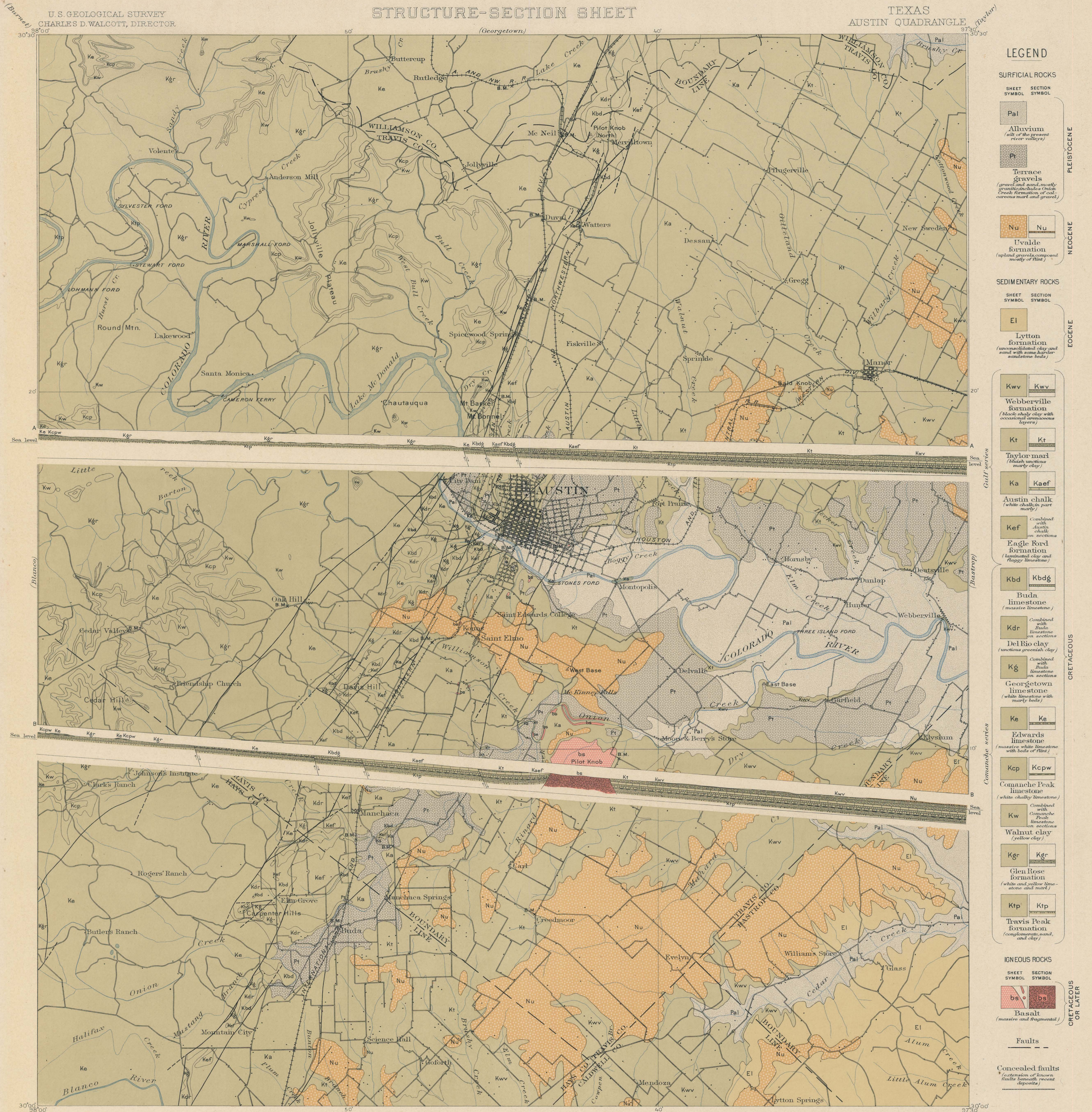
Sections

A — A
B — B

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

STRUCTURE-SECTION SHEET

TEXAS
AUSTIN QUADRANGLE



Henry Gannett, Chief Topographer.
E. M. Douglas, Topographer in charge.
Triangulation by E. M. Douglas.
Topography by T. M. Bannon and W. B. Corse.
Surveyed in 1895-96.

Bannon
Corse
Bannon

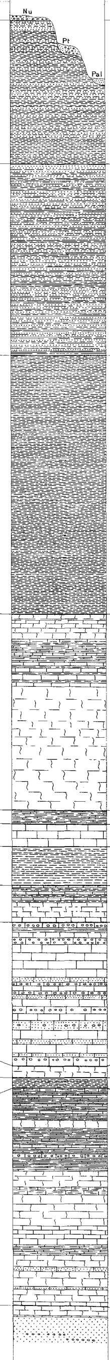
Edition of Dec. 1901.

Geology by Robt. T. Hill
and T. Wayland Vaughan.
Surveyed in 1894 and 95.

COLUMNAR SECTION SHEET 1

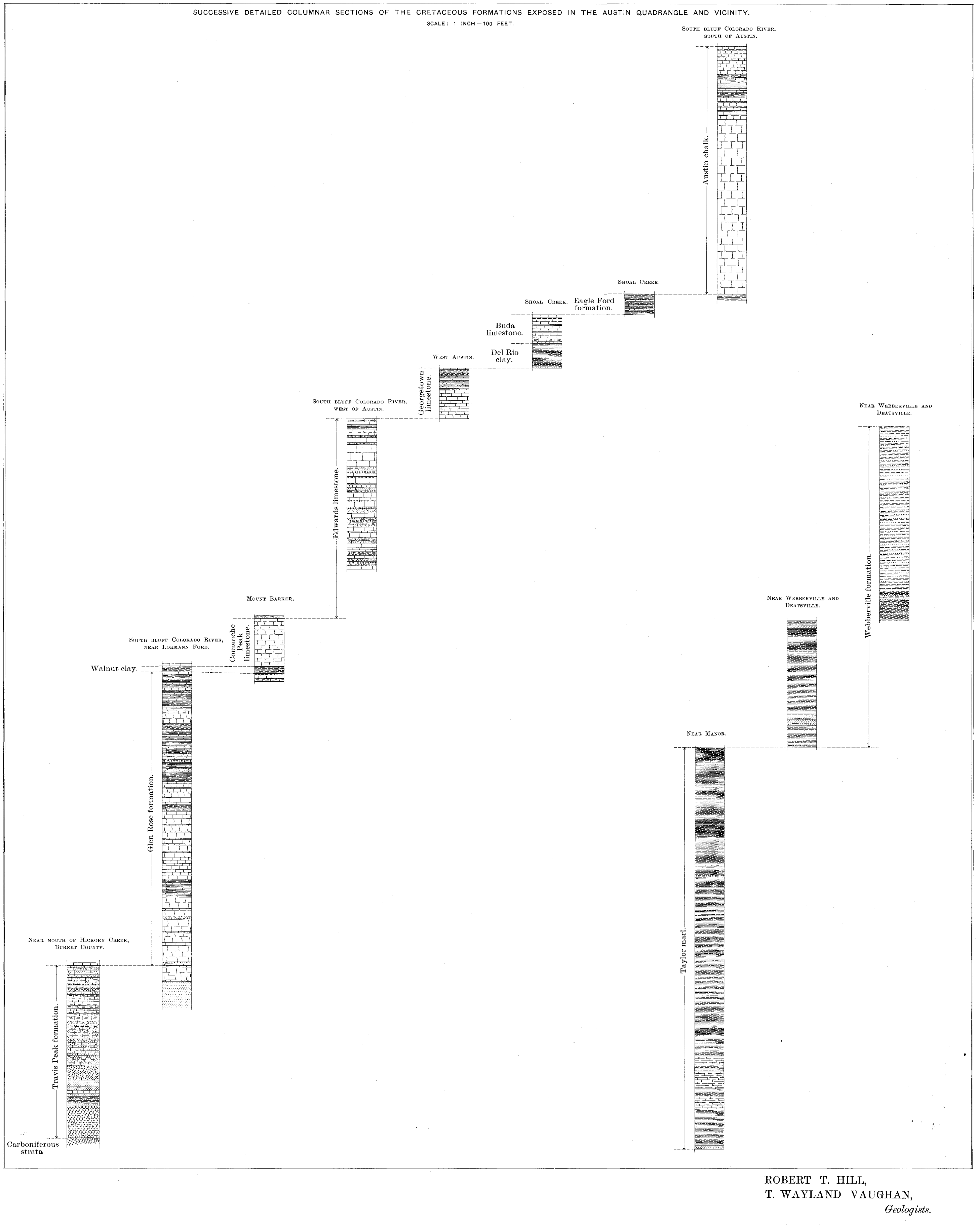
GENERALIZED SECTION FOR THE AUSTIN QUADRANGLE.

SCALE: 1 INCH = 200 FEET.

Period.		Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
PLEIS.		Alluvium.	Pal		0–40	Mostly silt.	Wide flats along the larger streams, heavily forested with hard wood, such as pecan.
PLEIS.		Terrace gravels.	Pt		0–50	Gravel and sand, chiefly granitic, and calcareous marl.	Lower terraces along Colorado River and Onion Creek, heavily forested with post oak and black-jack.
NEO-CENE		Uvalde formation.	Nu		0–70	Gravel, chiefly flints from the Edwards limestone.	Caps the higher hills east of the Balcones escarpment.
EOCENE		Lytton formation.	El		300+	Clay, laminated sand and clay, and sandstone, the latter often cross bedded. Excepting some hard sandstone beds, the rocks are unconsolidated.	Undulating surface with low hills. Sandy soil bearing a growth of oak timber, bordered on the west by dense mesquite thicket with opuntias.
CRETACEOUS	GULF SERIES	Webberville formation.	Kwv		400±	Black, shaly, bituminous clay with occasional arenaceous and harder layers. Distinguishable from the Taylor marl by the presence of greensand or glauconite and by its fossils.	Rolling prairie. Fertile, black, sticky soil with scattered growth of mesquite trees.
CRETACEOUS	GULF SERIES	Taylor marl.	Kt		540±	Bluish, unctuous, marly clay ("joint clay") which weathers into yellow laminated subsoil and black surface soil.	Rolling prairie. Fertile, black, sticky soil.
CRETACEOUS	GULF SERIES	Austin chalk.	Ka		410±	White chalk with conchoidal fracture. Marly in the upper portion.	Rolling prairie, broken in places by growth of live oak and juniper. Fertile, black, argillaceous soil.
CRETACEOUS	GULF SERIES	Eagle Ford formation.	Kef		30±	Laminated blue clay and flaggy limestone, containing fish bones and teeth.	Prairie with fertile, stiff, argillaceous soil, and elm and hackberry growth in places.
CRETACEOUS	COMANCHE SERIES	Buda limestone.	Kbd		45	Massive thick-bedded pinkish-yellow limestone with nodular fracture.	Stony surface with shallow soil and live-oak growth.
CRETACEOUS	COMANCHE SERIES	Del Rio clay.	Kdr		80	Unctuous greenish clay weathering light blue or yellowish. Contains numerous specimens of *Exogyra arietina*.	"Hog-wallow" prairies. Stiff, argillaceous soil covered by thin growth of mesquite bushes.
CRETACEOUS	COMANCHE SERIES	Georgetown limestone.	Kg		80	White limestone with irregular fracture, slightly arenaceous and frequently containing marly beds.	Stony prairie. Inferior shallow soil with juniper and live-oak growth.
CRETACEOUS	COMANCHE SERIES	Edwards limestone.	Ke		300±	Massive white limestone with beds of flints.	Rocky summits and highlands with cliffs and canyon walls. Shallow black and chocolate-colored soil covered with live oak and scrub oak.
CRETACEOUS	COMANCHE SERIES	Comanche Peak limestone.	Kcp		40	White chalky limestone.	Usually barren chalky slopes.
CRETACEOUS	COMANCHE SERIES	Walnut clay.	Kw		15	Yellow clay, containing many specimens of *Exogyra texana*.	Steep slopes with sterile clay soil.
CRETACEOUS	COMANCHE SERIES	Glen Rose formation.	Kgr		450	White and yellowish limestone in bands of various thickness, flaggy and marly in places, and sandy toward the top and base.	Slopes, terraced by harder beds, with vertical cliffs along stream bluffs. Prairie, in places covered with juniper and sumac growth.
CRETACEOUS	COMANCHE SERIES	Travis Peak formation.	Ktp		100+	Conglomerate, grit, sand, clay, and calcareous beds.	Lower slope and bottom of Colorado Canyon.

ROBERT T. HILL,
T. WAYLAND VAUGHAN,
Geologists.

COLUMNAR SECTION SHEET 2



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T. WAYLAND VAUGHAN,
Geologists.

ILLUSTRATION SHEET

FIG. 4.—TERRACE OF OLD ALLUVIUM UPON UPPER BEDS OF THE EDWARDS LIMESTONE, COLORADO VALLEY, WEST AUSTIN.
Showing previously eroded surface of the limestone.

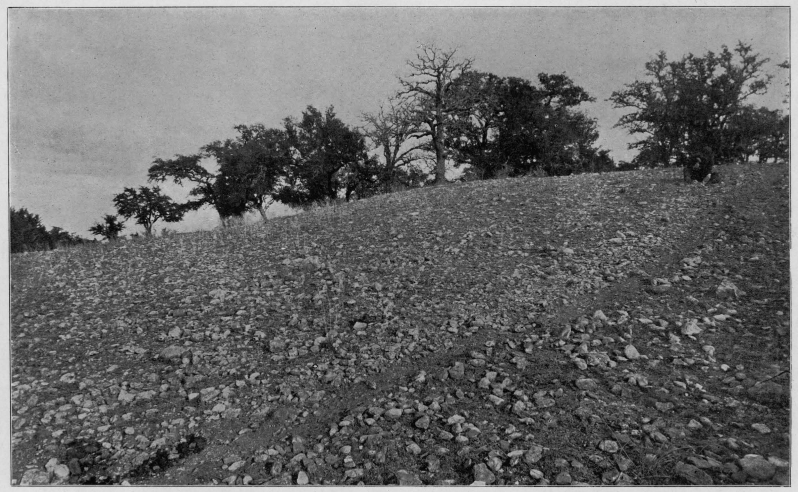


FIG. 5.—RESIDUAL GRAVEL OF THE UVALDE FORMATION IN THE BLACK PRAIRIE REGION.
Composed of flint nodules derived from the Edwards limestone in the region of the Edwards Plateau.

FIG. 6.—MINOR BLOCK FAULTING IN THE EDWARDS LIMESTONE, BARTON CREEK.
Showing the type of faulting in the Balcones fault zone.

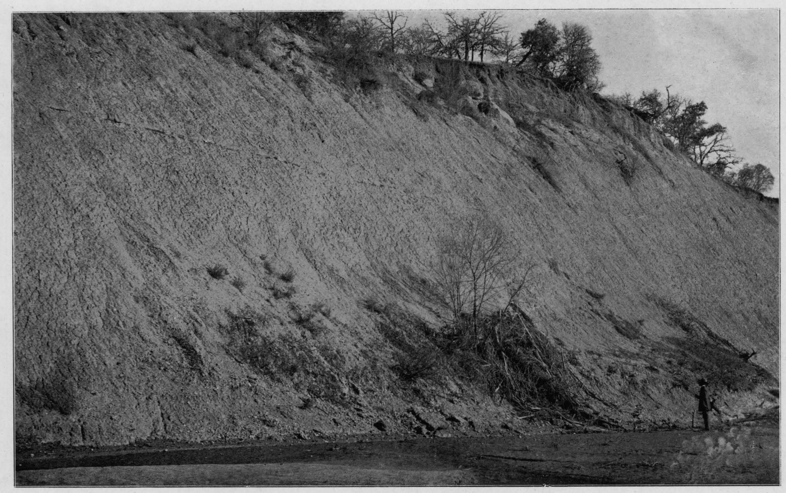


FIG. 7.—TYPICAL EXPOSURE OF TAYLOR MARL, BLUE BLUFF, COLORADO RIVER.
Remnant of a gravel terrace caps the bluff at the right.

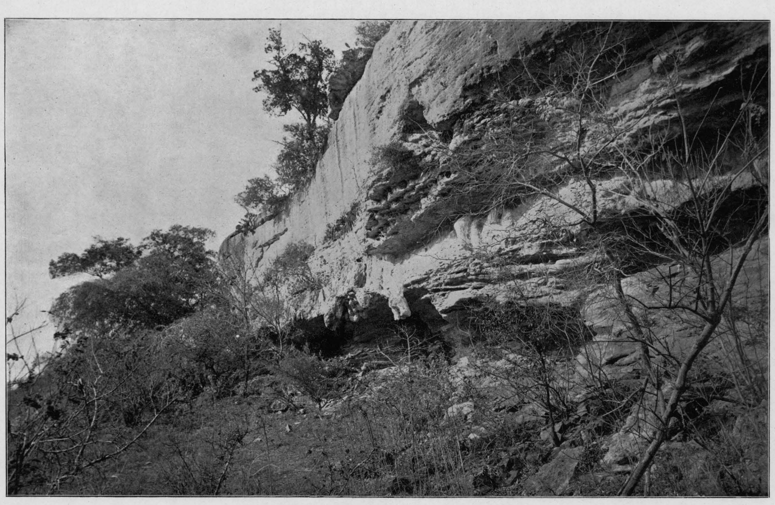


FIG. 8.—CLIFF OF AUSTIN CHALK, ONION CREEK.
Interbedded volcanic tuff at the base of the exposure.

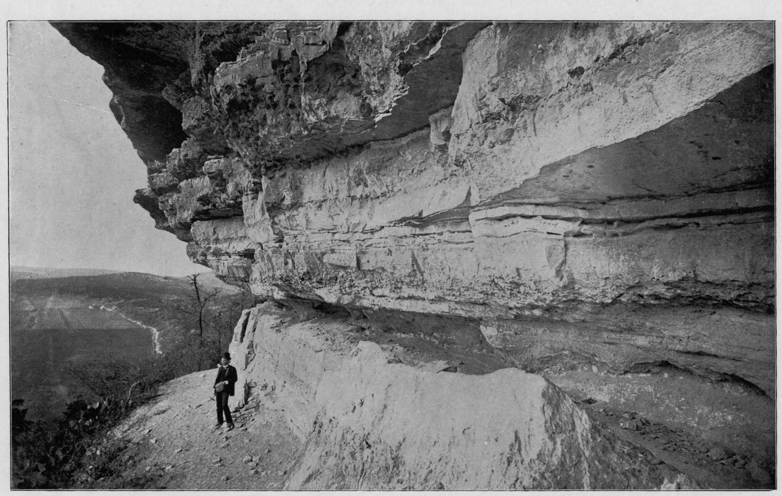
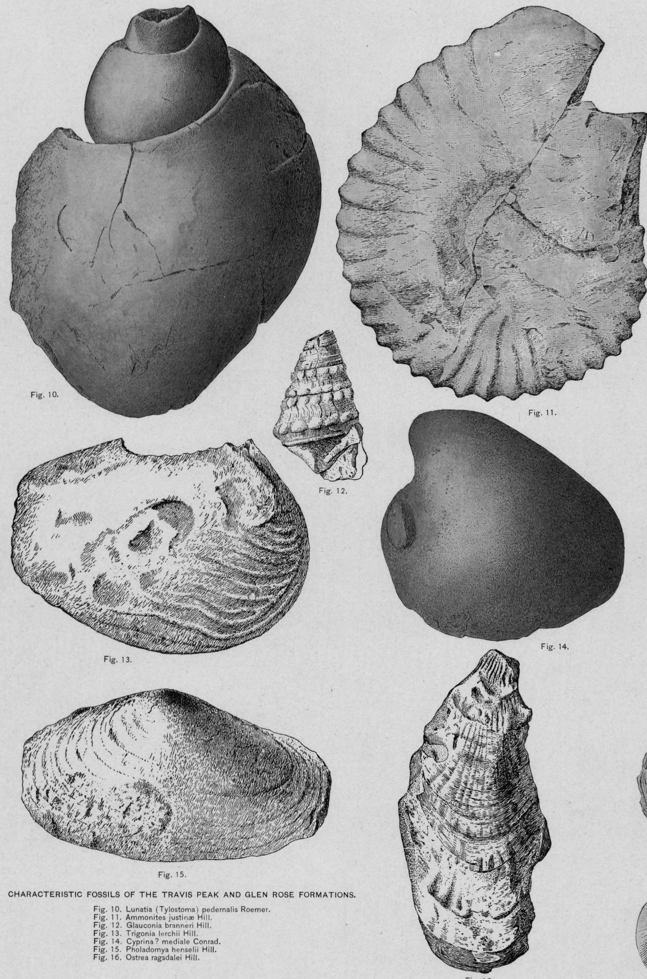


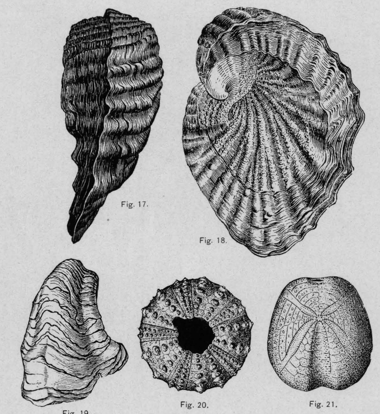
FIG. 9.—GLEN ROSE FORMATION, FORMING WEST BLUFF OF MOUNT BONNEL.
Old alluvial plain of the Colorado River, cut in the Edwards Plateau, is shown in the valley on the left.

ILLUSTRATION SHEET



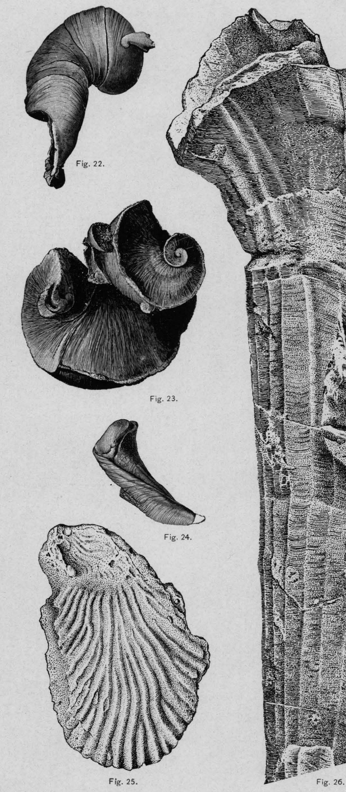
CHARACTERISTIC FOSSILS OF THE TRAVIS PEAK AND GLEN ROSE FORMATIONS.

Fig. 10. Lunatia (Tylostoma) pedernalis Roemer.
Fig. 11. Ammonites justinæ Hill.
Fig. 12. Glauconia branneri Hill.
Fig. 13. Trigonia lerchii Hill.
Fig. 14. Cyprina? mediale Conrad.
Fig. 15. Pholadomya henselii Hill.
Fig. 16. Ostrea ragsdalei Hill.



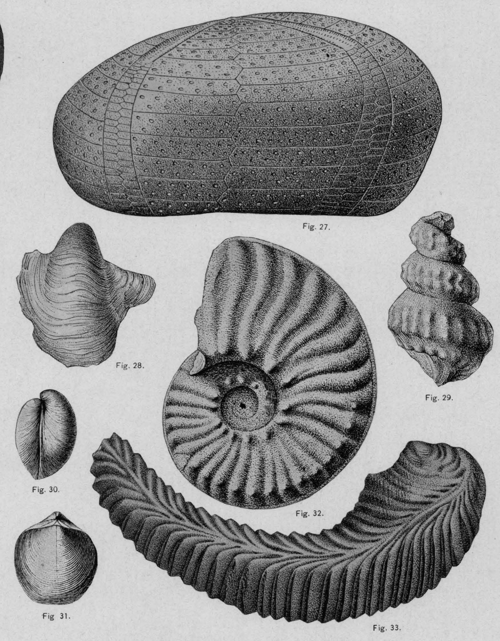
CHARACTERISTIC FOSSILS OF THE WALNUT CLAY AND COMANCHE PEAK LIMESTONE.

Figs. 17, 18. Exogyra texana Roemer.
Fig. 19. Gryphæa marcoui Hill and Vaughan.
Fig. 20. Pseudodiadema texanum Roemer.
Fig. 21. Enallaster texanus Roemer.



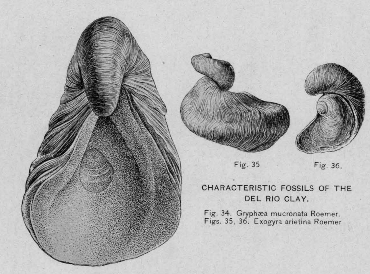
CHARACTERISTIC FOSSILS OF THE EDWARDS LIMESTONE.

Fig. 22. Monopleura pinguiscula White.
Fig. 23. Requienia patigiata White.
Fig. 24. Monopleura marcida White.
Fig. 25. Chondrodonta (small specimen).
Fig. 26. Radiolites davidsoni Hill.



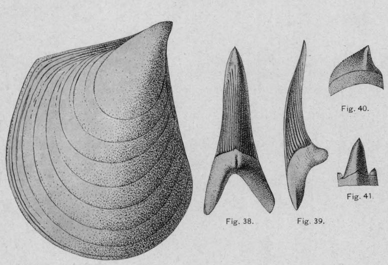
CHARACTERISTIC FOSSILS OF THE GEORGETOWN LIMESTONE.

Fig. 27. Epiaster elegans Shumard.
Fig. 28. Gryphæa washitaensis Hill.
Fig. 29. Turrilites brazoensis Roemer.
Figs. 30, 31. Terebratula (Kingena) wacoensis Roemer.
Fig. 32. Ammonites (Schloenbachia) leonensis Conrad.
Fig. 33. Ostrea (Alectryonia) carinata Lamarck.



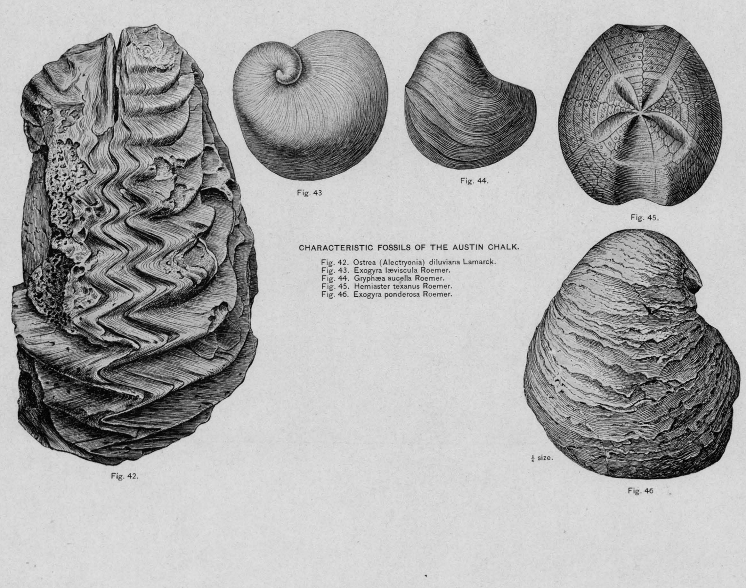
CHARACTERISTIC FOSSILS OF THE DEL RIO CLAY.

Fig. 34. Gryphæa mucronata Roemer.
Figs. 35, 36. Exogyra arietina Roemer



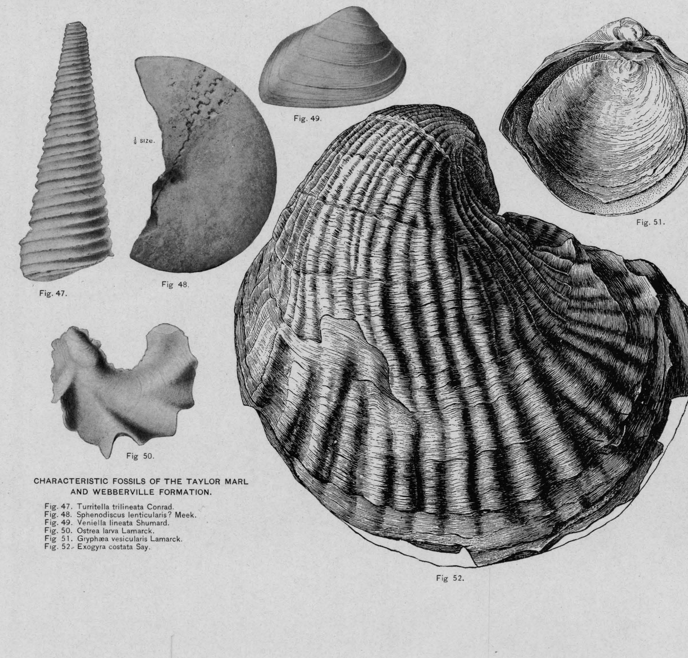
CHARACTERISTIC FOSSILS OF THE EAGLE FORD FORMATION.

Fig. 37. Inoceramus fragilis Hall and Meek.
Figs. 38, 39, 40, 41. Shark teeth.



CHARACTERISTIC FOSSILS OF THE AUSTIN CHALK.

Fig. 42. Ostrea (Alectryonia) diluviana Lamarck.
Fig. 43. Exogyra læviscula Roemer.
Fig. 44. Gryphæa aucella Roemer.
Fig. 45. Hemiaster texanus Roemer.
Fig. 46. Exogyra ponderosa Roemer.



CHARACTERISTIC FOSSILS OF THE TAYLOR MARL AND WEBBERVILLE FORMATION.

Fig. 47. Turritella trilineata Conrad.
Fig. 48. Sphenodiscus lenticularis? Meek.
Fig. 49. Veniella lineata Shumard.
Fig. 50. Ostrea larva Lamarck.
Fig 51. Gryphæa vesicularis Lamarck.
Fig. 52. Exogyra costata Say.

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