DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

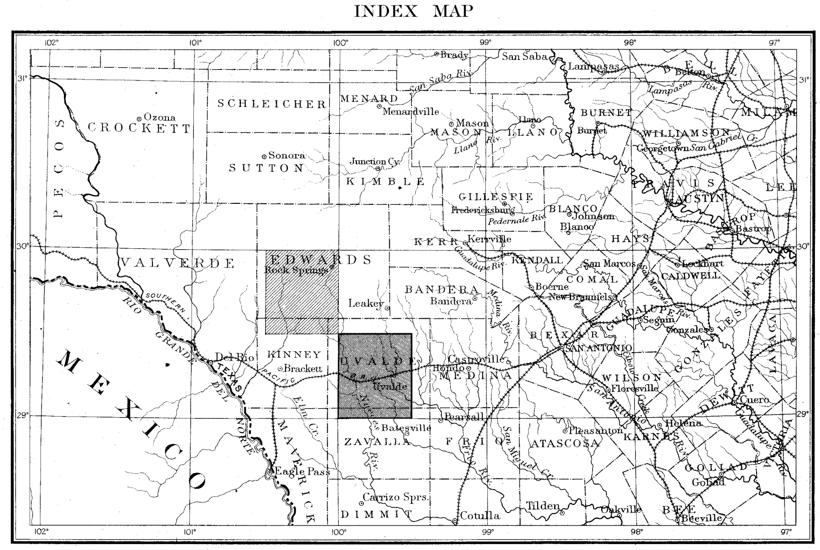
OF THE

UNITED STATES

UVALDE FOLIO

TEXAS

INDEX MAP



SCALE: 40 MILES - 1 INCH

AREA OF THE UVALDE FOLIO

AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION | TOPOGRAPHY | HISTORICAL GEOLOGY | STRUCTURE SECTIONS

FOLIO 64 | LIBRARY EDITION | UVALDE

WASHINGTON, D. C.

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

1900

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:

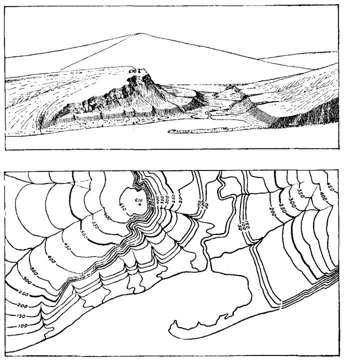


Fig. 1.—Ideal sketch and corresponding contour map.

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	Є	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:

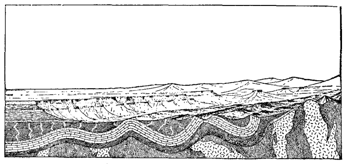


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

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:

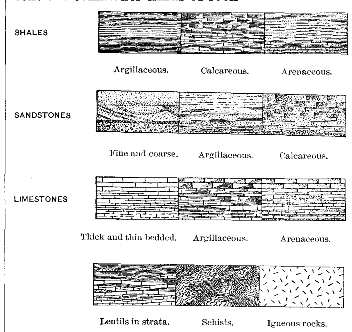


Fig. 3.—Symbols used to represent different kinds of rock.

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 UVALDE QUADRANGLE.

GENERAL RELATIONS.

Area. The Uvalde quadrangle embraces an area of 1039.96 square miles, extending from latitude 29° 00′ on the south to 29° 30′ on the north, and from longitude 99° 30′ on the east to 100° 00′ on the west. It is named from the town Uvalde, the principal town and the county seat of Uvalde County. It includes the greater portion of Uvalde County and the northern portion of Zavalla County. The adjacent quadrangles, so far as mapped, are the Brackett quadrangle on the west and the Nueces quadrangle on the northwest.

Topographic provinces. Two large topographic provinces of Texas are represented in the Uvalde quadrangle.* Its northern boundary extends beyond the southern edge of the Edwards Plateau, while its southern boundary lies in the Rio Grande Plain. The two provinces are separated by the Balcones Escarpment.

The plains. *The Plateau of the Plains.*—The Llano Estacado and the Edwards Plateau together constitute the Plateau of the Plains of Texas. This lies within the area inclosed by the Canadian River on the north, the Pecos River on the west, the Balcones Escarpment on the south and southeast, and an irregular line of scarps along the headwaters of the eastward-flowing drainage of the Colorado, Brazos, and Red rivers of Texas. It is over 500 miles in length and in places 280 miles in width. The central portion of the plateau still presents a general level, but its borders are cut by headwater erosion into a fringe of projecting divides, accompanied by many buttes and mesas, which are remnants of the once more extensive plateau and show to what extent the plateau has been and is being gradually etched away.

The Llano Estacado and Edwards Plateau merge into each other along the central portion of the greater plateau; no sharp line can be drawn between them. The former, in its typical development, has a surface composed of soft material, loams, marls, and sands, while the surface of the latter is often very rocky, owing to the outcropping of the underlying limestone ledges.

The Edwards Plateau occupies nearly the whole of Crockett, Valverde, Edwards, Sutton, Schleicher, Kimble, Kerr, Bandera, Gillespie, and Kendall counties, and about one-half of Crane, Upton, Tom Green, Irion, Concho, Menard, Travis, Hays, Comal, Bexar, Uvalde, and Kinney counties. The northeastern and northwestern boundaries are cliffs due to erosion. The former overlooks the Colorado River; the latter overlooks the Pecos. The southern and southeastern boundary is formed by the Balcones Escarpment. The altitude of this plateau in Edwards County is 2500 feet or more; near its eastern border near Austin 1000 or 1100 feet; near its southern boundary in Uvalde County between 1800 and 1900 feet above sea.

The Balcones Escarpment limits the Edwards Plateau on the southeast and south. It is a southeastward- or southward-facing escarpment, running from a few miles west of Austin a little south of west through Travis, Hays, Comal, Bexar, Medina, Uvalde, and Kinney counties to Valverde County, where it meets the Rio Grande. Near Austin its summits are about 400 feet above the lower plain; in Uvalde County they may be almost a thousand feet higher.

The Rio Grande Plain is a gently southeastward-sloping plain included by the Balcones Escarpment, the sierras of northern Mexico, and the Gulf of Mexico. Along the northern margin of this plain, especially in Uvalde County, are many hills due to igneous intrusions or faulting.

TOPOGRAPHY.

Two topographic provinces. As has already been indicated, the Uvalde quadrangle belongs in part to two topographic provinces. That portion of the quadrangle which belongs to the southern margin of the Edwards Plateau lies northwest of a line drawn north of east from where the West Nueces River enters the quadrangle to the windmill 2½ miles north west of Vanham ranch, and thence northeast to where the Sabinal River enters the quadrangle. That portion of the quadrangle south and southeast of the above line lies within the northern margin of the Rio Grande Plain. The line between the two topographic divisions is the Balcones Escarpment. The portion of the area belonging to the Edwards Plateau is very much dissected, the larger streams, such as the Nueces, Frio, and Sabinal, having cut canyons, often with precipitous walls, 400 to 500 feet deep. Hills a short distance back from the Nueces rise more than 750 feet above the river. The whole of this portion of the area is cut into buttes, mesas, or narrow divide summits, so that now the original plateau level is represented by only the summits of the highest hills and divides. The highest point is Sycamore triangulation station, which has an altitude of 1925 feet. The surface of the Edwards Plateau a few miles back from the escarpment is almost horizontal, having a slope of only about 2 to 4 feet per mile. The slope of the surface corresponds to the dip of the rocks, and both slope and dip increase very rapidly just north of the Balcones Escarpment. They are nearly 100 feet to the mile from Davenport Hill to the hill on the south side of the west-to-east bend in the Dry Frio River, northeast of Chilton ranch.

Slope of the Edwards Plateau. The sudden increase in steepness of slope of the surface of the Edwards Plateau along this portion of its southern margin is not only an important topographic feature, but is also important structurally and will be referred to again under the heading Structural Geology. The Balcones Escarpment in this area is due very largely to an increased steepness of the slope of the surface of the Edwards Plateau and increased steepness in the dip of the rocks. Erosion along the front of this fold, accompanied by and in part due to faulting, has aided in producing the escarpment.

Topographic features of the Rio Grande Plain. That portion of the quadrangle belonging to the Rio Grande Plain can be divided into a relatively hilly area and a plain. The hilly area is bounded on the southern side by a line running from near Wagon Wheel Hill north of east to Engelmann's ranch on the Frio, and thence northeast to a point between Yucca siding and the eastern edge of the quadrangle, a line almost exactly parallel to the front of the Edwards Plateau. This area is characterized by numerous hills of limestone and of basaltic material, which rise from a few feet to 300 feet above its general level. The highest of these hills is the one on which Allen triangulation station stands. This is composed of basalt and rises some 300 feet above the level of the surrounding plain. Other hills belonging to this class, but not so high, are Sulphur, Obi, Nueces, Inge, Taylor, Black, and Blue. Big Mountain, 5 miles northeast of Uvalde, is an example of the limestone hills. This hilly area has a width of about 12 miles. South of its southern boundary there are no hills rising above the general level of the plain. The tops of these hills represent a fairly constant and persistent old level.

Altitude of the plain. The portion of the Rio Grande Plain within the Uvalde quadrangle slopes gently to the southeast. Its altitude along its northern margin, on the divides, is about 1100 feet, and along the southern margin of the quadrangle the old level is about 900 or 950 feet, giving a slope of about 150 or 200 feet in 22 miles. The slope is steeper along the northern margin, and if this part of the area be excluded the slope will be very small indeed. The stream valleys are very different from those in the Edwards Plateau. Here, instead of finding canyons with high and steep walls, one finds shallow streamways, rarely with bluffs of sandstone or limestone 75 to 100 feet high. Here, too, the river terraces, instead of flanking the streams and resting against the canyon walls, frequently spread out over the banks and are miles in width, the outer limit often being formed by a low bluff or escarpment. The stream beds themselves, instead of having rock floors or thin deposits of gravel, are frequently gravel clogged, and the water of a stream which may be running in its canyon portion disappears in the gravel as it debouches upon the plain.

The main drainage channels of the quadrangle are the Nueces, Leona, Dry Frio, Frio, and Sabinal rivers. They all flow in a general southeasterly direction.

GEOLOGY.

Kinds of rocks. The rocks of the quadrangle are divisible into two classes: *First*, those of sedimentary origin; *second*, those of igneous origin, which came into their present position when in a molten state. The sedimentary rocks belong to two categories: (*a*) those deposited in the sea, or marine sediments; (*b*) those deposited in fresh water, which are of fluvial, or, in some instances, probably, of lacrustine origin. The marine sediments belong to two periods: the Cretaceous and Eocene. The fresh-water sediments are in part Neocene (Pliocene) and in part Pleistocene. The total thickness of the Cretaceous sediments represented in the quadrangle is between 1700 and 1900 feet; the thickness of the Eocene sediments is about 800 feet, making the total thickness of the marine sediments between 2500 and 2700 feet. The Neocene and Pleistocene sediments have been spread over the surface by streams, i. e., they are surficial, and are extremely variable in thickness, ranging from a mere veneering to many feet.

MARINE SEDIMENTS.

CRETACEOUS.

COMANCHE SERIES.

The oldest formation. *Glen Rose formation.*—This is the oldest formation exposed in the quadrangle, only some 60 or 70 feet of it being shown in the deepest canyon cuttings along the northern margin of the area. This portion of it is composed of soft, yellowish or cream-colored, flaggy, argillaceous limestones. The formation is exposed along the Little Blanco and both forks of the Frio for short distances south of the northern margin of the quadrangle. It occurs at the base of the bluffs or in stream beds. It extends on the Nueces River as far south as the Francis Smith (Molesworth) ranch at the mouth of Sycamore Creek, where it disappears below the stream bed.

A limestone containing oyster shells. *Comanche Peak limestone.*—This formation is a yellowish or cream-colored, argillaceous limestone, forming a more or less massive ledge on the top of the Glen Rose formation. This limestone is usually not flaggy, as is the Glen Rose, but is nodular; its nodular appearance on a weathered surface being one of its most constant features. The oyster *Exogyra texana* is its most characteristic fossil. The thickness of the bed is from 50 to 60 feet. It outcrops in the extreme northern portion of the quadrangle along the Little Blanco River, Hackberry Creek, both forks of the Frio River, Sycamore Creek, and the Nueces River.

A widespread limestone usually containing flints. *Edwards limestone.*—The next higher formation is the Edwards limestone. This limestone occupies a larger area within the quadrangle than any other one of the marine formations. It consists of thick ledges of hard or chalky limestone, white, bluish, cream-colored, or yellowish. Its weathered surface is almost invariably grayish no matter what the original color was, and when weathered, the rock almost invariably becomes indurated, so that it is usually hard and rings under the blows of a hammer. An especially characteristic feature of its weathered surface is the peculiar formation of a minature mountainous topography; there are sharp crests an inch or two in height, with well developed lateral spurs, which are separated from each other by valleys from one to several inches wide. This feature of the formation is due to the solvent effect of rain water falling on the often much heated surface of the rocks. We have borrowed for it the Swiss name *karrenfelder*. The texture of the rocks is variable; it is sometimes granular, sometimes soft and chalky, and it may be horny. This formation may usually be recognized by the occurrence in it of flints, this being the only formation in the Cretaceous of Texas that contains these bodies. The flints are of many kinds, varying in color, size, and shape. They may be blackish, bluish, or pink in color, and some become encrusted with a reddish coating when weathered out, the red color being produced by the oxidation of the contained iron. They vary in size from very small, the size of a hen's egg or even smaller, to masses several feet in diameter and weighing several hundred pounds; their form may be oval, tubular, or irregularly nodular; they may be in expanded masses several feet across with irregular outlines, or they may form continuous sheets of undetermined extent. The siliceous segregation in the limestone may not always be complete, and patches of cherty limestone may be found in the purer limestone; there may sometimes be a shell of flint surrounding a cavity, which may be studded with quartz crystals. The different kinds of flint quite often occur in definite horizons that are persistent throughout an area many miles in extent.

Thickness and composition. The thickness of the Edwards limestone is slightly more than 500 feet. Because of faulting, the exact top was not determined. The lower 60 or 80 feet are usually composed of hard, thick, yellowish ledges, without flints; then follow 200 to 250 feet of ledges, becoming flaggy at the top, in places being more or less argillaceous, and containing a considerable number of flint beds distributed through them. These ledges are overlain by about 160 feet of soft, chalky limestone, which becomes indurated on exposure, except when forming precipitous bluffs. No flints were found in these ledges. The following fossils that do not occur in the Edwards limestone in the Austin quadrangle were collected in the Uvalde quadrangle: *Kingena wacoensis* (Roemer), *Lima wacoensis* Roemer, and *Ostrea* cf. *subovata* Shumard. Above these beds are from 40 to 60 feet of flint-bearing ledges. Near the base of these ledges is a zone of enormously large blue flints. This zone seems very persistent throughout a strip of country 10 or 15 miles wide in the northwestern portion of the quadrangle. The highest stratum known is one containing large siliceous segregations and cherty shells. This is certainly very near the base of the next higher formation.

Character. The Edwards limestone, excepting the argillaceous layers mentioned and the siliceous flints, is very pure carbonate of lime. The silica of the flints is probably mostly derived from the siliceous skeletons of lower marine organisms, chiefly sponges. The limestones, as a whole, were deposited in deep water, beyond the point where coarse land-derived material was transported seaward.

Extent. This limestone occupies the whole of that portion of the quadrangle belonging to the Edwards Plateau, excepting the silt and gravel-filled stream valleys and the lower portion of bluffs of the stream canyons along its northern margin. There are also areas of it forming hills, due to upthrow faulting, in the Rio Grande Plain as far south as Rocky and Frio hills. These areas are shown on the map, and detailed description of them is not necessary.

Caves in the Edwards limestone. As would be expected in a limestone of the thickness of this formation, caves are abundant. A careful description, with illustrations, of one found in the Nueces quadrangle in southern Edwards County is given in the Nueces folio. A cave on the south side of Cave Hollow, about 1½ miles above the Little Blanco River, was visited. It offers nothing very peculiar or interesting. It is about 200 yards long, from 50 to 100 feet wide, and the roof is probably 50 feet above the floor. The entrance is large, and the mouth is used as a camping ground. The interior of the cavern is a bat roost, and there are considerable accumulations of bat guano.

Georgetown limestone.—This formation, named

* For broader geography of Texas region, see Topographic Folio No. 3, United States Geological Survey.

A limestone with few exposures.

by Mr. R. T. Hill from its occurrence at Georgetown, Williamson County, Texas, is equal in part to the limestone formerly called the Fort Worth limestone. It is almost unexposed in the Uvalde quadrangle, because in very nearly every instance it has been faulted out of sight. It consists of yellowish argillaceous limestone, containing a large number of the fossil *Kingena wacoensis* (Roemer). As the exposures are so small no estimates of its thickness could be made. Judging from exposures in the Brackett quadrangle to the west, and from some examined in the vicinity of Del Rio, its thickness is provisionally given as 40 feet. Exposures of it are seen at several places on the Dry Frio River near the old Bennett (Little) ranch.

Clay beds containing fossils.

Del Rio clay.—The Georgetown limestone becomes very argillaceous at the top, and by both lithologic and paleontologic intergradation passes into the Del Rio clays. This clay, as seen in the exposures along the streams, hillsides, etc., is always of an ocher-yellow color with occasional vermilion bands, and is more or less calcareous. There are in some places ferruginous slabs or layers a few inches thick. *Kingena wacoensis* (Roemer) occurs in the basal layers of the formation. The little ram's horn oyster, *Exogyra arietina* Roemer, is extremely abundant throughout practically its whole thickness. Quite frequently these fossils are cemeted together so as to form slabs. This clay has a considerable distribution in that portion of the Rio Grande Plain broken by faulting and igneous intrusions, especially east of the Nueces River. There is a small patch of it at the Blocker silver mine and another in the first draw northeast of Crane's house, in the Edwards Plateau. These two patches owe their presence in the localities to faulting, or possibly, in the case of the Blocker mine, to slipping. No section showing a thickness greater than 50 feet was measured. The thickness probably does not very much exceed this amount. In the Austin quadrangle these clays have a thickness of between 75 and 90 feet. At Del Rio they are about 100 feet thick.

A speckled limestone.

Buda limestone.—The Del Rio clay becomes more calcareous at the top and passes into what Mr. R. T. Hill now calls the Buda limestone, formerly described as the Shoal Creek limestone. This limestone is hard, breaks with a conchoidal fracture, and posesses a rather homogeneous texture. A very constant characteristic of it is the presence of small brownish or pinkish specks on the broken surfaces. The limestone, when weathered, has a very pronounced tendency to fall into small angular bits; a piece thoroughly weathered may be shattered by a stroke of a hammer. The soil derived from the disintegration of this limestone usually contains angular pieces of limestone and fragments of limonite, the latter in small, usually flat pieces. The soil is a very fine gray silt. The thickness of the formation is about 50 feet, or slightly more. It is found in the faulted northern portion of the Rio Grande Plain, in the bed of the West Nueces River and in the bluffs on the south side of the river, along the southern front of the Edwards Plateau east of the Nueces, and in one place it occurs as far south as Mount Inge. Within the area of the Edwards Plateau it occurs at only one locality, which is just northeast of Crane's ranch, where its presence is due to faulting.

GULF SERIES.

Beds widely varying in character.

Eagle Ford formation.—This formation immediately overlies the Buda limestone. It consists of yellowish, thinly laminated, argillaceous-calcareous material. In some layers, the argillaceous constituents are in excess, a thinly laminated calcareous marl resulting. In places the laminæ are as thin as wafers; in other layers the calcareous elements are in excess, and calcareous flags result. The flags may become indurated and possess a crystalline texture. The very close lithologic resemblance between this formation and the Anacacho formation deserves especial mention. The lithologic resemblance very often is so close that they can be distinguished only by the fossils if the stratigraphic relations are obscured by coverings of surficial deposits or by faulting. The areas of the respective formations in the Uvalde quadrangle are indicated on the geologic map. The Eagle Ford formation becomes chalky at the top and grades imperceptibly into the next higher formation, the Austin chalk; in fact, no sharp line can be drawn between them. The thickness of the former seems to be 75 feet, the difficulty in determining its thickness lying in the vagueness of its upper limit. The flaggy beds are thicker in the Brackett quadrangle, where they possess an estimated thickness of 250 feet, in the vicinity of the town of Brackett. They seem to thicken still more to the westward. They are thinner in central Texas, in the vicinity of Austin, but become more argillaceous, and much thicker in northern Texas.

This formation is exposed only in the faulted portion of the Rio Grande Plain. It occurs on the south side of the West Nueces River, overlying the Buda limestone. There are occasional remnants near the southern front of the Edwards Plateau. There is a rather large area between Elliot ranch and Blue Mountain, extending westward to Black Mountain and thence southward beyond Ange siding on the Southern Pacific Railroad. There is another considerable area on the south side of Frio Hill.

A chalky limestone.

Austin chalk.—This formation consists of soft, chalky limestone, with some argillaceous layers. The chalk is usually either white or yellowish, the latter color being due to the oxidation of the iron pyrites that it contains. It is brownish when in contact with the igneous intruded rocks. The thickness of the formation could not be determined with accuracy, because the only considerable exposure of it within the quadrangle is associated with the most extensive basaltic intrusion found in the area. A satisfactory section obtained by establishing horizons, correlating from bluff to bluff, and then by adding together the thickness of the various beds could not be made, and where the dip is so variable an estimate based upon it is not reliable. In one hill on the east side of the Nueces River, opposite Soldiers Camp Spring, 150 feet of chalk are exposed. Basing an estimate on the dip from the high bluff on the west side of the Nueces River, between the Southern Pacific Railroad and the West Nueces, it is probable that there are 200 feet of chalk below the base of the first chalk bluffs on the west side of the river south of the railroad. The base of these bluffs seems to correspond to the base of the bluff opposite Soldiers Camp Spring. These data would make the chalk probably 350 feet thick. At Manor, Texas, near Austin, it has a thickness of 410 feet. It is quite probable that the estimate of 350 feet is too small; probably the thickness is 400 feet or slightly more.

The position of the largest area of this chalk has been indicated. There are small areas along the northern margin of the Rio Grande Plain. These may be small patches not covered by surficial deposits, or may be remnants, overlying the Eagle Ford formation, left along the fault lines.

Hard, yellow limestones with beds of marl.

Anacacho formation.—This formation takes its name from the Anacacho Mountains, in the Brackett quadrangle, where it is typically developed. It immediately overlies the Austin chalk. In the western part of the Nueces quadrangle it consists for the greater part of hard, yellowish limestones, but contains some marly beds, several of which, from 15 to 20 feet thick, are interstratified with the limestones near the base of the formation. A notable marly bed about 40 feet thick occurs about 70 feet below the top of the formation. The marly beds are yellow in color, and are usually thinly laminated. The limestones may be in thick ledges or in slabs. They are not pure, but sometimes contain large quantities of clay and sometimes are arenaceous. The yellow color is due to the presence of hydrated oxide of iron. The texture is usually coarse. These limestones are largely of evident organic origin, and quite often are made up of comminuted shell fragments. The presence of siliceous concretions or segregations in the limestones, especially when in proximity to igneous masses, is deserving of special mention, but it does not seem that well-formed flints are ever present. By combining a series of sections along Turkey Creek the thickness was ascertained to be 300 feet or slightly more.

Variations in the Anacacho.

Along the eastern margin of the quadrangle the formation shows considerable variation from its characters along the western margin. It still consists of yellow limestones and yellow clays, the clays and limestones being of the same nature as along the western margin, but the clays have increased in importance, while the limestones have decreased. The formation has also decidedly increased in thickness. A well sunk on Nolton Creek, about one mile north of the railroad, was driven 300 feet through blue or gray clay, according to the well driller, Mr. Tournat. Probably beds of soft, argillaceous limestone were penetrated and not noticed. The well was sunk at the foot of a hill in which are at least 75 or 100 feet more of limestone and clays. There are exposures of the formation farther south along Blanco River, south of Wish's ranch. Because of disconnected exposures and disturbance by basaltic intrusions no accurate estimate of the total thickness could be made, but it is not less than 400 feet and may be more. Near Sabinal the formation contains asphaltum and some petroleum.

The largest area of the formation is south of the Southern Pacific Railroad and west of the Nueces River, in the vicinity of Allen Hill and Sulphur Mountain. No undoubted exposures were seen between the Nueces and Frio rivers. It probably has been faulted out of sight, but as most of this area is covered by surficial deposits, outcrops that may have existed are now obscured by these later deposits. There is a considerable area exposed along the Blanco River above the Southern Pacific Railroad, and there are occasional outcrops along the river for several miles south of the railroad. There are excellent exposures of the formation along the Sabinal River, a short distance east of the eastern margin of the quadrangle.

Ferruginous sandstones with oyster shells.

Pulliam formation.—This formation is named from Pulliam ranch, on the Nueces River, just south of the northern boundary of Zavalla County. The uppermost layers of the Anacacho formation become an arenaceous limestone, and this passes into brown ferruginous sandstone, the basal member of the Pulliam formation. This formation consists of brown ferruginous sandstones occurring in ledges or slabs, some beds of clay, and near the top, a bed of soft, unconsolidated sand, impregnated at Waxy Falls just above the Pulliam ranch, with asphalt. Above this sandstone are several very fossiliferous layers, and an agglomerate of the oyster *Ostrea cortex* Conrad forming the uppermost bed of the formation as here defined. Its thickness could not be determined with precision, for exposures are few and often unsatisfactory. The total thickness exposed from the base of the Eocene to the top of the Anacacho formation is not very much more than 100 feet; it might be 200, but this is scarcely probable. This probably does not represent the total original thickness of the formation, because we can not at present determine how much of the formation is covered by the overlapping of the subsequently deposited Eocene formations. The Pulliam formation is the representative in the Uvalde quadrangle of the Eagle Pass formation, exposed above and below Eagle Pass along the Rio Grande. This formation along the Rio Grande has an estimated thickness of 4000 feet or more. Below the lowest *Ostrea cortex* horizon on the Rio Grande there are about 1700 feet of strata (an artesian well having penetrated over 1500 feet); while below the *Ostrea cortex* horizon on the Nueces River there are at the outside limit not more than 200 feet of strata, showing a thinning of the Eagle Pass formation to the northeastward of 1500 feet in a distance of about 50 miles, measured in a straight line. The Pulliam formation outcrops between the Nueces River and the western margin of the quadrangle in southern Uvalde County, and for several miles along that river, north of Pulliam ranch. There are some exposures along the Frio River between Engelmann's ranch and the Eocene contact, to be discussed under the next formation. There are almost no other exposures, because the country in which it would outcrop is so completely covered by surficial deposits.

EOCENE.

Sandstones and clays, blue and black, turning yellow and brown.

Myrick formation.—This formation is named from its typical occurrence along the Frio River at Myrick's lower apiary. It extends along the river from a point 2 miles in a straight line below Engelmann's ranch to beyond where the river passes beyond the eastern margin of the quadrangle. Along this river it consists of soft yellowish or brownish sandstones and clays, which, when unoxidized, are bluish or blackish in color. The stratigraphic relations existing between the Eocene and Cretaceous deserve special consideration. The contact between the two series is seen at the locality 2 miles below Engelmann's ranch, and about a half mile (in a straight line) above Myrick's lower apiary. As much as the Texas Eocene and Cretaceous have been studied, only one actual contact had been previously found; this gives the contact on the Frio an especial interest and importance.

The following is the description of a section across the contact:

Section on Frio River along Eocene–Cretaceous contact.

	Ft.	In.
7. Rather soft, yellowish sandstone. An interesting lithologic feature of this sandstone is the occurrence in it of large oval sandy nodules, which stand with their long axes vertical. They are from 1 foot to 1 foot 6 inches in length, and vary between 3 and 7 inches in diameter. Sometimes these nodules, by breaking across, form sandstone disks. Some of the nodules are more nearly globular	22	6
6. Soft, yellow, sandy clay, with bluish streaks; some small pebbles in the lower part	2	6
5. Nodules of glauconitic sandstone. These contain a considerable number of small pebbles. In the lower few inches of this layer often a considerable number of *Ostrea cortex* Conrad are found. This layer is the principal horizon of a large new species of *Nautilus*		6
4. Soft, very argillaceous, yellow sands, quite glauconitic. There is a ledge of *Ostrea cortex* near the top of this layer; also a *Turritella*, probably *T. trilira* Conrad, was found in it. This stratum is the uppermost horizon of the Cretaceous	4	6
3. Harder sandy claystone, whitish blue or yellowish in color	1	4
2. Soft yellow, sandy clay	8	8
1. Sandstone, originally bluish, oxidizing brown and containing fucoidal impressions. The upper part of this stratum becomes softer, is more yellowish, and is in rather thin layers	11	9
Total	51	9

Beds 7–5 are Eocene, and 4–1 are Cretaceous.

Line between Cretaceous and Eocene.

A short distance downstream from this exposure, both opposite and above Myrick's lower apiary, the *Nautilus* found in stratum No. 5 is associated with such typically Eocene species as *Turritella mortoni* Conrad, *Cucullæa saffordi* (Gabb), etc. There is no doubt that stratum No. 5 is Eocene, and that stratum No. 4 is Cretaceous.

Conformity of dip at Cretaceous-Eocene contact.

No discordance of dip between the Cretaceous and Eocene and no unevenness of the upper surface of the uppermost bed of the Cretaceous could be discovered, so there is apparent conformity in the stratification of the two series. The presence of pebbles in the lowest Eocene is suggestive of erosion, but they may have been derived from an adjacent area and deposited here in shallow water, so their evidence is indefinite, while the evidence of the fossils is clear. The Cretaceous fauna is typical in stratum No. 4. The presence of *Ostrea cortex* in stratum No. 5 is due to the fact that the Eocene rests on a ledge of these oysters, and some of them are mixed with the Eocene deposits along the basal contact. The fauna above this contact is typically Eocene. Not a Cretaceous species passes above it, and not an Eocene species passes below it. Between the close of the deposition of stratum No. 4 and the beginning of the deposition of stratum No. 5 there was a sufficiently long break in the sequence of sedimentation to allow a complete faunal revolution to take place. It has been shown that in Arkansas, Mississippi, Alabama, and Georgia, the Eocene rests on the eroded surface of the Cretaceous. The basal Eocene fauna on the Frio River is the equivalent of the Alabama basal Eocene, i. e., the Midwayan fauna. Among the species in common are *Ostrea pulaskensis* Harris, *Ostrea crenulimarginata* Gabb, *Cucullæa saffordi* (Gabb), *Venericardia* *alticostata* (Conrad), *Turritella mortoni* Conrad, *Turritella humerosa* Conrad, etc. The sandstones and occasional clay beds of the Myrick formation form for the greater part the low bluffs, 50 to 60 feet high, of the Frio River until it passes beyond the eastern edge of the quadrangle.

The base of the Eocene was not established with precision on the Nueces River. The following gives the details of a section at Waxy Falls, just above Pulliam ranch:

Section at Waxy Falls, above Pulliam ranch.

	Ft.	In.
10. Flint gravel, lower rocks not exposed....	8	
9. Coarse-grained, laminated, and cross-bedded yellow sandstone..................	2	
8. Soft, yellow sandstone and clay..........	25	
7. *Ostrea cortex* embedded in clay and consolidated into a firm ledge............	2	
6. Laminated yellow sandy clays...........	3	6
5. Soft ledge, composed largely of fragments of oyster shells........................	1	
4. Soft, laminated yellow sandy clays.......	3	
3. Soft, fine-grained sandstone, frequently distinctly cross bedded and containing some asphaltum..........................	10	
2. Asphaltum-bearing sandstone—soft sandstone impregnated with asphaltum....	5	
1. Bluish clays to water's edge.............	2	
Total..............	61	6

10 is probably Pleistocene.
9–8 are referred to the Eocene (Myrick formation).
7–1 are Cretaceous (Pulliam formation).

Base of the Eocene.

The base of the Eocene is placed at the top of stratum No. 7. The general similarity of the section to the one made on the Frio is evident, but no marine fossils were found above stratum No. 7. About a mile farther down the river, in a higher horizon, a few feet above the coal seam exposed in the east bank of the river, some fossil leaves were collected. These were submitted to Professor Knowlton for determination, who expressed a somewhat doubtful opinion that they seem to be Eocene. The rocks above the *Ostrea cortex* zone are identical in lithologic character with those found between the Frio and Leona rivers and west of the Leona, between Uvalde and Batesville, which are of undoubted Eocene age. These rocks are frequently coarse-grained ferruginous sandstones, the grains often being quartz crystals. All of these facts taken together make it extremely probable that the base of the Eocene has been established with approximate accuracy on the Nueces River. As the boundary between the two series could not be located with certainty, it has been intentionally made an indefinite line west of the divide between the Nueces and Leona rivers.

Coal or lignite.

The Myrick formation along the Nueces River possesses practically the same lithologic characters that it exhibits along the Frio River, but it contains no marine fossils and includes several coal or lignite seams. It consists of soft, yellow or coarse-grained, brown ferruginous sandstones, as seen opposite Habey's ranch and in Sand Mountain at Turk's ranch on Turkey Creek. Sandstones similar to the latter have not been seen anywhere in the Cretaceous, but they attain great development in the Eocene from the Rio Grande northward. Along the Nueces, besides sandstones, there are carbonaceous clays containing a coal seam, exposed in the east bank of the river one half mile below Pulliam ranch; there is also a lignite bed exposed in the east bluff of the river above the ford at McDaniel ranch.

The estimated total thickness of the Myrick formation in the Uvalde quadrangle is somewhat over 800 feet. The upper limit of the formation has not been defined.

Area of the Myrick formation.

The area in the quadrangle occupied by this formation has already been outlined. Somewhat roughly speaking, it covers all that portion of the quadrangle south of a line drawn through a point where the Nueces River crosses the Uvalde-Zavalla county line, and one on the Frio 2 miles below Engelmann's ranch, about 5 miles north of the Uvalde-Zavalla county line, but throughout a large portion of its extent it is concealed by a blanket of surficial silt and gravel.

FRESH-WATER DEPOSITS.

NEOCENE.

Uvalde.

Uvalde formation.—This formation was first named by Mr. Robert T. Hill from its characteristic development in the vicinity of the town of Uvalde, whence the quadrangle whose geology is under discussion derives its name. It is of fluvial origin, and consisted originally of gravel embedded in silt. The silt has been removed by water in most instances, and the formation, as now seen, usually consists of great deposits of flint gravel. In some places, however, it is apparently left as remnants in its original condition, one such area being on the divide between the Nueces and Leona rivers and between the Uvalde-Carrizo Springs and Uvalde-Eagle Pass roads. The surface of the ground in this area is frequently a fine gray or black silt, below which or embedded in which are flint gravels. The gravels were brought down by the streams and subsequently the interstices between them were filled with finer sediments as the rush of the transporting waters became less violent. Another area of the Uvalde formation showing an upper surface of silt is in the vicinity of the Lewis windmill, on the divide between the Frio and Leona rivers. The surface features here are the same as those above described. Where the surface of the formation is silt, the country is always a level or gently rolling prairie, of very open character, with scattered mesquite bushes. When the silt has been washed away and only the gravel left, there is a dense and frequently matted growth of the acacious guajillo.

Flint gravel.

Gravel areas.

This is the upland gravel formation of the Rio Grande Plain. There is an extensive area of it between the Nueces and Leona rivers south of the road from Uvalde to the Tom Nunn ranch, on the Nueces River, just above Soldiers Camp Spring. There are patches of it on the hills between the Uvalde-Fort Clark wagon road and the Southern Pacific Railroad, and the long hill north of the railroad and south of Indian Creek is capped by it. There are also very extensive areas on the divide between the Leona and Frio rivers. The formation reaches almost as far north as the Southern Pacific Railroad, and extends southeastward beyond the southern and eastern limits of the quadrangle. Some of the hills between the Frio and Blanco rivers are capped by coarse gravel, which is mapped as the Uvalde formation. The ridge extending along the eastern side of the Blanco is capped by the coarse flint gravel. The masses of flint are sometimes a foot or more long, and weigh probably 50 pounds or more, showing the enormous transporting power of the waters.

Elevation of the strata.

The hypsography of the formation and its representation in the canyons now deserve consideration. Along the southern margin of the quadrangle the extreme elevation of the formation above the bed of the Nueces River is 265 to 270 feet, more than 200 feet above the silt terrace accompanying the stream. Along the Uvalde-Eagle Pass road the formation is about 200 and the silt terrace about 125 feet above the stream. At the mouth of Indian Creek the elevations are respectively about 125 and 75 feet. North of Indian Creek the Uvalde formation and the silt terrace of the river (Leona formation) become practically indistinguishable. This means that the levels of the Uvalde and Leona formation converge upstream, as the stream canyons are approached, and diverge downstream. These same relations obtain along the Leona, Frio, Blanco, and Sabinal rivers.

Beyond a certain line up the streams the Uvalde formation can not generally be distinguished from the Pleistocene river gravels and is included with them on the map. It can be recognized in places by a more consolidated old stream or valley filling, or is represented by a slightly higher terrace.

Uncertain boundaries of the Uvalde.

It is frequently difficult to draw exact boundaries for this formation, because as the gravel weathers it rolls down hill. The flint gravel may thus extend from the hill summits down to the level of the Leona formation. When there is only a little gravel on the surface it is frequently difficult to decide whether an area should be mapped as the Uvalde formation or whether the underlying formation should be indicated. Wherever possible an attempt has been made to bring out the distribution of the Uvalde material, and, if they could be determined, patches or areas of the underlying rocks are shown.

The maximum thickness of the formation could not be ascertained, as no authentic records of wells sunk in it were obtained and as estimates made by measuring from its lowest to its highest exposure on a hillside may be erroneous because of slipping and rolling of the débris. In its greatest development, where it had filled old valleys, it was probably originally more than 100 feet thick. Now it varies from a mere surface veneering to a sheet of undetermined thickness.

The Uvalde formation can probably be correlated with the Lafayette formation of the Atlantic coast and of the Gulf States east of the Mississippi River.

PLEISTOCENE.

Topography of Leona type locality.

Leona formation.—In order clearly to define this formation, its topographic relations in the type locality will be briefly indicated. As soon as the Nueces River passes southward out of its canyon the old flood plain, instead of being only a mile wide, as at the canyon mouth, spreads out over an expanse of country 5 or 6 miles in width. The northeastern margin of this flood-plain deposit skirts the edge of the southern front of the Edwards Plateau for some miles and then follows the foot of a southward-projecting divide until a point just north of Uvalde railroad station is reached. Here the flood plains of the Nueces and of the Leona meet. The old flood plains of the Nueces and the Leona rivers were in free communication across a strip of country about 4 or 5 miles wide. The southern boundary of these flood plains is an irregular line from a point on the Nueces about $4\frac{1}{2}$ miles south of the Southern Pacific Railroad to a point on the Leona about 3 miles south of Uvalde. The town of Uvalde is situated on the old flood plain of the Leona quite near the river, and the type locality of the formation is in the immediate vicinity. The Leona formation is the broad silt bed accompanying the larger streams of the quadrangle, forming the high terrace above the present flood plain of the streams. Along the streams it occupies a level about 30 feet or more above the stream bed, and reaches to a level of 70 or 100 feet above the streams along the outer margins of the valleys. Where it is typically developed, it occupies a level intermediate between that of the Uvalde formation and that of the present flood plains. The merging of the Uvalde and Leona formation levels as the canyons are approached has already been pointed out.

Gray silt and gravel.

The material of the Leona formation is fine, gray calcareous silt and gravel. The silt nearly always forms the surface. Topographically the area occupied by it is very level, forming open prairies, upon which the principal shrub is mesquite, sometimes thickly crowded together.

Area of the Leona.

The area of the Leona formation is probably larger than that of any other one formation on the quadrangle. It attains a great development along the Nueces River; it extends eastward from the Nueces, and in the vicinity of Uvalde merges into the deposits along the Leona River. Its development along the Leona is great, the deposits accompanying this stream grading into those of the Dry Frio on the north side of Black and Blue mountains. The whole area between the Frio and Blanco rivers is covered by it, excepting occasional hills of other formations standing above it or occasional exposures made by erosion into older formations. North of the Southern Pacific Railroad the deposits along the Little Blanco and the Sabinal rivers are joined.

Gravel terraces.

The formation extends up the canyons of the streams as a terrace deposited against the canyon walls. What apparently may be best described as two small lake beds, which are probably of this age, occur along the main Frio. One of these beds is the "Shut In." This was caused by the river having to cut a channel across some hard ledges at the lower end of the "Shut In." During the process of cutting, at least in time of flood, the waters above were temporarily dammed. The Florea ranch is situated on a similar lake bed. The damming of the waters was here caused by the river having to erode a channel at the southern end of the lake. During a part of the time of this cutting, a portion at least of the waters found an exit to the Dry Frio across the low divide north of Florea windmill. There is some very pure tufaceous limestone in the lake bed on Brushy Creek at the road crossing.

The Leona formation can probably be correlated with the Columbia of the Atlantic and Gulf States, in a way similar to the correlation of the Uvalde with the Lafayette.

Later terraces and present flood-plain deposits.—There are several smaller terraces below the Leona terrace, but they occupy an insignificant area and are not represented on the map by a distinctive color. They present the same characters, both lithologically and topographically, as the Leona formation. The streams at present are bringing down silt and gravel, but the flood plain is comparatively small.

Storm-swept beds of rock débris.

Wash.—By atmospheric action the various rocks are weathering into more or less finely divided material. In this arid region the principal factor in this action is variation in temperature, which ranges from as much as 110° in the shade in the middle of the day in summer to 70° or less during the night. The result of this great diurnal variation is a breaking up of the rocks, producing a constant accumulation of rock débris on the hill sides. A large part of the rainfall of this section of the country is of the peculiar cloud-burst type. The rain comes down in torrents for a short time and then ceases. The water gathers all of the loose material not too large to be transported and sweeps it down the hill slopes. The water very often after reaching the foot of the hills sinks into alluvial material previously deposited, adding more material of a kind similar to that already brought down, or the rush of the water is checked on reaching the lower and flatter ground, and it drops a large part of its burden. Material deposited by these means is called wash. It occurs at the foot of practically all hills in the quadrangle, and one of its effects is to cover and hide contacts of geologic formations and make them difficult to find.

The Leona formation, the later terraces, the present flood-plain deposits, and the wash are represented on the map by one color, and as the Uvalde and Leona formations near the canyon mouths on the Rio Grande plain and in the canyons of the streams can not be differentiated sufficiently even for purposes of mapping, these two formations in these areas are represented by the Leona color.

IGNEOUS ROCKS.

Petrographic Descriptions, by Whitman Cross.

The igneous rocks of the Uvalde quadrangle belong to two strongly contrasted groups, the one a series of very basic basalts of several varieties, the other a group of phonolites, rich in silica and the alkalies. The basalts are much more abundant than the phonolites, as is shown by the map, and several important varieties are distinguished by different patterns, while the phonolites belong to two types.

Plagioclase-basalt.—This is a dark, fine-grained, gray, massive rock in which the naked eye can distinguish only the numerous white specks of feldspar, many yellowish or dark glassy grains of olivine, and some prisms of augite. The microscope shows that the feldspar is chiefly labradorite, that the augite is of common basaltic habit, and that the olivine is very abundant and in many cases very fresh. Magnetite is present in usual amount, and there is a little dark-red biotite.

Plagioclase-basalt occurs in the low area between Sulphur Mountain and Nueces Hill. It also forms the mass of Green Mountain, 12 miles north of Uvalde. At the latter locality a coarse granular rock composed of augite, labradorite, and magnetite was found in certain small spots, the relations to the surrounding basalt not being exposed. These coarse masses resemble gabbro. They contain only very small amounts of olivine and biotite.

The rock of a knoll northeast of Big Mountain, which is grouped with plagioclase-basalt on the map, is rich in alkali feldspars and carries some nepheline and an obscure alteration product of some unknown constituent. It is poor in olivine. In chemical composition this rock is closely related to the Uvalde phonolite, but the development of its constituents gives it a decided basaltic habit.

Nepheline-basalt.—A large part of the basalts of the quadrangle contains no feldspar, its place being taken by nepheline in very typical development. These rocks all contain a comparatively small amount of nepheline, olivine and augite being the most important constituents. Ordinarily the nepheline is quite invisible to the unaided eye, the rocks being very dark and fine grained, of steel-gray or almost black color, sometimes wholly aphanitic, or with only a few recognizable grains of olivine or augite. In most cases there is a strong porphyritic structure, nearly all of the olivine and some of the augite being present in distinct crystals in a groundmass which is chiefly made up of augite, nepheline, and magnetite. The nepheline is sometimes quite well defined in short hexagonal prisms. All of the olivine occurs in large crystals in some rocks.

The nepheline-basalts vary greatly in texture. While the majority are very fine-grained and strongly porphyritic, others are almost granular, and are then usually so coarse-grained that one can almost make out the constituent grains with the naked eye.

There is a very marked variation in the amount of nepheline present in different places. While nepheline is here never so abundant as augite or olivine, it is still an important constituent in many cases, but the specimens collected show a transition to rocks almost free from nepheline or other alkali silicate. Some of these may properly be called *limburgite*, bearing a little nepheline, but all such rocks are included with nepheline-basalt in mapping.

In the mass of Nueces Hill the rock varies in this way from nepheline-basalt to forms nearly free from nepheline, and the transition from one to the other takes place gradually. No sharp lines can be found between the extremes.

Two of the most basic rocks, near limburgite, occur in small knobs west of the Nueces River and east of Wagon Wheel Hill.

Nepheline-melilite-basalt.—The rocks of this variety are indistinguishable from nepheline-basalt in outward appearance, but are characterized by the presence of melilite, a colorless silicate rich in lime and poor in alumina. In all other respects the minerals of the two basaltic varieties are identical, and the structures vary in both alike. The presence of melilite indicates an unusual amount of lime in the magma, and an analysis of one of the melilite-bearing basalts of this quadrangle showed the presence of 16 per cent of lime. The melilite is perfectly fresh in many specimens collected, but in others it exhibits characteristic modes of decomposition.

Like the nepheline-basalts those characterized by melilite grade into rocks closely approaching limburgite through the decrease in amount of nepheline. There is also a very variable amount of melilite present in different parts of the Allen Mountain mass, and perhaps in other places, some of the rock being pure nepheline-basalt.

Phonolite.—The rocks of this type differ widely from the basalts in composition, containing large amounts of alkali feldspar and nepheline, with the soda-bearing pyroxenes ægirite or ægirite-augite as the prevailing dark mineral. The rocks have usually a pronounced greenish color, due to the minute prisms or needles of ægirite, which are not visible to the naked eye. In only one case are these ægirite needles developed in bundles of branching fibers, producing a spotted appearance. This rock occurs at Rocky Hill, southwest of Uvalde.

The greater number of these phonolites are massive, dull green rocks in which but few crystals of any kind can be distinguished by the unaided eye. Some of them have crystals of glassy sanidine or nepheline scattered through them, and a few contain short prisms of a brown hornblende. In only one case is a porphyritic structure very prominent; namely, in a hill midway between Black and Big mountains.

In appearance some of these phonolites approach to the allied rock variety called tinguaite. In the field, the phonolites are characterized by a platy cleavage, and the formation of a light-colored outer zone on weathered faces.

Uvalde phonolite.—The rock occurring at Inge Mountain, near Uvalde, is unlike any other type of the region. It is a very dark porphyry, with predominant aphanitic groundmass containing a few distinct crystals of sanidine, nepheline, brown hornblende, augite, and olivine. The groundmass consists chiefly of sanidine, nepheline, and augite, with a little magnetite and apatite. Sanidine and nepheline make up about two-thirds of the rock and it is, therefore, more nearly related to phonolite than to basalt, though the presence of augite and olivine brings out a certain affinity with the latter group.

The rock of Mount Inge was described by A. Osann as "basanite," but there appears to be no lime-soda feldspar in the rocks collected by Mr. Vaughan.

Amygdaloid.

This class of material is found at many localities within the quadrangle. It is in each case only a contact facies of some one of the recognized types of rocks. The center of Chatfield Hill, on the Dry Frio River, just below the Southern Pacific Railroad, is composed of massive, columnar nepheline-basalt. As the contact with the Austin chalk is approached, the basalt becomes more rotten. Between the solid basalt and the chalk, into which it is intruded, is a wide zone of amygdaloidal material. The actual width of this zone is difficult to determine, because the exposure along the river cuts the contact diagonally, and surface exposures are not satisfactory. The nepheline-basalt along the Blanco River, near the Southern Pacific Railroad, has an extensively developed amygdaloidal contact facies. The nepheline-melilite-basalt at Black Waterhole, on the Frio River, also has an amygdaloid at the contact with the overlying chalk. The phonolite at Connor's ranch has an amygdaloid at the contact with the Austin chalk. Therefore, it is evident that the amygdaloids do not belong to any one class of rocks. The intrusions in most instances were probably not very deep seated. Therefore, when the basalts or phonolites came into contact with soft chalky limestones much gas was driven out of the soft limestones. This caused the amygdaloidal character of the intrusive rocks along the contacts. In the cases of harder limestones, an amygdaloidal contact facies was not observed.

It is not possible to refer an amygdaloidal outcrop to the class of rock to which it belongs, unless it can be associated with the rock of which it is a facies; therefore, some areas are represented simply as amygdaloidal basalts.

STRUCTURAL GEOLOGY.

Dip of the Edwards Plateau.

North of this quadrangle the Edwards Plateau is composed of very slightly tilted southward-dipping rocks. The amount of the dip is so very slight that a section many miles long must be made before any dip can be detected; it is about 4 or 5 feet to the mile. As the Balcones Escarpment is approached the dip increases very rapidly, so much so that in the Uvalde quadrangle, near the escarpment front, the dip is fully 100 feet to the mile, or even more. This increase in dip along the southern front of the Edwards Plateau is one of the most important structural features of the quadrangle.

Structural causes of the Balcones Escarpment.

Faults.—The Balcones Escarpment owes its existence to two primary structural causes: the first is the increase in dip along the front of the Edwards Plateau, which has been sufficiently described; the second is a zone of faulting which follows approximately the escarpment front. This is not a simple fault, but a complex system marking the southern termination of the plateau. The total result of the faulting is to bring the top of the Buda limestone below the top of the Edwards limestone, the downthrow usually aggregating approximately 200 feet. In some cases it may be slightly more, while in others it is less. The faulting along the escarpment front may be resolved into two systems. There is a series of faults parallel to the escarpment front, which determine the direction of the escarpment line. These faults strike north of east, or northeast. The second system consists of faults which cut the first at an angle, usually striking northwest. For limited areas the faults of each of the two systems show remarkably close parallelism of direction among themselves. The area around the head of Boon Slough is a good illustration. The result of this kind of faulting is to produce tongues of the Edwards limestone projecting into the higher formations and reentrant tongues of the higher formations projecting into the area of the Edwards limestone. By a combination of faults an area of the latter formation may occasionally be completely surrounded by higher formations. Because of the great extent of surficial deposits the details of this faulting could not be fully worked out.

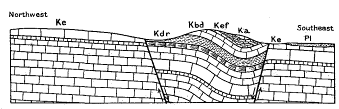


Fig. 1.—Structure section along line BB on map.
Horizontal scale: 1 inch = ½ mile. Vertical scale: 1 inch = 500 feet.

A downfallen block of limestone.

In one place north of Crane's ranch an area of Buda limestone has been dropped down into the main area of the Edwards limestone. At the silver mine near the northern margin of the quadrangle a very small patch of the Del Rio clay has sunk almost to the level of the Comanche Peak limestone, at least 450 feet below its original position. The explanation of the presence of this minute area at this level is difficult, but apparently it is due to faulting.

Basaltic intrusions.

The structure of the remaining portion of the area is so intimately connected with the intrusions of the basalts and phonolite that the geologic structure and geologic occurrence of the igneous rocks must be discussed together. It should be stated here that the igneous masses whose geologic relations could be determined are clearly intrusive. Excepting one large and three very small areas, all of the igneous rocks occur in the Rio Grande Plain. These exceptional areas occur in the Edwards Plateau. There is the large mass of plagioclase-basalt, containing some small masses of gabbro, forming Green Mountain, 3 miles west of Chilton's ranch. This mass is a stock pushed up into the Edwards limestone. A very small patch of basalt occurs about 1½ miles north of Green Mountain. Another small patch of basalt occurs at the Clark and O'Brien prospect, on Indian Creek, above Vanham's upper windmill. There are three small patches of basalt at Crane's ranch, near the point where the Little Blanco emerges from its canyon. All of this basalt is intruded in the Edwards limestone.

Areas of basalt and phonolite.

The area in the Rio Grande Plain in which the basalt and phonolite occur is limited on the north by the Balcones Escarpment and on the south by a line which is parallel to the escarpment. This line runs north of east from Wagon Wheel Hill to Engelmann's ranch, and thence northeast to a point between Yucca siding and the point where the Southern Pacific Railroad passes beyond the eastern margin of the quadrangle. The area included between the Balcones Escarpment and this line includes all of the basalt and phonolite found in the quadrangle excepting the areas mentioned above as occurring in the Edwards limestone. It also includes all of the faults excepting the two faults to which the small patch of Del Rio clay at the silver mine and the area of Buda limestone near Crane's ranch owe their presence and a fault across the Little Blanco River parallel to Cave Hollow. The strip of country included between these two lines is one of structural weakness. Its structure will now be described in such detail as is possible. It is in this area that the Leona formation reaches its most extensive development, so that the underlying rocks frequently can not be studied at all. For these reasons the data on the structural geology are fragmentary.

A notable anticlinal ridge.

One of the most striking structural features of this strip of country is a semicircular anticlinal ridge that extends from Blue Mountain, north of Elliot ranch, through Big Mountain and around to Frio Hill. The structure between Blue Mountain and Frio Hill is synclinal, a line drawn from Ange siding to Yucca siding, from southwest to northeast, following the pitch of the syncline. It should be noted that this line of pitch is parallel to the Balcones Escarpment. The structure of the semicircular anticline will now be described. Blue Mountain is a mass of nepheline-basalt intruded into the Eagle Ford formation and the Austin chalk. West of this hill is a large hill of Edwards limestone, nearly 200 feet high. The Eagle Ford formation is faulted down to its foot on the west, south, and east, and is flanked on the north by the Leona formation. West of this hill is Black Mountain. The summit of this hill is of nepheline-basalt, below which is the Austin chalk, the Eagle Ford formation, and the Buda limestone. Southwest of this hill is another high hill of Edwards limestone, with a mass of phonolite apparently intruded into its southwestern foot. The Eagle Ford formation is faulted down to its base on the northeast and east, and the Buda and Eagle Ford on the south. There is a small mass of phonolite in line between this hill and Big Mountain, intruded into the Buda limestone, and to the southeast of this phonolite outcrop is a mass of plagioclase-basalt resting upon or intruded into the Eagle Ford. At Ange siding a mass of phonolite is intruded into the Eagle Ford. Big Mountain is composed of Edwards limestone and the Buda and Eagle Ford are faulted down to its foot on the north and east. The Leona formation and the wash surround it on the other sides. There are several outcrops of Edwards limestone between Big Mountain and Inge Mountain in the Leona Flat. A little more than a mile north of east from Inge Mountain is another hill of Edwards limestone, with the Del Rio clay faulted to its base on the south. There is another hill of Edwards limestone one mile farther east. Frio Hill is composed of the same limestone, and the Eagle Ford is faulted down to its foot on the south and east. The occurrences bring out three facts: *First*, the structure of Big Mountain and Frio Hill is quaquaversal, i. e., they are domes; *second*, a line of basalt or phonolite intrusions follows the semicircular anticline, as may be seen along a line beginning at Schuddemagen's ranch and extending around to Connor's and Engelmann's ranches, though the intrusions are usually not exactly along the anticlinal axis but to one side or the other of it; *third*, no intrusive rock cuts the Edwards limestone or forms a hill above it; the intrusive rocks either cut the formations younger than the Edwards limestone, or, in one instance, cut the Edwards limestone at the foot of a hill and near a fault line. The following apparently is the explanation of these phenomena: The Edwards limestone was not so easily cut as the other limestones, so it was floated up along breakage lines, making, so far as can be determined, a series of quaquaversal hills, in this way allowing a portion at least of the igneous material to escape by being intruded into the less resistant geologic formations of more recent age. The formations around the foot of these Edwards limestone hills have been spoken of as having been faulted down. It would probably be more correct to speak of the Edwards limestone as having been faulted or floated up, because that limestone has been moved upward beyond the younger formations.

As one goes northeastward along the direction of the pitch of the anticline successively higher formations are encountered. The Austin chalk outcrops at several places along the Frio River. The Anacacho formation occurs on both sides of the Southern Pacific Railroad along Blanco River, and is well exposed along the Sabinal River farther northeastward, beyond the eastern margin of the quadrangle.

Strip between Leona and Nueces rivers.

So much of the portion of the strip between the Leona and Nueces rivers is covered by surficial deposits that only a few remarks, and these of the most general character, can be made on the structure. Evidently the tongue of Buda limestone projecting southward north of Uvalde railroad station is anticlinal in structure or it is a part of a westward-dipping monocline. It will be noticed that the Buda limestone occupies successively lower levels as the Nueces River is approached. The structural relations between this tongue of limestone and the semicircular anticline are completely obscured by surficial deposits. The appearance is that it is a part of the anticline; i. e., a part of the western limb. There is a small hill of Edwards limestone 1½ miles south of west from Uvalde court-house, and another, Rocky Hill, about 3 miles southwest of the court-house. A mass of phonolite is intruded into the southeastern foot of the latter hill. There is undoubtedly extensive faulting around these hills, as the close proximity of areas of Austin chalk shows, but as the hills themselves are completely surrounded by the Leona formation the structure can not be discovered.

Structure west of the Nueces.

The structure west of the Nueces River is more easily deciphered than that between the Nueces and the Leona. The western margin of the quadrangle is almost along the axis of a gently southward-pitching syncline. The axis of the syncline is a little farther west in the Brackett quadrangle, but is near its eastern margin. The distribution of the various formations south of the West Nueces and between the Nueces proper and the western margin of the quadrangle shows this clearly. The great basalt intrusions west of the Nueces are in the eastern limb of this syncline.

There are other faults in this strip along the northern edge of the Rio Grande Plain, but the surficial deposits occupy such large areas that they could not be traced.

Structure south of the faulted zone.

South of the faulted zone the structure, as a whole, is simple; the rocks have a gentle southeasterly dip. There is one exception to this uniform structure: the Nueces River from the crossing of the Eagle Pass–Uvalde road to Pulliam ranch flows along a syncline pitching gently southeastward. The rocks along the stream show small irregularities of dip, but the pitch of the syncline is equal to the fall of the river, as is attested by the almost continuous exposure along the river of the same bed between these two points. That the structure is synclinal is shown by the occurrence of the same bed along the stream, in the slopes of the valley on both sides, and at elevations considerably above the river. The asphalt-bearing sandstone above Pulliam ranch occurs in the trough of this syncline.

The relations between this syncline and the syncline along the western margin of the quadrangle, already described, could not be determined for lack of exposures. The dip of the Eocene rocks below Pulliam ranch is about 100 feet to the mile downstream. The dip along the Frio, below the Eocene-Cretaceous contact, seems to be about the same amount, also downstream.

Additional data on the mode of occurrence of the igneous rocks.—The structural relations of the igneous rocks have already been pointed out, and as the distribution of the kinds has already been given, not a great deal more needs to be said. In a considerable number of instances the contacts between the igneous and sedimentary rocks are obscured by talus or surficial deposits, making it impossible to determine the relations between the two classes. It has already been stated that all of the igneous rocks whose mode of occurrence could be determined are intrusive.

The largest connected igneous mass is that west of the Nueces and south of the Southern Pacific Railroad. Allen Hill is a mass of nepheline- and nepheline-melilite-basalt intruded into the Austin chalk and the Anacacho limestone. Sulphur Mountain is a peak of nepheline-melilite-basalt

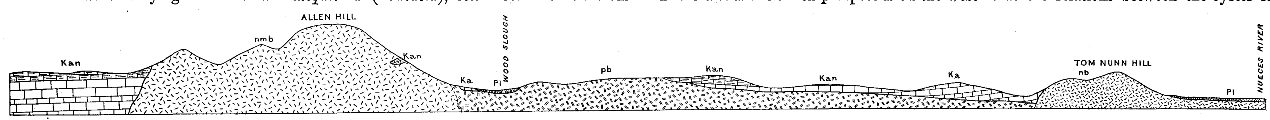


Fig. 2.—Structure section along line CC on map.
Horizontal scale: 1 inch = ½ mile. Vertical scale: 1 inch = 500 feet.

surrounded by silt and wash, but a few patches of rock in the flat around it show that it is intruded into the Anacacho limestone. Nueces Hill is composed of nepheline-basalt and limburgite. It is intruded into the Austin chalk. Tom Nunn Hill is composed of melilite-basalt which cuts the Austin chalk. These four hills represent the four corners of a large basalt area having a greatest length of about 5 miles and a width varying from one half a mile to 3 miles. The low area within is composed of plagioclase-basalt. This plagioclase-basalt has not formed high hills, but has floated the Austin chalk and Anacacho limestone upward on its upper surface, and is now exposed where the limestones have been eroded away. Long tongues of the limestone now project over the basalt, the limestone occupying the divides, while the basalt is exposed along the hillsides and in the draws.

A large mass of igneous rocks.

Weymiller Butte, Lewis, Obi, and other hills are apparently capped by remnants of basalt sheets intruded laterally beneath strata which have been removed by erosion. Several large fragments of Anacacho limestone were found above the basalt on the hill one half mile southeast of Weymiller Butte. The youngest rocks cut by the basalt are seen about 1½ miles east of Wagon Wheel Hill. They belong to the basal layers of the Pulliam formation.

No detail of especial interest can be given on the area between the Nueces and Leona rivers. There are many small areas of basalt, and there are two areas of phonolite. They are either surrounded by surficial deposits, or are of intrusive origin. There is a large patch of basalt on the top of the hill on the east side of the Nueces, opposite Tom Nunn ranch. The hill 3 miles north of Uvalde station is formed by phonolite that apparently is intruded through the Buda limestone.

Igneous rocks between the Nueces and the Leona.

The occurrence of igneous rocks along the anticlinal ridge between the Leona and Frio rivers has been sufficiently described. Inge Mountain, Taylor Hills, and the hill just north of the west end of Taylor Hills are surrounded by surficial deposits, and the mode of occurrence could not be determined. The phonolite at Connor's ranch on the Frio cuts Austin chalk, and the basalts at Black Waterhole and Chatfield Hill cut the same formation.

Between the Frio and the eastern margin of the quadrangle are numerous hills of basalt, but as these hills are surrounded by surficial deposits the contacts with the older rocks are obscured. Along the Blanco are large exposures of amygdaloidal material, which is only a contact facies of nepheline-basalt, overlain by the Anacacho limestone.

Basalt hills.

Summarizing the modes of occurrence of the igneous rocks, the following generalizations may be made: (1) No surface flows at all are known. (2) The intrusions may be divided into the following classes: (*a*) bosses, stocks, or necks, such as Green and Sulphur mountains and Nueces and Allen hills; (*b*) laccoliths, such as the large area of plagioclase-basalt west of the Nueces River and south of the Southern Pacific Railroad and the smaller laccoliths at the Black Waterhole and at Chatfield Hill on the Frio; (*c*) laterally intruded sheets, now usually forming the cappings of hills, such as Obi Hill and the hill one half mile south of Weymiller Butte; (*d*) dikes, probably, an instance being the phonolite at Connor's and Engelmann's ranches. The youngest rocks cut by the igneous masses are those of the Pulliam formation, i. e., uppermost Cretaceous. It seems most probable that the igneous activity took place in Eocene times.

Modes of occurrence of the igneous rocks.

ECONOMIC GEOLOGY.

The economic geologic products of the quadrangle consist of building stones, road material, flints (from the Edwards limestone, used in glass making), gold, silver, coal, iron, petroleum, and asphaltum. The most important problem of the economic geology is the water supply.

Building stone and ornamental limestone.—The Edwards limestone contains numerous ledges suitable for building purposes. Near the base of the limestone are ledges filled with the calcitized remains of fossils, belonging chiefly to the aberrant genera *Chamidæ*, *Monopleura* (*Schizopleura*), *Requienia* (*Toucasia*), etc. Stone taken from ledges containing these fossils, when polished, makes a beautiful ornamental limestone (or "marble") suitable for table tops, mantelpieces, etc. Good lime may be made by burning the limestone. Some of the Austin chalk may be utilized for building purposes, but the chalk is likely to crumble under great weight, and when exposed to the weather stains yellow because of its content of iron.

Road metal.—The Uvalde formation contains great beds of flint gravel that can be used either as ballast for railroads or for building highways. The Leona formation also contains gravel beds, and the Edwards limestone contains much material of value in road construction. It is of variable character and not all sufficiently hard.

Gold and silver.—There is a considerable number of veins (locally called "leads") of siderite and yellow limonite in the plateau portion of the Edwards limestone. These veins occur along certain lines and frequently can be traced for some distance. A number of prospects have been sunk along them. The prospects examined are one at Blocker's silver mine, two belonging to Judge Florea, one belonging to L. C. Davenport, one opened by James Kelley, and one opened by Clark and O'Brien. The positions are indicated on the map.

The Blocker prospect is located on the fault by which the Del Rio clay, in the northern part of the quadrangle between the two forks of the Frio, has been dropped down nearly to the base of the Edwards limestone. The prospect is in a vein along the fault plane, and has associated with it some brecciated country rock. The strike of the vein is N. 62° E. The vein is filled mostly with yellow limonite, some siderite, kaolin stained purplish, and some bluish or purplish clay and limestone. A series of assay samples was taken by digging into the material being prospected for ore, and letting the chips or scraping fall into a bag. The assays showed that the yellow limonitic material contains no gold and .075 ounce of silver per ton, and that the bluish clay contains no gold and .100 ounce of silver per ton. An assay of some purplish-gray altered and decomposed limestone gave .025 ounce of gold and .075 ounce of silver per ton.

L. C. Davenport's prospect, on the high hills on the south side of Rock Creek 3 miles above its mouth, was examined. The vein material is mostly siderite. The vein is about 2 feet 2½ inches wide, bounded by walls of Edwards limestone. It strikes N. 12° E. An assay sample was collected by making seven complete cross sections of the vein from 40 to 45 feet below the surface. The assay showed .020 ounce of gold per ton and .125 ounce of silver per ton. Some nepheline-basalt was found along the strike of this lead.

The Florea prospect 2 miles west of south of Judge Florea's house is in limonite mixed with some hematite. The material occurs in the Edwards limestone, but the relations to the limestone could not be determined for lack of good exposures. An assay sample collected by scraping the walls gave .050 ounce of gold per ton and .125 ounce of silver per ton.

Florea's prospect one mile northwest of Florea windmill is in yellow limonitic or iron carbonate material, also in the Edwards limestone. An assay sample from this locality yielded .025 ounce of gold per ton, and .100 ounce of silver.

A specimen of siderite, partly changed to brown limonite, was collected at the Kelly prospect, on Indian Creek. A few pieces of this picked up showed no gold or silver. This prospect is on a vein striking N. 68° W., and dipping S. 22° W. at an angle of 79°. The material is of the same kind as that seen in the other prospects, i. e., it is yellow limonite, siderite, and some purplish material.

The Clark and O'Brien prospect is on the west side of Indian Creek, in the line of strike of Kelley's vein. Here some nepheline-basalt was collected. It occurs in the middle of the vein.

The conclusions regarding these veins or leads are: (1) They occur along usually definite lines of jointing or faulting; (2) the fissures have been filled from solutions containing carbonate of iron (siderite, which has subsequently been changed to limonite or hematite) and calcite, the limestone in places having been partly changed to carbonate of iron, probably by replacement; (3) occasionally basalt dikes are associated with the veins; (4) only very slight mineralization has taken place, practically the whole of the filling of the fissures being the common material of the limestone, which has been concentrated in these cracks or crevices. Although precious metals occur in the veins, they are in small amounts.

Iron.—All of the data collected on iron have been given in discussing the gold and silver. There probably is not enough quantity at any one place to be of commercial value.

Coal.—Coal occurs on the Nueces River one-half mile below Pulliam ranch and in the bluff opposite McDaniel ranch on the east side of the river above the road crossings. The first-mentioned seam was not fully exposed when the locality was visited; it is reputed to be 4 feet thick. The following is a section of the second seam:

Section at coal seam on Nueces River opposite McDaniel ranch.

		Ft.	in.
11.	Flaggy clay and sandstone	25 to 30	
10.	Chocolate-colored clay	6	
9.	Coal	1 to 2	
8.	Chocolate-colored clay	3	
7.	Coal	1	10
6.	Chocolate-colored clay	6 to 7	
5.	Coarse sand		11
4.	Chocolate-colored clay and sand	3	4
3.	Coal		8
2.	"Bone"		3
1.	Chocolate-colored clay	6	

(Unexposed to water's edge about 20 feet.)

The total thickness of coal is between 2½ and 3½ feet, divided into three benches which are separated by beds of sand or clay several feet thick. No chemical analysis of the coal was made, as means for obtaining fresh samples were not available.

Asphalt.—Deposits of asphalt occur at two places within the quadrangle. The first locality is on the east side of the Blanco River, about one half mile below the Southern Pacific Railroad bridge. The asphalt has here impregnated some porous layer of the Anacacho limestone. The asphalt-bearing limestone, I am informed, occurs beneath decomposed or amygdaloidal basalt, above which is more limestone. The rock seems very rich in asphalt, but has been very little prospected, and no observations of value can be made by studying the surface.

The second area is along the Nueces River. The asphalt here occurs as an impregnation in a soft sandstone. Asphalt was found in a well 9 miles west of south of the Southern Pacific Railroad bridge over the Nueces River and about 3 miles west of the crossing of the Eagle Pass–Uvalde road over the same stream, along a trail going to Nunn and Smyth's ranch. About a half mile below the crossing of the Eagle Pass–Uvalde road other outcrops of the asphalt-bearing sandstone were seen. There are outcrops of the asphalt from place to place along the river to Pulliam ranch, about 5 miles farther down stream. A few hundred yards above this ranch are the Waxy or Asphalt Falls. This is the best exposure examined. A detailed section of the locality has been given in discussing the Pulliam formation. The dip of the rocks here is about 8 feet to the hundred to the northwest, upstream, producing several small falls. The upper fall is over the ledge of *Ostrea cortex;* the lower one over the asphalt-bearing sandstone. It should be noted that the relations between the oyster ledge and the asphalt-impregnated sandstone were found to be constant throughout an area several miles long. The latter occurs between 15 and 18 feet below the oyster ledge. No attempt was made to estimate the area of the asphalt rock, as surficial deposits are extensively developed and the horizon of the asphalt is overlain by higher strata. The area is rather large and the stratum is over 5 feet thick.

About 100 yards below Pulliam ranch is another exposure of the same bituminous sandstone. The section is as follows:

Section 100 yards below Pulliam ranch.

		Feet.
3.	Massive sandstone containing asphalt	5
2.	Shaly stratum	5
1.	Indurated argillaceous sandstone	4

The area underlain by the asphalt-bearing sandstone extends from a point on the Nueces River 9 miles below the Southern Pacific Railroad bridge for more than 3 miles down the river, measured in a straight line. The width can not be ascertained from observations on the surface, as the Leona formation covers the older formations. The geologic horizon of this asphalt deposit is higher than that of the deposit along the Blanco River near Sabinal. The sandstone in which it occurs is near the top of the Pulliam formation, and not far below what is here considered the base of the Eocene (Myrick formation). The geologic structure of this portion of the Nueces Valley has already been described; it is a shallow syncline. The asphalt occurs along the bottom of the syncline.

This bituminous sandstone has not been mined. It can not be stated at present how much of it is workable, because so large a portion is covered by the old fluvial deposits and good exposures are not frequent. The materials at Waxy Falls can be easily mined, as there is no overburden.

Mr. Geo. H. Clapp, of Pittsburg, Pennsylvania, has examined this locality, and has made determinations of the amount of asphalt in the rock, and has kindly allowed the publication of the same, viz:

Amount of asphalt in rock at Asphalt Falls.

	Per cent.
1. Outcrop:	
Asphalt	13.24
2. Two feet below surface:	
Asphalt	15.03
Sand	74.03
Oxides of iron and alumina	7.76
Organic matter, water, and undetermined	3.18
3. Four feet from the surface:	
Asphalt	12.36

Transportation facilities are good, as the main line of the Southern Pacific Railroad is only 12 miles distant. The intervening country is very level and is easily traversed.

Outcrops of bituminous limestone have been reported as occurring near the Nueces. These lie north of the area of the bituminous sandstone within the area of the Anacacho formation.

Petroleum.—This substance has been found, but not in economic quantities, in several wells sunk in the Anacacho formation near the eastern margin of the quadrangle. The wells in the vicinity of Sabinal often contain petroleum.

WATER SUPPLY.

STREAMS.

The mean annual rainfall is 25.33 inches at old Fort Inge, 2 miles south of Uvalde, and 24.02

inches at Fort Clark (Brackett). There is usually a short rainy season in the spring or early summer and another in the fall. All of the streams are intermittent. They flow during the rainy seasons, and for short periods immediately succeeding the rains, but during the greater portion of the year water occurs only in parts of the streamways. The extensive surficial deposits have already been described, and it has also been stated that portions of the stream courses are filled to some extent with gravels. There is not such an extensive development of the surficial deposits and not so much alluvium in the stream beds in the canyons as in those on the Rio Grande Plain. Much of the water that falls in the plateau country sinks into the porous, often cavernous Edwards limestone, and a large proportion of that which falls on the lower plain sinks down into the surficial formation.

In their canyons the streams, after the floods have gone down, are fed by springs that burst forth from the Edwards limestone in the canyon walls, and as the streams flow for considerable distances over rocky floors the water has no opportunity to sink. For these reasons many streams flow in the canyons, but when the plain is reached the stream beds are usually gravel clogged and the water disappears from view. Excepting in periods of extreme drought the gravels in the stream beds and the surficial deposits along the stream courses contain large quantities of water. Therefore, usually, when a stream in the plain cuts into bed rock, there will be flowing water until the next bed of gravel is reached. The water for these flowing portions of the stream is derived from two sources; one is the water reappearing again from beneath the gravel, the other is water coming from springs, issuing from the contact of the surficial deposits with the lower bed-rock formations. There are numerous instances of such flowing portions of streams in the Uvalde quadrangle. The flowing portions and the waterholes of the streams at the time of the topographic survey of the quadrangle are indicated on the topographic map. During periods of greater drought some of these waterholes may become dry.

SPRINGS.

Within the quadrangle there are but few permanent springs. There are very few or none from the Edwards limestone, except along both the Nueces and the Frio rivers in the northern portion, and these are sufficient to cause the streams to flow in that part of the quadrangle.

Not a spring issuing from a fissure along a fault plane is known within the quadrangle. Such springs occur elsewhere along fault lines, e. g., the San Felipe Springs at Del Rio, Las Moras Springs at Brackett, San Pedro Springs at San Antonio, Comal Springs at New Braunfels, and numerous springs around Austin. There are springs, however, that issue from beneath the surficial Leona formation at its contact with the underlying formations, and from one of these the Leona River derives its water below Uvalde. The discharge of these springs, according to a measurement by Mr. Cyrus C. Babb, in December, 1895, is 11 second-feet, or 7,000,000 gallons a day. Their flow varies with the length of the season of dry weather, and the above measurement may be above the average, but they give forth enough water to keep the Leona below them a running stream and to supply a considerable number of irrigating ditches. Another large spring of this type is the Soldiers Camp Spring, on the west side of the Nueces River, about a mile below the crossing of the Uvalde–Tom Nunn ranch road. The water flows from beneath the gravel at its contact with the Austin chalk. The spring is strong enough to cause the river to flow for some distance below it. There may be many more springs of this class, but these two are the most important ones.

WELLS (NONFLOWING).

WELLS IN THE SURFICIAL DEPOSITS.

Good shallow wells are found in these deposits wherever they attain a considerable thickness. The manner in which the rain water falls on the surface of these formations and sinks down into gravels has already been described. By digging through the silt and gravel and excavating a small reservoir in the underlying rock floor, the water of the gravels may be accumulated in the bottom of the well. Wells of this class are very numerous in the area occupied by the Leona formation, especially near the stream courses. This type of well is found at J. Francis Smith's (Molesworth) ranch, on the Nueces; at the ranch on the Uvalde–Fort Clark road, on the west side of the Nueces; at Moore ranch, on the Frio; and at Connor's and Engelmann's ranches, on the Frio. The most important of these wells is the one whence the town of Uvalde derives its water supply. It furnishes 40,000 gallons of water a day. The depth of the wells in the Leona formation is usually from 40 to 60 feet. Only one failure is known to me, among a very large number of records, but the supply of water varies with the drought, and some may go dry.

WELLS IN DECOMPOSED OR AMYGDALOIDAL BASALT.

Records of several wells that were dug into this kind of material were obtained. One of these wells at Myrick's upper apiary, just above Connor's ranch, yielded sulphurous, bad-smelling water. Another at John Gibbins house, near Engelmann's ranch, furnishes good water. A well dug by Engelmann about 1½ miles west of his house was sunk 40 feet through silt or sand and 20 feet into amygdaloidal basalt. The water is good. There are still other instances. All of these wells are really sunk into the Leona formation and obtain water in the basaltic material. The latter is quite often so rotten and porous that water can percolate through it. When the material becomes more consolidated it serves as a reservoir in which the water may collect, but the Leona formation really furnishes the supply. The water obtained in such rotten igneous rock may be very bad, but usually it is good.

A record of one well sunk into solid basalt was obtained; this well was dug by W. A. Crane at his house, between the Blanco and Little Blanco rivers. It was dug 4 feet in Edwards limestone, which had been turned to lime or marmorized by the basalt below, and 16 feet into basalt, the upper 12 feet of which had some lime mixed with it. This well was a failure.

WELLS SUNK IN THE MARINE FORMATIONS.

Glen Rose formation.—A well at Davenport's ranch, on the Little Blanco, 2 miles north of the northern margin of the quadrangle, is dug in the bed of the stream, and penetrates 4 feet into the Glen Rose formation. It yields a large supply of good water. Records of two other wells sunk into these strata were obtained; one was a success and one was a failure. The upper part of the Glen Rose beds sometimes yields good supplies of water, but the supply is not certain.

Edwards limestone.—As no water horizon is known in the Comanche Peak limestone, the next formation to be considered is the Edwards limestone. This limestone contains bountiful supplies of water. Records or notes of more than twenty wells sunk into this limestone within the quadrangle were obtained. Of this number only two failures are known, and one of these was a well so shallow that it could not be expected to be a success; this reduces the number of actual failures to one. The usual depth of wells that are started in the Edwards limestone along the front of the plateau, in or near the canyons, is about 200 feet; there are slight variations above and below this depth. The apparent horizon in which most of these wells start is about or slightly above the middle of the formation. This would show that the water supply comes from the porous ledges near the base of the formation. A considerable number of wells have been bored in the Rio Grande Plain immediately south of the fault line. These wells are invariably 300 feet or more in depth. They start in the Buda limestone or Del Rio clays, and penetrate 200 feet or more into the Edwards limestone. A point of value to those who intend drilling wells can be made here. If possible, the wells should be drilled in a draw or canyon within the area of the Edwards limestone, north of any fault lines. The well records show that water can be obtained north of the faults at least 100 feet nearer the surface, and there is no danger of the wells caving. The faulting has brought the middle of the limestone on the downthrow side of the fault opposite the lower ledges on the upthrow side, and apparently the water is transmitted from the porous beds on the upthrow side to porous beds on the downthrow side, directly across the fault plane. The water may sink down some along the fault fissures, or dip on the downthrow side of the fault may account for the greater depth to water on that side of the fault lines. Wells sunk into this formation frequently penetrate caverns.

Georgetown, Del Rio, and Buda formations.—No water horizons are known in these formations.

Austin chalk.—A few wells which probably obtain their supplies of water from this formation are known, but in general it is not one of the main water-bearing formations.

Anacacho formation.—A considerable number of wells sunk into this formation have been successful and they sometimes furnish good water, but the water is frequently contaminated by petroleum, as in the vicinity of Sabinal.

Pulliam formation.—Only one well in the quadrangle is known with a fair degree of certainty to obtain its water in this formation; this is the well at Hurd windmill, Piper ranch, west of the Nueces River. This well starts near the base of the Eocene and is 200 feet or more deep. It furnishes a bountiful supply of good water.

Myrick (Eocene) formation.—A large number of wells have been sunk in this formation, and are, so far as records go, always successful. The water is usually good. The basal sands in the southwestern corner of the quadrangle (e. g., Turk's ranch well) furnish very saline water having a bad taste, but which can be used. The water east of the divide between the Leona and Frio rivers is good. The depth of the wells is variable, but there is in the formation so much sandstone capable of absorbing water that any well bored a few miles south of its northern boundary will probably be successful.

GENERAL CONCLUSIONS ON NONFLOWING WELLS.

The Leona formation furnishes large supplies of water, but the wells may become dry in long periods of drought. The water is nearly always good, but may sometimes be bad when the bottom of the well is in decomposed igneous material.

The supply from the upper Glen Rose beds is not certain. The Edwards limestone contains large supplies of good water. The wells that derive their water supply from this formation should be located on the upthrow sides of the faults.

The Comanche Peak limestone, the Georgetown limestone, the Del Rio clays, the Buda limestone, and the Eagle Ford formation contain no water horizons, so far as known.

Successful wells are bored in the Austin chalk and in the Anacacho and the Pulliam formations, but not much is known about them. The water of the Anacacho may be contaminated with petroleum.

The Myrick formation furnishes good water, and wells sunk into it are, so far as known, always successful.

ARTESIAN WELL POSSIBILITIES.

No artesian wells have been obtained within the quadrangle. Harvey Donaho has two shallow artesian wells in the canyon of the Seco, 14 miles north of Sabinal. These wells are northeast of the Uvalde quadrangle. They must derive their water from the Glen Rose formation. It would be expected that similar wells could be obtained in the Uvalde quadrangle along its northern margin. No well has been sunk deep enough to discover whether the Travis Peak sands, which carry the artesian water at Kerrville, extend this far south. The geologic section above the Glen Rose is the same in the Uvalde quadrangle as in the vicinity of Kerrville, and one would suppose that the lower portions of the two sections would also be the same, but this can not be determined until a boring is made within the Uvalde quadrangle. The Glen Rose is probably 500 feet or more thick; therefore, any boring attempted should go at least from 600 to 700 feet below the base of the Edwards limestone, and probably might have to go somewhat deeper to give the subject a fair test. The only area in the northern portion of the quadrangle in which artesian water may possibly be obtained is north of the fault lines in the lower portions of the Edwards Plateau front and in the canyons. The water must come from the Glen Rose formation or from the stratigraphically lower Travis Peak sands. A positive prediction can not be made. There is one fact unfavorable to artesian possibilities: wherever artesian water has been obtained in other areas along the plateau front or along the northern margin of the Rio Grande Plain there are fault or fissure springs. These are natural artesian wells. The head of the water is sufficient to drive a portion of it to the surface along the fault planes, up the fault fissures. No such springs are known within the Uvalde quadrangle. If such springs exist, the water passes into the gravel of the Leona formation below the surface.

The conditions in the faulted portion of the Rio Grande Plain, where there has been so much igneous activity, are not favorable to procuring artesian water. The continuity of the rocks is broken both by faults and by igneous masses.

In general, the head of the water in the Myrick formation is not sufficient to drive it to the surface, though the water usually rises considerably in the wells. Flowing wells might be obtained in the stream valleys along the southern margin of the quadrangle, especially in the valley of the Frio, but no positive prediction can be made.

AGRICULTURE AND CATTLE RAISING.

The area embraced in this quadrangle is not an agricultural country. The semiarid climate makes any extensive agricultural enterprises impossible without irrigation. Over a large portion of the area the soil is very thin, frequently not even coating the surface of the rocks. This is true in practically all of the areas occupied by the Edwards limestone, the Buda limestone, and the Anacacho formation, in the basalt hills, and in most of the areas of the Austin chalk and Uvalde formation. The Del Rio clay and Eagle Ford formation produce argillaceous soils; the Pulliam and Myrick formations furnish poor sandy soils; the basalt, where occupying topographically low areas, often has deep rich soils. Practically all of the soils of any importance from an agricultural standpoint are confined to the stream valleys, and consist either of the silts of the Leona formation, or those of the later alluvial deposits. Along some of the streams corn, and some grain for feeding stock are raised without irrigation, but as the region is liable to long periods of drought the harvest is uncertain.

Irrigation is practiced only along the Leona River south of Uvalde, below the springs of the Leona. The soil of the river terrace is fertile and splendid crops are raised.

The following are physical analyses of some soils, made in the laboratory of Prof. Milton Whitney, Chief of the Division of Soils in the Department of Agriculture.

Analyses of soils.

No.	Locality.	Description.	Moisture in air-dry sample.	Organic matter.	Gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Fine silt.	Clay.
					2–1 mm.	1–.5 mm.	.5–.25 mm.	.25–.1 mm.	.1–.05 mm.	.05–.01 mm.	.01–.005 mm.	.005–.0001 mm.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
2700	Uvalde County	Wide silt terrace above present alluvial flat of the Nueces.	1.73	5.11	0.16	1.23	4.66	19.19	30.03	17.88	4.92	15 85
2697	Uvalde, 10 miles from.....	Wide silt terrace of Nueces River..........................	1.47	5.47	0.39	1.23	5.32	22.40	30.83	14.08	3.22	14.80
2699	Uvalde, 9 miles west of....	Basalt	8.04	9.17	0.99	1.26	3.24	8.14	20.72	11.74	6.18	31.95

The silt along the Nueces is frequently underlain by gravel, and this may have a bad effect should irrigation be attempted, because the water would tend to drain directly through the soil and a large part of it be lost.

The basalt soil is from the low area of plagioclase-basalt, southwest of Nueces Hill. It supports a fine growth of grass.

Although this is not an agricultural area, because of drought and frequent thinness or absence of soil, it is a fine pastoral country, and practically the whole is given to stock raising. It has been shown that there is enough water for such industries, and that there is sufficient soil for a fine growth of grass and such shrubs as the acacious guajillo. The liliaceous sotol (*Dasylirion*) grows luxuriantly in many valleys along the southern edge of the plateau, and the prickly pear (*Opuntia rafinesquei*), nopal of the Mexican, covers large areas in the Rio Grande Plain, and these furnish food for cattle in time of drought. The thorns of the cactus are burnt off before it is used in feeding. A considerable number of cattle may sometimes die from thirst or starvation in prolonged periods of drought, but the loss from such causes is usually more than offset by the returns of sales from the ranches. Though there are sometimes hard years, this section of country may, as a whole, be looked upon as one very favorable for pastoral industries.

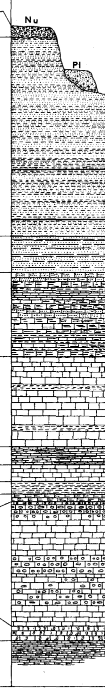
As a considerable number of plants, such as *Lippia*, the acacious cat's-claw, etc., when in bloom furnish much nectar, apiculture has attained a very considerable development.

T. WAYLAND VAUGHAN,
Geologist.

June, 1900.

COLUMNAR SECTION

GENERALIZED SECTION OF SEDIMENTARY ROCKS OF UVALDE QUADRANGLE.
SCALE: 400 FEET = 1 INCH.

Period.		Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soils.
PLEISTOCENE		Leona formation.	Pl		0-70	Silt and gravel.	Forms wide, flat terrace along stream courses, 30 to 75 feet above the bed. Soil is silt, usually with gravel foundation.
NEOCENE		Uvalde formation.	Nu		0-80	Mostly flint gravel, with some silt in places.	Caps hills and divides in the Rio Grande Plain. Soil in places is silt, but usually is mostly flint gravel.
EOCENE		Myrick formation.	Em		800-850	Coarse- and fine-grained sandstones, and clay; contains two coal seams in the lower portion along the Nueces River. Characteristic fossils: Ostrea crenulimarginata Gabb, Ostrea pulaskensis Harris, Cucullæa saffordi (Gabb), Venericardia alticostata Conrad, Turritella mortoni Conrad.	Hills and divides with gently sloping sides and low bluffs along larger streams. Soils usually sandy.
CRETACEOUS	GULF SERIES	Pulliam formation.	Kpl		100-200	Coarse- and fine-grained, yellowish and brown sandstones and clay; asphaltum horizon near top. Bed of Ostrea cortex Conrad at top. Sphenodiscus pleurisepta (Conrad) also occurs near the top.	Rounded forms. Soil usually sandy, sometimes argillaceous.
		Anacacho formation.	Kan		300-400	Yellow, usually argillaceous but sometimes arenaceous limestones, with beds of yellow marl or clay. The limestones are more developed in the western portion of the quadrangle and the clay in the eastern portion. Fossils: Radiolites sp., Sphærulites sp., Exogyra læviuscula Roemer, Exogyra ponderosa Roemer, Gryphæa vesicularis Lam., Baculites sp.	The hard beds cap low hills and divides with bluffs parallel to stream courses. Soil argillaceous and calcareous, brownish in color.
		Austin chalk.	Ka		350-400	White and yellowish chalk, with some marly beds. Fossils: Gryphæa aucella Roemer, Inoceramus cf. digitatus Sowerby, Mortoniceras texanum (Roemer), Pyrina parryi Hall.	Topographic forms usually with gentle slopes, making bluffs along the streams. Black, calcareous soil.
		Eagle Ford formation.	Kef		75+	Argillaceous and calcareous flags.	Rounded forms. Soil brownish; argillaceous and calcareous.
	COMANCHE SERIES	Buda limestone.	Kbd		60-75	Limestone, with splintery fracture; contains red and pink blotches.	Caps hills. Soil fine and silt-like.
		Del Rio clay.	Kdr		50-60	Yellow clay. Principal fossil is the "ram's horn oyster," Exogyra arietina Roemer.	In slopes of hills and divides. Soil brownish and very argillaceous.
		Georgetown limestone.	Kg		30+	Impure argillaceous limestone. Principal fossil: Kingena wacoensis Roemer.	No effect on topography.
		Edwards limestone.	Ke		520+	Limestone beds, usually hard, but sometimes chalky or porous. Zones of flints at the top and from the middle to within about 80 feet of the base. Contains caves. Fossils: Monopleura (Schizopleura), Requienia (Toucasia), and Nerinæa are the characteristic genera.	Forms precipitous canyon walls and very rugged hills, with numerous benches and steps. Soil, except in draws, always thin and consists mostly of the argillaceous residue of the disintegrated limestone.
		Comanche Peak limestone.	Kcp		60	Yellow, somewhat argillaceous limestone; weathering produces a nodular appearance. Principal fossil is Exogyra texana Roemer.	Occurs only in the lower portion of the canyons.
		Glen Rose formation.	Kgr		60-70+	Laminated, yellowish, argillaceous limestone and marl. Fossils: Cardium mediale Conrad, Pholadomya knowltoni Hill, Trigonia sp., Tylostoma pedernalis Roemer.	Occurs only at the base of canyon walls.

T. WAYLAND VAUGHAN,
Geologist.

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

TOPOGRAPHIC SHEET

TEXAS
UVALDE QUADRANGLE

LEGEND

RELIEF
(printed in brown)

1286

Figures
(showing heights above mean sea level instrumentally determined)

Contours
(showing height above sea, horizontal form, and steepness of slope of the surface)

DRAINAGE
(printed in blue)

Streams

Intermittent streams

Ditches

Lakes and ponds

Waterholes

CULTURE
(printed in black)

Roads and buildings

Private and secondary roads

Railroads

County boundary lines

Triangulation stations

B.M.
×
Bench marks

E.M. Douglas, Topographer in charge.
Triangulation by H.L.Baldwin Jr.
Topography by T.M.Bannon.
Surveyed in 1896.

Scale 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 Feb. 1900.

U.S. GEOLOGICAL SURVEY
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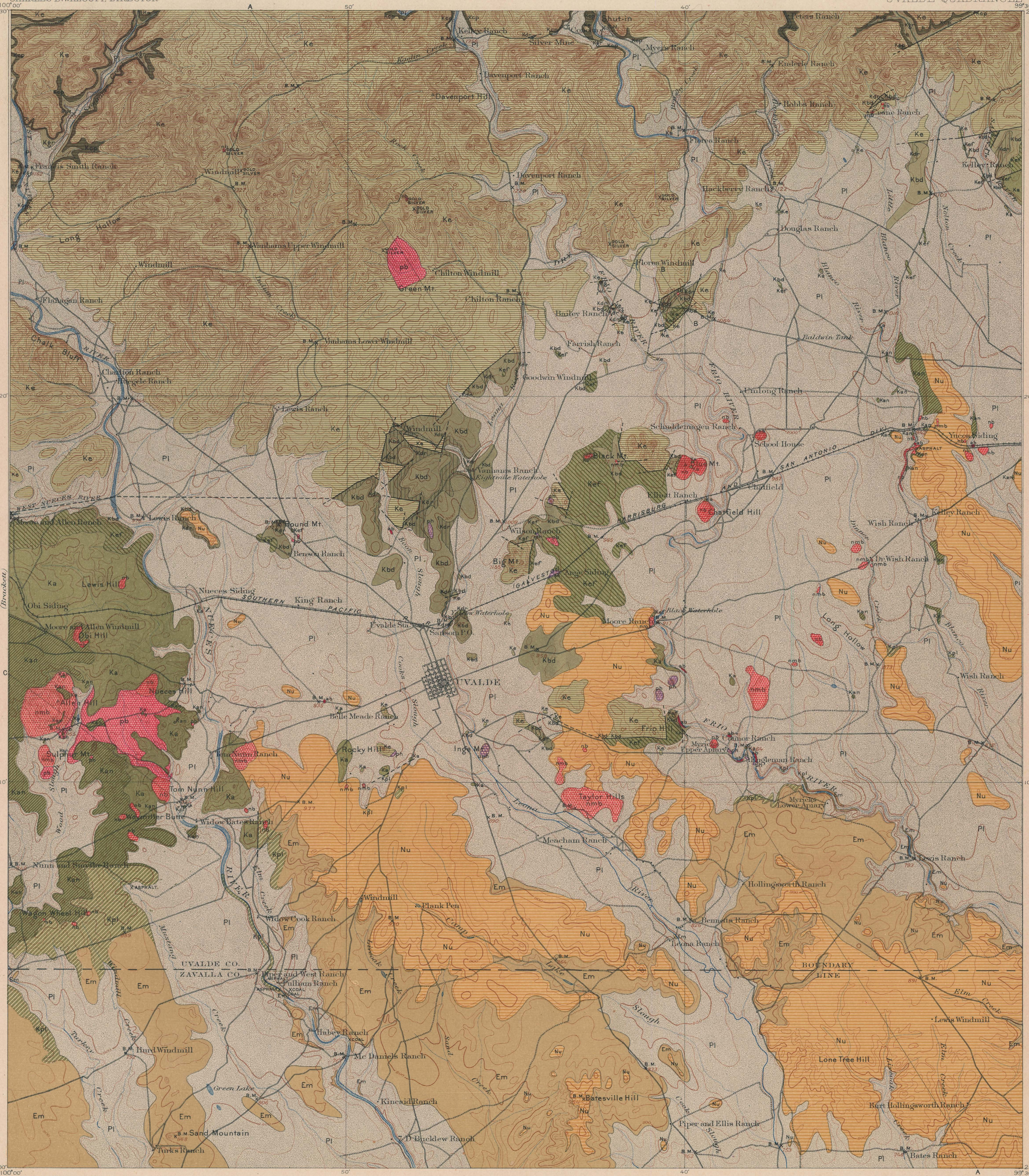
HISTORICAL GEOLOGY SHEET

TEXAS
UVALDE QUADRANGLE



E.M. Douglas, Topographer in charge.
Triangulation by H.L. Baldwin Jr.
Topography by T.M. Bannon.
Surveyed in 1896.

Scale 1/125000

Contour interval 25 feet.
Datum is mean sea level.
Edition of April 1900.

Geology by T. Wayland Vaughan.
Surveyed in 1896 and 1898.

LEGEND

SURFICIAL ROCKS

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

PLEISTOCENE

- Pl — Leona formation *(terraced silt and gravel including later alluvium and wash)*

SEDIMENTARY ROCKS

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

NEOCENE ?

- Nu — Uvalde formation *(flint gravel with some silt; included in Leona formation in the upper portion of flood plains)*

EOCENE

- Em — Myrick formation *(sandstone and some clay, contains several seams of poor coal)*

CRETACEOUS

Gulf series

- Kpl — Pulliam formation *(sandstone and clay)*
- Kan — Anacacho formation *(brown or yellow limestone and clay)*
- Ka — Austin chalk *(chalky limestone with some argillaceous layers)*
- Kef — Eagle Ford formation *(calcareous argillaceous flags and some laminated clay)*

Comanche series

- Kbd — Buda limestone *(limestone with splintery fracture and red blotches)*
- Kdr — Del Rio clay *(yellow clay)*
- Kg — Georgetown limestone *(argillaceous limestone)*
- Ke — Edwards limestone *(white or yellowish hard limestone with flints)*
- Kcp — Comanche Peak limestone *(yellowish limestone weathering to nodules)*
- Kgr — Glen Rose formation *(laminated or flaggy argillaceous limestone or marl)*

IGNEOUS ROCKS

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

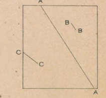
EOCENE ?

- pb — Plagioclase-basalt *(includes one rock near Big Mt. which contains alkali feldspar)*
- nb — Nepheline-basalt
- nmb — Nepheline-melilite-basalt
- ab — Decomposed amygdaloidal basalt *(variety undetermined)*
- ph — Phonolite
- uph — Uvalde phonolite

Observed faults

Hypothetical faults

Sections



× *Prospects*

U.S. GEOLOGICAL SURVEY
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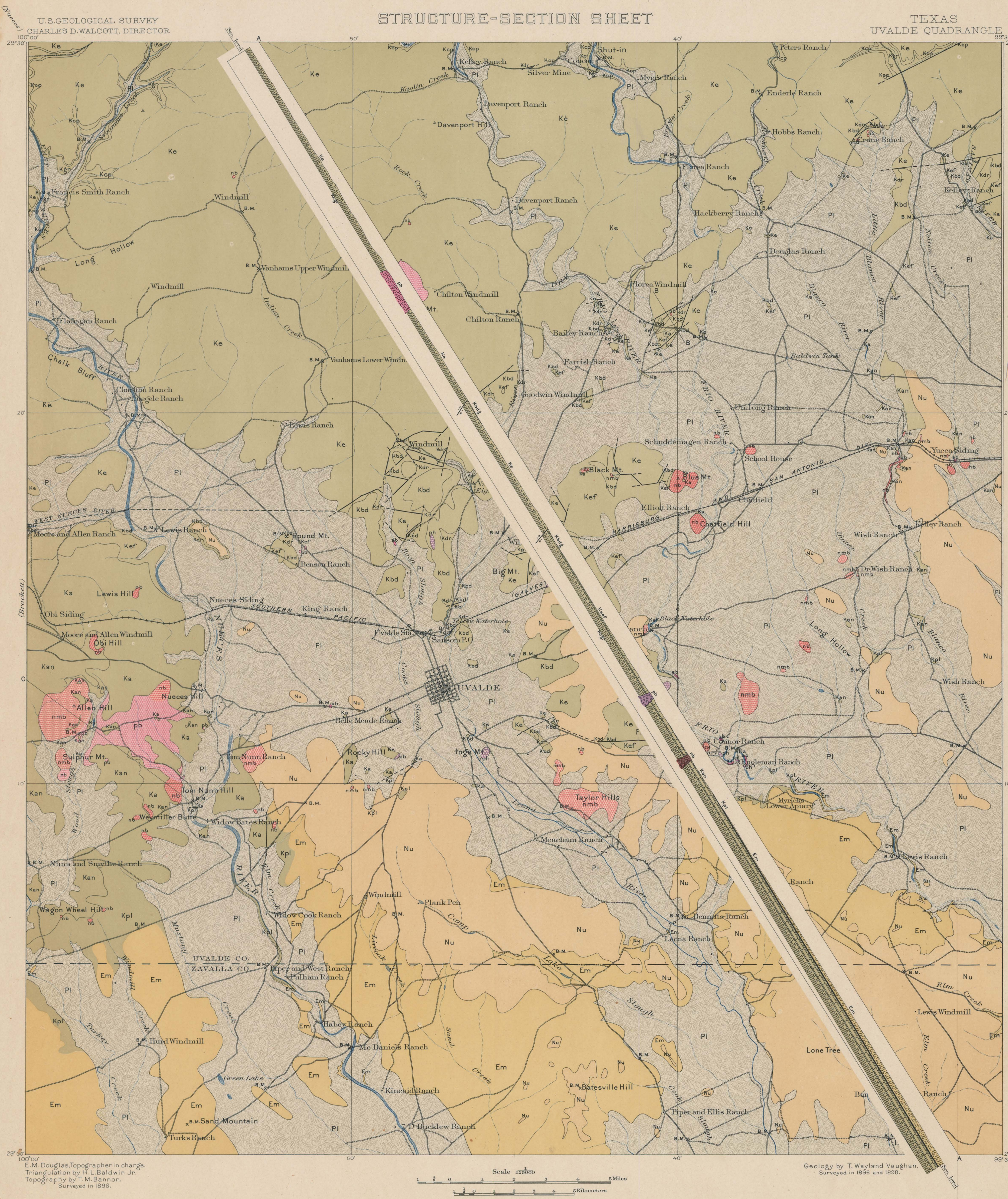
STRUCTURE-SECTION SHEET

TEXAS
UVALDE QUADRANGLE



LEGEND

SURFICIAL ROCKS

SHEET SYMBOL

Pl — Leona formation (terraced silt and gravel including later alluvium and wash) — PLEISTOCENE

SEDIMENTARY ROCKS

SHEET SYMBOL / SECTION SYMBOL

Nu — Uvalde formation (flint gravel with some silt; included in Leona formation in the upper portion of flood plains) — NEOCENE ?

Em / Em — Myrick formation (sandstone and some clay, contains several seams of poor coal) — EOCENE

Gulf series:

Kpl / Kpl — Pulliam formation (sandstone and clay)

Kan / Kan — Anacacho formation (brown or yellow limestone and clay)

Ka / Kaef — Austin chalk (chalky limestone with some argillaceous layers)

Kef — Combined with Austin chalk on section — Eagle Ford formation (calcareous argillaceous flags and some laminated clay)

Comanche series:

Kbd / Kbdg — Buda limestone (limestone with splintery fracture and red blotches)

Kdr — Combined with Buda limestone on section — Del Rio clay (yellow clay)

Kg — Combined with Austin chalk on section — Georgetown limestone (argillaceous limestone)

Ke / Ke — Edwards limestone (white or yellowish hard limestone with flints)

Kcp / Kcgr — Comanche Peak limestone (yellowish limestone weathering to nodules)

Kgr — Combined with Comanche Peak limestone on section — Glen Rose formation (laminated or flaggy argillaceous limestone or marl)

CRETACEOUS

IGNEOUS ROCKS

SHEET SYMBOL / SECTION SYMBOL

pb / pb — Plagioclase-basalt (includes one rock near Big Mt. which contains alkali feldspar)

nb / nb — Nepheline-basalt

nmb — Nepheline-melilite-basalt

ab — Decomposed amygdaloidal basalt (variety undetermined)

ph / ph — Phonolite

uph — Uvalde phonolite

EOCENE ?

Observed faults

Hypothetical faults

Sections along B-B and C-C are illustrated in the text on an enlarged scale.

E. M. Douglas, Topographer in charge.
Triangulation by H. L. Baldwin Jr.
Topography by T. M. Bannon.
Surveyed in 1896.

Scale 1/125000

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Edition of May 1900.

Geology by T. Wayland Vaughan.
Surveyed in 1896 and 1898.

Information Concerning

Topographic and Geologic Maps and Folios

and Other Publications of the Geological Survey

can be had on application to

The Director, U. S. Geological Survey,

Washington, D. C.