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194

GEOLOGIC ATLAS
OF THE
UNITED STATES

VAN HORN FOLIO
TEXAS

BY
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1914.
This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the interval between the less rugged county contour intervals is 10, 25, 50, and 100 feet are used.

Drawings.—Watercourses are indicated by blue lines. For a personed stream, the lower stream is represented by a line, and the number of mouths are represented by appropriate conventional signs in blue.

Cities.—The symbols for the works of man and all lettering are planimetrically shown.

Scale.—The area of the United States (exclusive of Alaska and island possessions) is about 2,527,000 square miles. A map of this area, when printed on the scale given to the text, would cover 2,527,000 square inches of paper and measure about 240 by 180 feet. Each square mile of ground surface would be represented by a single inch square, and a linear mile on the ground by a linear inch on the map. 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 inch =" is expressed as 1/63,360.

Three scales are used on the atlas sheets of the Geological Survey; they are 1:1,000,000, and 1:25,000,000, corresponding approximately in 4 and 14 miles, respectively, to an inch on the map. On the scale of 1:1,000,000, a square inch of map surface represents about 1 square mile of earth surface; on the scale of 1:25,000,000, each square inch on the map represents about 1 square mile of earth surface. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing values mentioned above and by numbers indicating distances in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map of the United States is being published in sheets and quadrangles, which represent areas bounded by parallels and meridians. These areas are called quadrangles. Each sheet on the scale of 1:1,000,000 represents an area of 1,000 square miles; each sheet on the scale of 1:25,000,000 represents an area of 125 square miles, and each sheet on the scale of 1:245,000,000 represents an area of 2,500 square miles. The scale represents areas on the map at a scale of about 3 inches to 1 mile. These maps are published.

The GEOLOGIC MAPS.

The maps representing the geology, by colors and conventional signs printed on the topographic base map, the distribution of rocks, their age, and the nature and extent of the structural sections, their underground relations, as far as known and in each detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds, and on the geological map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as igneous. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages or to the surface of the earth. Rocks formed by the consolidation of molten material, or magma, within those channels—that is, below the surface—are called intrusive. Where the intrusive rock solidifies in an essentially horizontal, parallel plane, it is called a slaty; where it fills a large and irregular conduit the mass is termed a ash. Where molten magma travels stratified rocks may be formed along bedding planes; such masses are called sills or strata if comparatively thin, and lava-beds if they occupy large volumes produced by the pressure of the magma on the normal crust. Some of the rocks are produced by the gradual cooling of a very hot molten rock, and lava often builds up volcanic mountains. Igneous rocks that have solidified at the surface are called extrusions or lava. Extrusive rocks are divided on the basis of their chemical composition and in a rock unit, especially in their superficial parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows are more vesicular, pieces of solidified glass, and larger fragments, termed lazurite, are common. These materials, when consolidated, constitute brecciae, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone erosion, which results in the deposition of volcanic ejected deposits in lakes and seas, or of materials deposited in such water bodies by chemical precipitation are termed sedimentary.

For purposes of geological mapping, rocks of all the kinds above described are divided into formations. A sedimentary formation consists of a series of rock units, rocks or strata, that are distinctively characterized by their lithology, or the manner in which they are arranged in nature. The lithology of a formation is described by the samples collected, and the rock unit is designated as the same name. This is given in the description of each rock unit. The rock unit is designated as the name of the formation, and the rock unit is described in detail. The rock unit is designated as the name of the formation, and the rock unit is described in detail. The rock unit is designated as the name of the formation, and the rock unit is described in detail. The rock unit is designated as the name of the formation, and the rock unit is described in detail.
INTRODUCTION.

The Van Horn quadrangle is situated in El Paso and Culberson counties, Tex., about 160 miles southeast of El Paso. It is bounded by parallels 31° and 31° 30' and meridians 104° 30' and 105° and includes 1019 square miles. This area lies within the Cordilleran region, about midway between Pecos River and the Rio Grande, and forms a part of what is known as trans-Pecos Texas. (See index map, fig. 1.)

TRAN-SPECOS TEXAS.

Characteristic features.—Trans-Pecos Texas, which lies west of Pecos River, is distinctly different from the eastern part of the State in topography, climate, and geology. The surface of the greater part of Texas consists of plains, but trans-Pecos Texas is mountainous, the boundary between the two parts being marked by the northern course of the Pecos.

The part of the Cordillera that is included in trans-Pecos Texas is the southern continuation of the central mountainous area of New Mexico, and is characterized by an assemblage of diverse topographic forms which individually resemble features of the Rocky Mountain province on the north, the Basin Range province on the west, and the Mexican Plateau province in the southeast. Topographically the trans-Pecos region forms a transition between these provinces.

Relief.—The trans-Pecos region lies in a belt of comparatively low country that extends across the interior of the continent. Pains, the highest point on the Cordillera range on the Sonora Route of the Southern Pacific system, has an elevation of 7902 feet, and the summit of the Texas & Pacific Railway, which is in the Van Horn quadrangle, has an altitude of 6000 feet. Only two peaks the higher than 8000 feet above sea level and the lowlands commonly range in height from 3500 to 4000 feet.

Meteorological records that have been kept for more than 30 years at El Paso indicate the general features of the climate of trans-Pecos Texas. The mean annual precipitation is only 9.8 inches, most of which occurs in heavy local showers and more than half of which falls during July, August, and September. The mean annual temperature is 65.4° F., the mean monthly maximum ranging from 75° in January to 96° in June. The average daily range of temperature for the year in a thermometer shelter is about 26° and the exposed rock surfaces is probably more than twice that amount. The mean annual relative humidity is 38.8 per cent and the annual evaporation is about 82 inches. The annual average wind velocity is 10 miles an hour, the maximum figure on record being 78 miles an hour. Velocities of 50 to 60 miles an hour for short periods are not uncommon.

Geology.—The volcanic rocks of trans-Pecos Texas include representatives of almost all the systems from the Algolikian to the Quaternary and are interbedded or overlain, in part, by a variety of igneous rocks, as stated under the heading “Descriptive geology” (p. 3).

NORTHERN TRANS-PECOS TEXAS.

Across the northern part of trans-Pecos Texas, in the midst of which the Van Horn quadrangle is situated, run three belts of highland separated by parallel belts of lowland, all having a northwest-southeast trend. (See fig. 2.) Named in order from west to east they are the Franklin Mountains, the Hueco Bolson, the Diablo Plateau, Salt Flat, the Guadalupe-Debawars-Apachita Mountains, and Terah Basin (Pecos Valley), An outline geologic map of this strip of country is shown in figure 3.

Franklin Mountains.—The Franklin Mountains are the southern extremity of a broken chain about 30 miles wide and 250 miles long, lying east of the Rio Grande valley and extending from the terminal of the main mass of the Rocky Mountains in northern New Mexico southwest to El Paso. The main part of the Franklin Range lies entirely in Texas and in 15 miles long and about 3 miles wide, but low outlying hills extend from the range northward a few miles beyond the State boundary. The mountains rise more than 3000 feet above the Rio Grande valley on the west and the Hueco Bolson on the east, culminating in a peak 7152 feet above sea level. The western face of the range is comparatively little eroded and in the main constitutes a dip slope; the eastern face, on the contrary, is much dissected and exposes cross sections of the strata.

The Franklin Mountains are composed chiefly of pro-Cambrian and Paleozoic rocks that strike in general parallel to the trend of the range and dip westward at steep angles. The pro-Cambrian rocks consist of quartzite overlain by phyllite and siltstone, the Paleozoic strata consist of Cambro sandstone overlain by limstone containing Ordovician, Silurian, and upper Carboniferous (Pennsylvanian) fossils. Devonian time, so far as known, is not represented by sediments, although some relatively thin bedded limstone that overlies the massive Silurian beds may be of Devonian age. The Mississippian and Pennsylvanian rocks are the Granite of post-Paleozoic age outcrops along the eastern base of the mountains. Faults border the eastern and western margins of the range and other faults cut it internally. The range is a northwest-dipping fault block in a mature stage of erosion.

Hueco Bolson.—One of the largest of the intermittent plains of the trans-Pecos region is the Hueco Bolson, which, with its northward and southward continuations, is more than 200 miles long, about half of it lying on each side of the Texas-New Mexican boundary. Its width is irregular, averaging possibly 25 miles. Its greater part lies about 4000 feet above sea level and is bordered by mountains that rise 2000 to 5000 feet higher. On the west are the San Andres, Organ, and Franklin ranges and others in Mexico; on the east are the Sierra Blanca, Sacramento, Hueco, Findlay, and Quitman mountains. As a whole the bolson is a unit, but it is divided into two distinct parts by a low transverse deltaic-veined divide a few miles north of the State boundary. The northern part, known as the Tularosa Desert, is a closed basin with no drainage outlet, a large part of its surface being occupied by salt flats and dunes of white gypsum sand. The southern part contains practically no salt or gypsum and is crossed by the Rio Grande, which has cut its valley more than 200 feet beneath the general level. Structurally the bolson is a trough occupied by more than 3000 feet of unconsolidated deposits, the upper part of which is proved by fossil bones to be of Pleistocene age, though the lower part may be Tertiary.

Diablo Plateau.—Northwest of the Hueco Bolson is the Diablo Plateau, a flattish-topped upland having an area of
about 2500 square miles. A general view of the plateaus
expanse from the east is shown in Plate II. The surface
includes few broad, flat areas and in general slopes gently east-
ward in the western part and northward in the eastern part, yet
as a whole its plateau character is distinct.

The eroded escarpments of the Diablo Plateau are known by
different names. One of these, the Sierra Diablo, at the
southwest border of the plateau, bounds on an irregular quadi-
lateral area—on the south by an east-west escarpment 15 mile
long, on the west by a north-south escarpment 20 miles long,
and on the northeast by a northwest-southeast escarpment 15
miles long. The Sierra Diablo is highest along its eastern
escarpment, culminating in a series of ridges from 3000 to 3600
feet above sea level. From the crest the general surface slopes
gradually toward the center of the plateau. North of the Sierra
Diablo, near the San Jacinto Mountains, the south border of the
plateau is marked by the Carrizales Mountains and the Sierra
Juega Pinta, two groups of isolated peaks of igneous rock and
lava-capped mesas flanked by broad canyons. The western
border of the plateau, north of the Texas & Pacific Railway,
is known as the Fimlay Mountains, and further north, near the
Fort Stockton boundary, as the Sand Dunes Mountains, the
two areas being separated by an escarpment about 500 feet
high and 20 miles long. Southeast of the Diablo Plateau is an
area of relatively low hills and ridges known as the Carrizo
Mountains.

The plateau is formed of horizontal or gently inclined strata
of Carboniferous age, exposed in places by Coyote Buttes and
underlain locally by older Paleozoic strata that outcrop in
places on the lower slopes of the escarpments. The crests of
the escarpments are at most places formed by strata of
Carboniferous age. The bases of the Fimlay Mountains are
defomed into a rude dome and are extensively intruded by
dikes, suggesting that the dome-like bulges of the several
mountain ranges are formed chiefly of rocks of pre-Cambrian
ear Paleozoic age. The beds have been deformed, the pre-
Cambrian strata have been metamorphosed, and the whole
complex is overlain unconformably by Cretaceous (?), Oligo-
cene, and Cenozoic strata. The plateau is bordered on both
sides by faults separating it from the lowlands, and it is also
bordered by a number of crest faults.

Salt Flat.—Another large basin of the Texas-Pueblo country
is known as Salt Flat. It is more than 100 miles long, in
average width is about 60 miles, and it has a maximum area
of about 2250 square miles, or slightly more than the
 Diablo Plateau. This portion of the basin lies between the Texas &
Pacific Railway and the Rio Grande, which is a major watercourse
flowing northwest-southeast trend. It occupies a structural tuff and
is a closed basin with no drainage outlet. The lowest point on
its floor is less than 3000 feet above sea level, and the low-
point on the divide bounding its drainage area is about
4250 feet above sea level. With adequate rainfall the basin
would fill up to that level forming an enormous lake, and
would overflow into the Rio Grande, which is 18 miles south of
the Van Horn quadrangle, at the mouth of Van Horn Creek,
has an elevation of only 200 feet.

The tributary drainage area of Salt Flat, consisting of more
than 5000 square miles, is bounded by the Sacramento
Mountains on the north, by the Fimlay and Sand Dunes
Mountains on the west, by the Chihuahua Mountains on
the south, and by the Sierra Verde, the Van Horn and Eagle
Mountains, and the Diablo Mountains on the east. South of part of
the basin lies the Texas & Pacific Railway and
extends into New South. Much of the railroad is divided
into a central part from north to south and which at the
middle and southern end is formed by the spring created by
the Carrizo Mountains and Decorah Springs. The eastern side
of the quadrangle is occupied by the Delaware Mountains and
the western end of the Apache Mountains. The Sierra
Diablo in the north and by the Carrizo Mountains and
Beech Mountain in the south. Near the center of the
quadrangle the Baylor Mountains project northward across
Salt Flat.

The altitude of the lowland ranges from 2575 feet above
sea level in Salt Lake, about 20 miles south of the quadrangle,
to 4250 feet in places along the base of the mountain escarp.
The mountains rise 1000 to 3000 feet higher, the highest being the
Sierra Diablo, much of which is more than 6000 feet above sea
level. A peak 34 miles southwest of Figure Two ranch head-
quarters is the highest in the quadrangle, attaining an altitude
of 9250 feet.

The greater part of the lowland surface is nearly level or
gradually sloping, but the mountainous areas are much dissected
and are often covered with steep slopes and precipi-
tious escarpments. In the Carrizo and Apache mountains the
relief is not so pronounced and the topography is more subdued,
the continuity of the mountains being broken by rather broadly
open and nearly bottomed valleys.

The surface forms of the quadrangle are intimately related
to the character of the uplands to which it is connected. The
most prominent features are of structural origin but have been
modified by erosion and alluvial deposition. The highlands are
areas of relative uplift above the surrounding rocks, remnants of
larger masses that have been removed by erosion. Salt Flat,
on the other hand, is a depressed trough, the floor of which is
an aggraded surface composed of unconsolidated deposits
derived from the dissection of the rocks of the highlands and
depleted under arid conditions. The lowlands are there-
fore being built up by the wearing down of the highlands, and the
ultimate result, if erosion is not offset by further uplift,
will be the reduction of the area to a plain. Several relative
upsilts of the highlands and depressions of the intervening low-
lands have no apparent source since the initial post-Cenozoic
dissection. Some of the resulting escarpments are relatively
little eroded; others are more eroded and are evidently older
deposits. The severe nature of the area is a direct consequence of the prevailingly arid climate.

Salt Flat.—The lowland crossing the middle of the quad-
rangle extends north to south as part of the Salt Flat basin.
In the northern part of the area it is about 15 miles wide
between the Sierra Diablo on the west and the Delaware
Mountains on the east. In the southern part of the quadrangle
its width is reduced to about 5 miles by the Baylor Mountains, which
project into it from the southeast. A valley 2 to 3 miles wide, in
the center of which is sparsely settled, is formed by the
Sierra Diablo, a part of the lowland, as is a similar poorly defined
canyon extending southwestward for a few miles between the
Delaware and Apache mountains. A long narrow valley
the lowland is much wider, its width at the south side of the quad-
rangle, between the Carrizo Mountains on the west and the
Apache Mountains on the east, reaching 20 miles.

The central portion of the basin is in general a nearly level
surface underlain by fine-grained wash from the mountains
in part sorted and redeposited by the wind. The surface of the
sand is locally diversified, but the wash varies in width and
declivity and are composed of heterogeneous but generally
coarse-grained wash deposits. West of Salt Lake, at a point
more than 6 miles wide and in that distance descending 500 feet. On
the opposite side of the basin, at the base of the Delaware
Mountains, the wash is about 50 feet wide and descends only
80 feet to the salt. At the months of the larger canyons there are conspicuous alluvial fans, which coalesce with the
wash along the base of the highlands. A view of Salt Flat,
showing the town of Van Horn, is given in Plate V.

Sierra Diablo.—The northeastern part of the quadrangle is
occupied by the Sierra Diablo, the steep eastern escarpment
of which, bordered by a fault, extends southwestward into the
quadrangle for 20 miles. The escarpment rises abruptly from
the marginal basin slopes, the crest in many places being less
than 2 miles back from the base of the mountains and stand-
ning about 3000 feet above Salt Flat. The prominent upper
promontories extend from the crest to more than 500 feet,
being nearly vertical in places, and is formed of massive
beds of almost flat-lying limestones.

The northern part of the escarpment is highest and most
rugged, being carved entirely in limestones. About Apache Peak the escarpment is deeply gashed by several small canyons
and by the larger washes that issue from them and extend
southwestward into the Diablo Plateau. About Victor Peak the escarpment is also much dissected and is deeply cut by Victor Canyon. South of Victor Peak the formation extends for about 10 miles across the crest of the Sierra Diablo and is more regular and is not so deeply notched by the short canyons that dissect the slope. (See Pt. II.) In that part of the mountain the escarp is lower, and the slope, being formed of homogeneous sandstone, is not so steep. Near the high point northwest of the Hall-Coxon ranch, the scarps turn abruptly westward and northwestward, and the washes extend around the
Bend's ranch. This portion of the escarpment, facing south
ward toward the Carrizo Mountains, is broken by two parallel faults forming by a platform 2 to 8 miles wide.
The lower scarps are about 500 to 700 feet high and the upper
500 to 800 feet high.

Back from the crest of the escarpment the surface slopes
westward to the general level of the Diablo Plateau, conforming
to the general westward dip of the underlying limestone. The altitude of the surface decreases from 6200 feet or more
along the crest of the Sierra Diablo to 5000 feet or less at the
west side of the quadrangle.

Carrizo Mountains.—The southwest corner of the quad-
rangle, south of the Sierra Diablo, is occupied by the Carrizo
Mountains, which lie chiefly in the Van Horn quadrangle but
extend westward into the Sierra Diablo quadrangle and south-
ward into the Chisos quadrangle. They consist of irregular
groups of hills and low mountains separated by broad,
comparatively open washes, bordered by the Texas &
Pacific Railway, which reaches its greatest altitude, 4900 feet,
west of which it crosses the divide, about 9 miles west of
Van Horn.

The topography of the two parts of the Carrizo Mountains
that lie on opposite sides of the railroad is distinctly different
owing to differences in the character and structure of the
underlying rocks. The area north of the railroad consists
mostly of low rounded hills and open valleys developed on
relatively soft, homogeneous sandstones, though ridges here
and there are formed of steeply dipping, more resistant beds.
Next to the railroad is a narrow fan-topped ridge underlain by
horizontally layered, outcings of remnants of which form the promin-
ent butte situated west of Carrizo Spring. The topography
of the area south of the railroad is characterized by a series of
ridges and valleys that have developed along the northeast-southwest
trend, conforming with the strike of a group of metamorphic
rocks, the ridges being formed by the relatively harder beds.
The highest point in the Carrizo Mountains is 7285 feet above
sea level, about 10 miles west of the railroad. Hackney Peak, near
the southern margin of the quadrangle, is nearly as high, its summit being just a mile or
so above sea level.

Beach Mountains.—Northwest of the Carrizo Mountains
is Beach Mountain, a roughly circular mass about 5 miles
in diameter. Beach Mountain is not separated from the
Carrizo Mountains by a well-defined valley but is differentiated
from them by its greater altitude and more rugged surface, rising
rather abruptly 800 to 1000 feet above the hills to the west and
standing in a point having an elevation of 4305 feet.

Beach Mountain is capped by limestone, which dips in
generally gently outward and is much dissected by several deep,
narrow, crooked valleys.
Boylor Mountain.—In the central part of the quadrangle is an isolated highland area, trending northeast-southwest and about 10 miles long, lying 6 miles in greatest width, called the Boylor Mountains. The eastern part and rugged flanks of the Boylor Mountain, the Boylor Mountains form one of the most striking topographic features of the quadrangle. They rise out of Salt Flat, which is occupied by the dry Salton Sea, rising abruptly 1500 to 2000 feet above the lowland. The highest point, 5500 feet above sea level, is in the southeastern part of the mountains, and the bighorn summit is in general, on the east side of the mass. The mountains are underlain by gently warped limestone, which is dissected by deep, narrow, and crooked canyons, and are at the base, north, and east. The southeastern slope is gentle, steep, and broken by badlands.

Wylie Mountains.—A small irregular highmass area that intervenes between the two branches of Salt Flat at the north side of the quadrangle is called the Wylie Mountains. Only their northern part lies in the Van Horn quadrangle. On the west the Wylie Mountains rise in a fault scarp more than 1000 feet above the western branch of Salt Flat, one peak reaching 5501 feet above sea level. From the crest of the bluff the mountains decrease in altitude eastward and in a few miles become low hills surrounded by washes.

Delaware Mountains.—The northeastern part of the quadrangle, as far north as Seven-Heart Gap, is occupied by the Delaware Mountains. They consist of a dissected monoclinal with a westward-facing escarpment in which are exposed the eroded edges of sandstone and limestone beds that dip eastward, causing the top of the mountains to be a dip slope. The elevation of the crest increases northward and ranges from 4874 feet near Seven-Heart Gap to 5870 feet at the northern end of the quadrangle. Accordingly the top of the mountains ranges in height from 1500 to 2000 feet above Salt Flat. East of the rim rock the drainage is down the dip slope and is tributary to the Pecos River. The escarpment is dissected by relatively short arroyos, which drain into Salt Flat. The topographic detail differs from place to place, varying with variations in the hardness of the rocks, the softer beds forming arroyos and outlying hills and the harder beds generally forming cliffs. Northeast of Seven-Heart Gap a number of small badlands, outliers of the Delaware Mountains, break the surface of the range and afford good views of the adjacent valley between the Delaware and the Apache mountains. At the north end of the quadrangle a belt of low foothills, due to a fault block, lies at the base of the mountain.

Apache Mountains.—The southwestern part of the quadrangle is occupied by the western end of the Apache mountains, a long, narrow, dissected area trending northeast-southwest, underlain by massive flat-lying limestones. Its highest point in the quadrangle, 5000 feet, is a summit about 6 miles south of Seven-Heart Gap. The mountains are cut by several broad valleys.

DESCRIPTIVE GEOLOGY. PREVIOUS GEOLOGIC WORK. Little has been published on the geology of the Van Horn region. W. H. Van Stry venerably described parts of the area in the four annual reports of the Geological Survey between 1880 and 1889, but that organization was discontinued before a geologic map or a systematic report on the area was published. E. T. Dumble, director of the Geological Survey of Texas, reviewed the progress of Van Stry's work in his annual reports, and in 1906 he announced the probable pre-Cambrian age of the fine-textured red sandstone of the Millon Formation. E. T. Hill has briefly referred to this general region in a number of publications. The Van Horn quadrangle is included in the region examined by the present writer in 1906.

STRATIGRAPHY. SEQUENCE OF THE ROCKS. The rocks of the Van Horn quadrangle consist of consolidated and unconsolidated sediments and a few small igneous masses. The consolidated rocks range in age from Algolinian (7) to Cretaceous, and the unconsolidated are in part at least Pecosian. The general stratigraphy of the quadrangle is outlined in the columnar section. (See fig. 4.)

At the base of the section is a great mass of Algolian (7) rocks which have been separated into two formations. One, the Carrizo, consists of schists, quartzite, slate, and associated altered igneous rocks, and the other the Million, consisting of sandstone, conglomerate, and cherty limestone. The stratigraphic relations of these two formations are concealed, but the more northerly in which the Carrizo has undergone indicates that it is the older. The Van Horn sandstone, of probable Cambrian age, lies at a few feet or more below the Million and the Algolian rocks. It was found in several exposures in the area and is a hard, massive, buff-colored sandstone that is of some economic interest.

The rocks of the Van Horn quadrangle are divided into two major units: the sandstones, shales, and limestones of the Million Formation, and the sandstones, conglomerates, and limestones of the Carrizo Formation.

SEDIMENTARY ROCKS. ADJUVANT (7) SYSTEM. CARRIZO FORMATION. Description.—The Carrizo formation is a complex of quartzite, slate, and a variety of schists, which outcrops in the Carrizo Mountains, in the Texas & Pacific Railway. The name was first used for the formation by Van Stry in 1906.

Distribution and character.—The formation is exposed over about 25 square miles at the southwest corner of the quadrangle, where it forms the southern portion of the Carrizo Mountains. It outcrops in parallel ridges and intervening valleys having a general northeast-southwest trend. The ridges are underlain by harder rocks and the valleys by softer ones, the topographic trend corresponding to the strike.

The formation consists of fine conglomerates, quartzite, and shales and has extensive outcrops which are of economic interest. They are generally more or less undulating in character and are of two principal types: (1) those that are fine-grained and are characterized by a fine gravel or sand matrix, and (2) those that are coarse-grained rocks. The fine-grained types are generally more or less well sorted and are characterized by a fine gravel or sand matrix. The coarse-grained rocks are generally more or less well sorted and are characterized by a fine gravel or sand matrix. The coarse-grained rocks are generally more or less well sorted and are characterized by a fine gravel or sand matrix. The fine-grained rocks are generally more or less well sorted and are characterized by a fine gravel or sand matrix.
ages. In Bess Canyon, 7 miles southeast of Van Horn, immediately south of the quadrangle, an exposed section shows almost horizontal Van Horn sandstone containing pebbles of the underlying rocks lying upon one another virtually tilted strata. The Van Horn sandstone is probably Cambrian, and in view of the marked unconformity at its base and the metamorphism which the Carrin formation has undergone, there can be no doubt of the pre-Cambrian age of the strata.

Data for exact correlation are lacking, but the Carrin formation bears a general resemblance to the Lower Cambrian series of central Texas and to the Pinedale series of eastern Montana, where it is described. For the present, the authors are, therefore, of the opinion that the correlation is probably to the upper Cambrian reservoirs.

FORMATION.

Definition.—The Millan formation, named from Millan’s, 13 miles north-west of Van Horn, consists of fine-grained red sandstone, cherty limestone, and conglomerate. The fine-grained red sandstone was called the Diablo sandstone by Von Seinschutz and the Hard sandstone by Dumale, but it has been found impossible to separate it metamorphic from the cherty limestone and conglomerate.

Distribution.—The formation occupies a considerable area in the southwestern part of the quadrangle, chiefly in the Carrin Mountains, between the Texas & Pacific Railway and the escarpment of the Sierra Diablo. It outcrops in disconnected areas separated by wash, and its sequence, thickness, and relations are not exposed.

The sandstone occupies most of the undulating hill district constituting the northern part of the Carrin Mountains and extends along the lower part of the southwestern escarpment of the Sierra Diablo, where it outcrops conspicuously. A small area of it is developed in the valley which surrounds Sheep Peak and another peak 1 mile to the southeast. The rock is so coarse that it generally underlies an area of out- 

The Millan formation consists of sandstone, siltstone, and conglomerate, with interbedded sandstone and conglomerate, forming an interstratified series of beds. The sandstone is fine-grained, with a thickness of 5 to 7 feet, and is found in places where it is more than 10 feet thick. It is characterized by the presence of fossils, which are abundant and well-preserved. The fossils consist of marine organisms, including a variety of marine invertebrates such as brachiopods, bryozoans, and corals. The presence of these fossils indicates that the Millan formation was deposited in a marine environment.

Distribution and character.—As the El Paso quadrangle the El Paso limestone forms the greater part of El Paso Mountain. It occurs in the southern basin of the Estacado Mountain and in a few small hills in the valley between the Estacado Mountains and the Sierra Diablo. The formation is made up of finer homogenous, massive and poorly bedded limestone containing a few irregularly distributed small boulders of basalt, which are 5 to 10 feet thick, forming a base in some places. A sample of the rock from the southern basin of the Estacado Mountain, analyzed by Chase Palmer, of the United States Geological Survey, contained 75% of limestone. The thickness of the formation in the El Paso quadrangle is exposed in El Paso Mountain, where the section was measured.

Section of El Paso limestone northeast of Brooks range.

El Paso Limestone.

Lincoln, 13; Mexico, 10.

This section is exposed in an area of about 500 square miles, near the junction of the Estacado and the Sierra Diablo. The limestone is fine-grained and massive, with a thickness of about 300 feet. The section is divided into three parts: the Lower, Middle, and Upper Ranges.

Lower Range.—The Lower Range consists of a thick sequence of fine-grained limestone and dolomite, with interbedded conglomerate and sandstone. The section is about 100 feet thick, with a basal conglomerate and sandstone, followed by a thin bed of limestone, and then a thicker bed of dolomite and limestone. The dolomite is massive and gray, with a thickness of 20 to 30 feet, and is succeeded by a bed of limestone, which is about 100 feet thick. The limestone is fine-grained, with a thickness of about 150 feet, and is succeeded by a bed of dolomite, which is about 200 feet thick. The dolomite is massive and gray, with a thickness of about 100 feet. The section is divided into three parts: the Lower, Middle, and Upper Ranges.

Middle Range.—The Middle Range consists of a thick sequence of fine-grained limestone and dolomite, with interbedded conglomerate and sandstone. The section is about 500 feet thick, with a basal conglomerate and sandstone, followed by a thin bed of limestone, and then a thicker bed of dolomite and limestone. The dolomite is massive and gray, with a thickness of about 150 feet, and is succeeded by a bed of limestone, which is about 200 feet thick. The limestone is fine-grained, with a thickness of about 150 feet, and is succeeded by a bed of dolomite, which is about 200 feet thick.

Upper Range.—The Upper Range consists of a thick sequence of fine-grained limestone and dolomite, with interbedded conglomerate and sandstone. The section is about 750 feet thick, with a basal conglomerate and sandstone, followed by a thin bed of limestone, and then a thicker bed of dolomite and limestone. The dolomite is massive and gray, with a thickness of about 150 feet, and is succeeded by a bed of limestone, which is about 200 feet thick. The limestone is fine-grained, with a thickness of about 150 feet, and is succeeded by a bed of dolomite, which is about 200 feet thick.
**Fossils and age.**—The Montoya limestone carries an abundant fauna, especially in the upper cherty beds. The following species from the Van Horn quadrangle have been identified by E. O. Ulrich:

- **Bivalvia**
  - *Brachiopoda sp.*
  - *Codiumella fenestrata.*
  - *Dobsonites obtusa.*
  - *Rugosites grandis.*
  - *Rhyolithochiria levis.*

In the El Paso fold to the Montoya limestone, on the authority of E. O. Ulrich, was described as containing two distinct faunas, one identified as Silurian and the other as Ordovician. A recent study of the collections from the El Paso and Van Horn quadrangles and of the type section in the Franklin Mountains by Edwin Kirk, of the United States Geological Survey, shows that the entire formation is of Ordovician age, with which conclusion Mr. Ulrich now agrees.

This fauna has a widespread distribution. It occurs in the Bijou dolomite of Wyoming, the Fish Haven dolomite of northeastern Utah, the Fremont limestone of Colorado, and elsewhere.

**Carboniferous System.**

The greater part of the exposed consolidated rocks in the Van Horn quadrangle belong to the Pennsylvanian Permian series of the Carboniferous system. The beds are divided into the Horseshoe limestone, Delaware Mountain formation, Castle gypsum, and Castle limestone. The Horseshoe limestone in the Pennsylvania and the other three formations are referred to the Permian.

The Castlegate gypsum and overlying Rustler limestones are part of the system of red beds of the Permian in Texas. In the Van Horn quadrangle these formations occur on the eastern side of the Delaware Mountains in a fault block separated from their main occurrence a few miles to the east.

**Pennsylvania Series.**

**Horseshoe Limestone.**

**Definition.**—The Horseshoe limestone is a phase of the Horseshoe formation which is widely distributed in the trans-Pecos region. Its name is derived from the Horseshoe Mountain in the El Paso quadrangle. In several areas the formation consists entirely of limestone, but in others, notably in the Sacramento Mountains, N. Mex., it comprises a considerable sandstone and shale section, including red beds, and in many places a basal conglomerate. In Texas the Horseshoe is at least 5000 feet thick, of which about 2500 feet are exposed in the Van Horn quadrangle.

**Distribution and character.**—The Horseshoe limestone outcrops conspicuously in the Sierra Diablo, where it forms the eastern escarpment of Diamon Park and the crest of the escarpment of that peak; it also underlies the surface of a large part of the Diablo Plateau. It forms nearly the whole mass of the Bayou and Wylie mountains, making a large part of the ridge lying north of the railroad west of Van Horn, and occurs in small outlying hills here and there in the western part of the quadrangle. The thickness of the cliff it forms are shown in Plates II, VI, and VII.

In the Van Horn quadrangle the Horseshoe formation consists almost wholly of limestone, but in some places it includes thin beds of dark clay slate, gray clay, gray sandstone, and a conglomerate. The limestone ranges from massive to thinly bedded, the transition being well shown in some of the cliffs along the escarpment of the Sierra Diablo. In some areas bedding planes are scarcely distinguishable, but in others the limestone is distinctly thin bedded and laminated. The limestones are typically nonskeletal, an analysis by Chase Palmer of a specimen from an outcrop east of bench mark 4603, on the Texas & Pacific Railway, showing only 0.98 per cent of magnesite, thus agreeing with two analyses of the Horseshoe limestone in the El Paso quadrangle, each of which showed less than 1 per cent of magnesite. On the other hand, a specimen from the top of the Sierra Diablo 4 miles southwest of the mouth of Apache Canyon, contained 10.69 per cent of magnesite.

The conglomerate is very irregularly distributed, being in place 100 feet thick and in other places absent. The pebbles, which range in diameter from a fraction of an inch to several inches, are round fragments of the underlying rocks.

**Elevation.**—The Horseshoe lies with pronounced unconformity on the older rocks. In places there is a marked discordance of dip between the Horseshoe and the underlying beds. In the eastern part of the quadrangle the formation is 6 miles north-northwest of Van Horn the basal conglomerate is well exposed, lying almost horizontally on Van Horn sandstone that dips 25°. Ne., and in other places the conformable. Plate VIII shows the Horseshoe resting on Van Horn sandstone in Theronville and across, the valley to the north, the El Paso limestones resting on the Van Horn. At the south end of the Bayou Mountains the unconformity at the base of the formation is also plainly evident. The limestone, with a basal conglomerate containing a variety of fragmental interbeds of sandstone fossiliferous El Paso limestone, lie in places on an eroded surface of Van Horn sandstone near by on El Paso limestones. (See fig. 6, b.)

**Along the southern escarpment of the Sierra Diablo the unconformity is clearly shown by the Horseshoe limestone, with its basal conglomerate containing pebbles of the underlying rocks, rests on an eroded surface of the Milltonian formation.**

**Delaware Mountain Formation.**

**Deposition.**—The Delaware Mountain formation is a mass of sandstone and limestone having a thickness of at least 2200 feet. Its base is concorded by the Quartzary deposits of Salt Flat, and at the type locality, in the Guadalupe Mountains, it is overlain by the Capitan limestone, but in the Delaware Mountains, from which the name is derived, it is overlain by the Castle gypsum.

**Distribution and character.**—The formation makes up the whole of the Delaware Mountains and of the Apache Mountains, except in the valley extending northwest from the Seven Heart Gap. It also forms the low hills at the base of the Delaware Mountains in the north part of the quadrangle.

In the part of the Delaware Mountains north of the Van Horn quadrangle the formation is pervasively sandy and contains only thin beds and lenses of limestone. Southward the sandstone decreases and the limestone increases in amount, and in the southern part of the mountains the formation consists of gray limestone with subordinate beds and lenses of sandstone. In the Apache Mountains the rocks are entirely limestones and are separated from the main mass of the formation by a fault.

The sandstone is quartzo-feldspathic, massive to thin bedded, and buff to tuffaceous. The limestone is massive to thin bedded, gray and green. These analyses indicate that the limestone of the Delaware Mountain formation is practically nonskeletal. A sample from the crest of a ridge in the Delaware Mountains near bench mark 5870 shows .025 per cent of magnesite; from a hill west of Jones's ranch, 0.45 per cent; and from the Apache Mountains a mile northwest by bench mark 3850, 0.29 per cent.

The following section measured on the western escarp of the Delaware Mountains at the north end of the quadrangle, west of bench mark 5850, shows the general character of the formation.

**Partial section of the Delaware Mountain formation at the north end of the quadrangle.**

**Age and correlation.**—In regard to the age and correlation of the Horseshoe limestone G. H. Girty says:

The Horseshoe formation is Pennsylvania in age, but, owing to the peculiar Jurasia facies which its fossils share with most of the Cenozoic faunas of the West, it is impossible to indicate its exact position in the typical Pennsylvanian section.

Collections of fossils made at different points in the Horseshoe formation are likely to show different faunas. This difference is not always due to differences in horizon, but in part at least the lower part of the Horseshoe seems to be more or less differentiated from the upper, although no definite boundary has been established. Thus the paleontological evidence suggests that certain horizons at the base of the Horseshoe in the Mountains may be lacking in the Van Horn quadrangle.

Fossils more or less closely similar to the Horseshoe are widely distributed through the Cenozoic rocks of the Pacific coast, but fossils have been found in the Kalathas limestone of the Ashby group of Arizom, in the Simms group of New Mexico, and in the upper part of the Delaware Mountain formation at Arizom, and these formations are intimately correlated with the Horseshoe.

**SUMMARY.**

The formations assigned to the Permian in the Van Horn quadrangle are the Delaware Mountain formation, the Castle gypsum, and the Rustler limestones. The Delaware Mountain formation and the overlying Capitan limestones (not recognized in this area) constitute the Guadalupe group and contain the unique Guadalupe faunas described by G. H. Girty, which is distinctly different from the Horseshoe formation. For this reason and because of certain resemblances between its fauna and the late Paleozoic faunas of Asia and Europe, the Delaware Mountain formation is classified with the Permian.
The Castle formation, consisting of massive gypseous, including trona, and flint, is about 25 miles north of the Van Horn quadrangle. The main mass of the formation occurs several hundred square miles between the eastern base of the Delaware Mountains and the Rustler Hills.

**Distribution and character.**—The Castle gyspum occupies a few square miles at the east side of the quadrangle in the valley between the Delaware Mountains and the Apache Mountains. The gyspum is a massive white granule variety. A characteristic sample analyzed qualitatively by W. T. Schaller shows it to be of no unusual composition. On the surface the gyspum is generally disaggregated and earthy and commonly weathered gray with rough solution surfaces. In the Van Horn quadrangle the thickness of the formation is about 275 feet.

**Relations and age.**—Throughout its extent in Texas the Castle gyspum apparently lies unconformably on the Delaware Mountain formation. Because of its occurrence as part of the red beds of the Pecos Valley, which are generally recognized as of Pennsylvanian age, this formation is here included in the Pennsian series.

**Rustler limestone.**

**Definition.**—The Rustler formation is about 200 feet thick and consists of fine-grained grey to whitish amphibolite limestone and associated sediments. It is unusual from the Rustler Hills in eastern Collier County, Tex. The sandstone beds are lenticular and not persistent, and in the Van Horn quadrangle the formation consists entirely of limestone.

**Distribution and character.**—The Rustler limestone caps a few hills in the valley occupied by the Castle gyspum between the Delaware Mountains and the Apache Mountains. The rock is fine-grained grey to whitish amphibolite gyspum. A sample analyzed by W. T. Schaller had the following composition:

<table>
<thead>
<tr>
<th>Analysis of Rustler limestone.</th>
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<tr>
<td>Isolable</td>
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<tr>
<td>Alumina and iron</td>
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<tr>
<td>Lime</td>
<td>15.49</td>
<td></td>
</tr>
<tr>
<td>Magnesia</td>
<td>4.16</td>
<td></td>
</tr>
<tr>
<td>Ignition</td>
<td>46.36</td>
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</tbody>
</table>

**Relations.**—The fact that the Rustler limestone was deposited directly upon the Castle gyspum shows that the conditions of sedimentation had changed and that marine waters had gained free access to the more or less indented basin in which the gyspum deposits were laid. But no evidence has been found of considerable unconformity.

**Fossils and age.**—Fossils are extremely rare in the Rustler limestone. None have been found in the Van Horn quadrangle, but a few were obtained in the Rustler Hills, concerning which G. H. Crittely reports as follows:

Two fossil shells are included in this collection, one of them suggesting by its shape a small Mytilus, the other being perhaps Schinonod and having the general shape of S. horrei. The former is a distinctively shell which might be a Modiolus or even a member of some arctic genus.

Neither the Castle gyspum nor the Rustler limestone can be traced far beyond their type localities. They are typical members of the red beds of the Pecos Valley, which consist of lenses of gyspum and limestone interbedded with red sandstone and shale. In one of these lenses of limestone in the red beds of the Pecos Valley south of Lakewod, N. Mex., J. W. Beede in 1906 collected fossils which he correlates with those of the Quaternary formation and those of the Whitehouse sandstone member of the Woodward formation. These formations are parts of the well-known Pennsian red beds of northern Texas and Oklahoma.

**Comanche system.**

**Comanche series (lower cretaceous).**

**Definition.**—The Cretaceous strata in the Van Horn quadrangle are outcrops remnants of the great mass of Lower Cretaceous rocks in eastern Texas. In this area the Comanche series has its typical development. The series is divided into three groups—the Trinity at the base, the Frederickson in the middle, and the Weatherford at the top. In this quadrangle generally all three groups are represented, the Trinity group is well developed south of the Texas & Pacific Railway, but only

<table>
<thead>
<tr>
<th>Faults.</th>
<th>J. W. Beede, and the northern part of the Kansas season.</th>
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<tbody>
<tr>
<td>Tattoo</td>
<td>42.45</td>
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</tr>
<tr>
<td>Trinity</td>
<td>42.45</td>
<td></td>
</tr>
<tr>
<td>Weatherford</td>
<td>42.45</td>
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</table>

The surface of Salt Flat and all of the lowland areas outside the quadrangle are covered by undisturbed and undisturbed debris derived from the disintegration of the rocks of the adjacent highlands. The deposits cover a large part of the quadrangle and are thickest in the valley. The material extends in broad slopes up the mountain sides for several hundred feet above the lowlands. Material derived from the disintegrated rocks accumulates at the base of the mountains and is readily sorted and washed toward the lowlands chiefly by the torrential streams characteristic of the region. This debris merges with the alluvial fans that head up in the canyons and form a sheet over the base of the highlands according to a great mass of alluvium. Near the mountains the gradient is steep, the slope becoming less and less until it merges into the low debris of the lowlands. Torrential streams are the chief transporting agent for the coarse debris, but a slow gravity creep aids, and the wind does important work in shaping the finer material. Some erosion, staining, and fine deposits constitute the surface of the lowlands.

The composition of the material differs with the character of the terrain in the adjacent highlands. The limestone areas are bordered by an outward slope of limestones, cemented into indurated masses by lime, ranging from thin flint to a deposit of almost pure calcite cemented several inches in thickness, known as caliche. Caliche is not specially abundant in this region, but in places of great confluence. For instance, a low bench along the east end of the mouth of Victoria Canyon is formed by a thin bed of it. The deposit is formed by the precipitation of calcium carbonate, in some places from surface water and in other places from ground water brought to the surface by capillarity.

Along the base of the Delaware Mountains, where there is considerable sandstone, a long belt of sand forms the eastern base of Salt Flat. Sand is abundant also in the southeast corner of the quadrangle. In the vicinity of Van Horn is a great body of reddish sand, and interstratified with it is derived from the Van Horn sandstone.

The composition and arrangement of the unconsolidated deposits beneath the surface of Salt Flat nothing is definitely known, for although a number of wells have been sunk satisfactory records of the drilling have not been kept. It is probable that several hundred feet of these deposits that have been accumulated in a lake were formed and are more regular in their occurrence. The thickness of the unconsolidated material is not known; the deepest wells are those at Salt Flat, which show a depth of 900 feet near the margin of the basin. The deposits contain a thickness of 1000 feet or more in the main part of Salt Flat.

**Igneous rocks.**

In the Van Horn quadrangle igneous rocks are of very minor occurrence. They include only a few small stocks and dikes, some of which are indicated on the map but the smallest of which cannot be shown on the small scale used. In the pre-Cambrian area it is impossible to separate the metamorphic rocks of igneous origin from the sedimentary schists.

Light direct evidence as to the age of the igneous rocks is obtainable in the quadrangle. Presumably they are to be referred either to the pre-Cambrian or to the Tertiary, as those were the two main periods of igneous activity in the Trans-Pecos region. In the Carrizo formation, the metamorphic igneous rocks doubtless antedate the deposition of the Van Horn sandstone, and must if not all of the metamorphosed intrusive rocks were associated with the organic movements of Tertiary time.

The most conspicuous bodies of igneous rock in the quadrangle are diabase dikes in the Carrizo formation from 3 to 6 miles southeast of Van Horn. One of these forms a prominent ridge more than 2 miles long. It cuts the pre-Cambrian rocks and extends parallel to their general strike; in the respect being similar to the metamorphosed igneous rocks included in the Carrizo formation. The diabase is the oldest of the ancient igneous rocks, however, in being distinctly massive. It is greenish-black, dense, and so fine grained that the component minerals are not generally distinguishable in hand specimens. It is distinctly granular with a tendency toward ophtic texture and consists of feldspar and pyroxene in about equal amounts, with secondary chlorite and mica and subordinately biotite. The feldspar ranges from calcic oligoclase to sodic plagioclase and the pyroxene is augite.

Dikes of similar appearance outcrop in an isolated hill south of the eastern boundary of the quadrangle. Its occurrence is in line with a fault which brings the11 El Paso limestone in contact with the Carrizo formation. The diabase dikes are a series of nearly parallel sheets, the thinner of which cut the Carrizo formation. The topographic occurrence, however, is less distinctly marked and their surface exposures are much deeper.

A mile southeast of the Texas & Pacific Railway pumping station in the Carrizo Mountains near the western border of the quadrangle a low hill almost surrounded by wash is composed
of rhyolite. The surface is greatly weathered, but fresh exposures show a dense fine-grained grayish to reddish rock composed of small, well-foliated crystals of orthoclase and white intergrown as intergrowth in a glassy matrix consisting of minute grains of interlocked quartz and feldspar, carrying small patches of iron oxides. The phenocrysts are much broken and the rock shows evidence of having been subjected to pressure. It is similar to some of the altered rhyolite occurring in the southernmost part of the mine.

Two names of igneous rocks are introduced into the Huron limestone in the exposure of the Sierra Diablo southwest of Figure Two numeros hands and headquarters. The southwesterly of these names is important because it has been supplemented the adjacent limestone into a valuable marble (p. 9). The intrusive rock is diorite, in which the diorite has been a separate occurrence, the main structural features are normal faults. Most of the highlands area are bounded by faults that strike in general with the main trend of the region, though sometimes in a more diagonal direction. In general, the strata either nearly flat in the plutons or are inclined at greater or lesser angles that form, according to the degree of dip, narrow mountain ridges or broad monocline slopes. In pieces masses of igneous rock have been and tilted the strata through which they have been intruded.

The major faults apparently were initiated with the Tertiary continental emergence and developed between then and the late Tertiary or early Quaternary uplift. During Mesozoic and Paleozoic time there was in general comparatively little disturbance of the strata in Texas-Pensacola Texas north of the Texas & Pacific Railway, although there is evidence of a number of regional uplifts and subsidence and of slight local Pre-Pennsylvanian tilting (p. 8). It should be noted, however, that the general presence of structural disturbances in this area during the Paleozoic and Mesozoic era is in contrast with the sharp folding of the Paleozoic strata in the vicinity of Marathon, Brewster County, Tex., about 100 miles southwest of Van Horn, which R. T. Hill and J. A. Edden consider to have taken place in pre-Cretaceous time. In pre-Cambrian time profusely developed structural disturbances occurred, and a movement of which lateral pressure was the effective agent in contrast with the vertical movements which produced the dominant later structures.

STRUCTURE OF THE VAN HORN QUADRANGLE.

Types.—In the Van Horn quadrangle both the earlier lateral and the later vertical types of structure are developed, although here, as throughout the region, the vertical type is the more prominent.

The earlier structure is recorded by the steeply tilted and obviously folded Albinsian (7) rocks, in which two main structural trends are present—one northeast-southwest and the other east and west.

The later movements, produced by vertical forces, resulted in normal faults with steep dip, which range in displacement from a few feet to more than 1000 feet. The faults strike in various directions, the most prominent trending northwest, though some strike northeast and east, and others have different trends.

Silt Flat.—Silt Flat is the central structural feature of the quadrangle. It is a deformed trough, whose highland masses on both sides have been relatively rigid. The differential movements along the border of the basin apparently began during the Cretaceous uplift and were continued, at intervals, through Tertiary time. Different dates of uplift are indicated by the relatively young fault scarp of the eastern Sierra Diablo and the manner of dislocation some along the base of the Delaware and Apache mountains. The attitude of the bedrock underlying Silt Flat is concealed by the thick cover of drift. The Cerritos Mountains.—Two main structural trends are developed in the Albinsian (7) rocks of the Cerritos Mountains. In the north the three major, and the most widespread, are in general the northern, and in the south that of the Cerritos formation is northeast and southwest.

In the southern part of the Cerritos Mountains the rocks strike northeast-southwest and dip 20° SE to 90°, averaging possibly 90° in the southeast and 25° in the northwest part. A more nearly east strike is developed in the northwestern part of the exposure of the Cerritos formation, contiguous to the Texas & Pacific Railway, indicating an approach to the structure of the Million formation.

The area in which the Cerritos formation outcrops is bounded by the north, south, and east by normal faults. On the north the fault strikes almost east, on the east the strike is northeast, and on the south it is northwest. By these faults the Alpinsian (7) area south of the railroad has been uplifted, so that the ancient rocks are in contact with the Huron limestone on the south and with the Huron limestone and the Cambrian series on the north. The dislocation at the south is well shown by the dislocation of the shingling of the Cerritos formation, slipping 45° SE, against the Huron limestone, dipping 17° SW. A subsidiary fault north-northwest is developed 11 miles southeast of Hallett Peak, where the pre-Cambrian rocks are in fault contact with a small area of Van Horn sandstone and Huron limestone.

In the northern part of the Cerritos Mountains the structure is more varied and obscure than in the southern part. North of the railroad the most pronounced structure is a general east-west strike, accompanied by steep southwest dips. These features are best brought out by the beds of limestone and conglomerates, for the homogeneity of the fine-textured sandstone member of the Million formation makes it almost impossible to determine its structure over a large part of the area north of the railroad. The Huron limestone on the north, its east strike and steep southwest dip are evident. The general eastward strike is well shown between Cerritos Springs, where the faulting of the Texas & Pacific Railway's pumping station, where beds of cherty limestones and breccia stand nearly vertical or are tilted southwest at a high angle. East of Million's much of the structure is indicated by northwest and southwest dipping beds of limestone, but the structure is complex and poorly defined.

Morris Peak, a mile out of Grapevine Spring, is formed by an eastward-plunging asymmetric syncline bounded on the east and south by a fault. The Million formation, of which the mountain is composed, is in fault contact on the east with the Huron sandstone and the El Paso limestone. (See Pl. III.) In the northern part of the mountain cherty limestones and breccia are prominent. A line of 45° SE, and in accordance with the plunge of the syncline at the west end of the mountain the strata curve around so that at the southern end of the upfolds the dip is about 30°

Another fault extends southwestward toward Grapevine Spring separating the Million formation on the north from the relatively downwashed Van Horn sandstone on the south. Possibly this disposition continues southwestward toward Grapevine Spring and connects with the fault south of Morris Peak, but the conditions are obscure. Presumably also the Million formation is cut by other faults which are not mapped.

Booth and Baylor mountains.—Booth and Baylor mountains are almost entirely composed of Ordovician and Carboniferous limestones. In the Baylor Mountains these rocks lie in general parallel to the surface, but in the Booth Mountains they exhibit a pronounced low inclination to the northeast, and in places in both areas they show diverse dips. The eastern termination of the Booth Mountains, the southern boundary of Salt Flat is in such marked elongation that it is highly probable they are delimited by a fault which trends northeast and whose continuation to the Sand Flat mountains from Salt Flat at the south end of the quadrangle.

The abrupt, almost straight termination of the southern end of the Booth, the Cerritos Mountains indicates also that a cross fault delimited this area on the north, but no other evidence of its existence has been found.

Faults separate Booth and Baylor mountains from each other and from the Sierra Diablo. Subsidiary faults are also present. At the north end of Booth Mountain the Huron limestone is in fault contact with the El Paso limestone and Monterey limestone, and at the southwest end of the mountain the Van Horn sandstone and El Paso limestone are slightly offset. (See Pl. IV.)

Sierra Diablo.—The strata of the Sierra Diablo in general lie almost horizontal, but in places they dip divergently, and in the northern part of the quadrangle the top of the mountain forms a dip slope. On the south the Sierra Diablo is delimited by two parallel faults about 3 miles apart and south of this the north end of the El Paso (See structure-section sheet.) In both, the relative upthrow is on the south, the displacement of the southern fault being about SOO feet and that of the northern one approximately 800 feet, the contact of the Huron limestone with the Million formation affording the basis for measurement. The southern fault pre- dominance in the upper part of the displacement south of Morris Peak. The three are shown in figure 8. In the northern fault a series of a few fractured red sandstone of the Sierrita formation in a small area north of Booth's ranch. The displacement is well exposed in the canyon a mile north of the Huron mine, the fault plane passing up the canyon and exposing a remnant of the Van Horn sandstone sheeting against the Million formation and the Huron limestone in the upper part of the structure—section sheet.) The displacement of the Huron limestone by the fault at the western edge of the quadrangle is shown in figure 8, c.

Figure 8.—Sections showing normal faulting.

One of the principal zones of displacement of the quadrangle is the eastern boundary of the Sierra Diablo, along which the movements have taken place that have raised the mountains above Salt Flat trough. The southern extension of this displacement separates the Sierra Diablo from the Baylor Mountains, in which the Huron limestone has been dropped relatively to its occurrence in the Sierra Diablo to the west. An idea of the approximate displacement is afforded by a comparison of the elevation of the top of the Million formation in a hill in the downwashed block west of the north end of the Baylor Mountains, not shown on the map, with approximately the same horizon on the flanks of the Sierra Diablo to the west.

This shows a displacement of about 1300 feet. An example of "drag" along the fault is shown about a mile north of the mouth of Victoria Canyon, where east-dipping beds of Huron limestone on the downwashed side shut against practically horizontal strata on the opposite side of the fault. (See section E-E', structure-section sheet.)

Delaware Mountains.—The Delaware Mountains are an outstanding monocline bounded on the west by a fault, which separates them from Salt Flat. The disturbed zone is marked in places by a belt of fault blocks, forming a downwashed block, in which the northern part of the strata is 15° SE. The rocks of the main Delaware Mountains dip 1°-2° NE. At the extreme southern end of the mountains there are diverse dips and direction of dip.

Area between the Delaware and Apache mountains.—Immediately south of the Delaware Mountains and north of the Apache mountains the eastern part of the fault of roughly triangular outline at least 10 miles long and 2 miles wide. The block is bordered on the south by a fault whose southeastern extension beyond the margin of the quadrangle along the northern base of the Apache Mountains, and whose northwestward extension is concealed by the unconsolidated deposits in Salt Flat. The outcrops in this block are chiefly the Ootsila gypsum and the overlying Rostler limestone, which have been faulted down into the Delaware Mountain formation. The strata lie almost horizontal, but the delimiting fault lines, although in part concealed by QUaternary wash, are well exposed in places. For instance, at the head of the valley, 5 miles east of boot ranch on the Delaware Mountain formation in the updipped block east of the fault is in contact with both the Rostler limestone and the Cortes gypsum. The fault is shown in figure 8, b. A hint of quartz occurs along the fault plane. This block is intersected by minor faults, as shown on the structure-section sheet.

Apache Mountains.—The limitation of which the Apache Mountains are composed is in most places so massive that its structure is difficult to determine. Where bedding planes are apparent the strata in general are seen to lie practically horizontal, though here, as throughout the region, the prevailing attitude of the beds is disturbed by local deformations. In the belt of faultblocks at the extreme western end of the mountains the intrusions dip 5° W, owing to a zone of disturbance along the lawland north of Jones' ranch. In the low hills immediately north of the railroad, northeast of Plateau, the beds dip 5° W. The presence of Cretaceous (7) sandstone in the hills at the eastern edge of the quadrangle at a lower elevation than what appears to be the same bed in the hills to the west indicates a small fault.

Van Horn
GEOLoGIC HISTORY.

ALGONKIAN (1) PERIOD.

The Carrión and Million formations, of sedimentary origin, bear witness to the existence of an old land mass from which their component materials were eroded and transported by streams to a body of water in which beds of graywacke and conglomerate, sandstone, shale, and limestone, were inundated by igneous rocks, were deeply buried and in part metamorphosed, to schist, quartzite, and sandstone, which were transported, uplifted to the surface, possibly to form part of a mountain area, and were acted upon by erosion. These events occurred before the beginning of Paleozoic time.

PALEozoIC ERA.

The apparent absence of Lower and Middle Cambrian deposits implies that this area, in common with a large region in the southeastern United States and the adjoining periods, when the Algonkian (2) rocks probably formed a land area. In other parts of the Cordilleran region there is evidence that the Algonkian (2) rocks were present in parts of the Van Horn quadrangle the few exposures, such as the contact of the Van Horn sandstone with the Millerton formation west of the San Rich Area, have been so youngized when the sandstone was laid down upon it. The character of the basin conglomerates and of the red arkose sands in the lower part of the Van Horn illustrations may suggest that they are of sub-serial origin, and the well-sorted quartz sands, containing worn boulders and feldspar-like remains, in the upper part of the formation indicate that the Upper Cambrian (?), sea had finally spread over the land area.

Apparently the Van Horn sandstone was uplifted and somewhat eroded before the deposition of the El Paso limestone. The irregular basin layer of shale and the sandstone interbedded with the limestone in its lower part indicate variable conditions of deposition similar to Ordovician time. More exact conditions followed, during which the deposition of terrigenous material practically ceased, and the several hundred feet of the upper part of the El Paso limestone containing the Bectorniantum fauna was laid down.

The hiatus shown by the absence of the Middle Ordovician formations, together with the later conglomerate sandstone of the Montmorency limestones, indicates that a period of emergence and nondeposition was followed by submergence and by the deposition of offshore material, succeeded by the accumulation of the limestone of the Montmorency, which contains the Richmond fauna. Sluierian time, so far as known, is not represented by sediments in the Van Horn quadrangle, although it is possible that some of the limestone, which forms part of the outcrop, have not been found, lying between the Montmorency and Huaco limestones may be of Niagaran age and may represent the Fossils of limestone of the El Paso quadrangle. Devonian and Mississippian rocks do not occur in the Van Horn quadrangle, but whether they were never deposited or were removed by erosion is not known.

Prosimians between Upper and Middle Ordovician time there were several periods of emergence and subsidence produced by broad vertical movements. Practically no evidence exists of lateral movements in this region during Ordovician time, the only structural disturbance being the slight eastward tilting of the Van Horn sandstone before the deposition of the Huaco limestone.

The emergence immediately preceding the Pennsylvanian epoch was accompanied by profound erosion in the Van Horn region, and during the succeeding subsidence the basin con- 

glomerates of the Huaco limestone was laid down in the advancing Pennsylvanian sea on an uneven surface of the underlying formations. As a result, the deposition of terrigene- 
ous material was succeeded by the accumulation of the great thickness of Huaco limestone, which is so well developed in the Diablo Plateau, where the conditions are more diverse, and by the deposition of the Delaware Mountain formation and of the overlying Castle creek graywacke and Member limestone. The divers- ity of these formations and their equivalent in adjacent areas emphasizes the variability of late Carboniferous stratigraphy in this region. While limestone was accumulating in one area, sandstone was being deposited in another, and red beds in a third. This variation is an expression of changing geographic conditions which accompanied the emergence of the continent at the close of Paleozoic time. Apparently the open sea which advanced on a land area at the beginning of Pennsylvanian time gave way with some shallower water to seawater included basins, until the close of the Paleozoic, the sea being marked by continental uplift, which, however, in this area, was not, as in other regions, accompanied by folding of the rocks.

MESoZoIC ERA.

During the early part of the Mesozoic era part of the trans- 

Pecos region was a seaway, with the principal features of the small rainfall, chiefly by heavy downpours which arose local torrential floods, the high temperature, and the large diurnal changes in temperature. In consequence, (1) there is no permanent run-off, streams flowing for only a few hours after storms and disperse by absorption and evaporation. (2) Vegetation is scanty and of the desert type and does not protect the highlands from the effects of wash. The summits are marked by alpine tundra, and the valleys and the lower slopes by beds of graywacke and conglomerate which are covered by the rocks collecting at the base of the highlands in graded slopes that extend toward the center of Salt Flat. (3) The expanse of the plain is such that there is no surface drainage of the base rocks to stresses of expansion and contraction which facilitate their disintegration. (4) The absence of active soil and the scarcity of organic life further compound the processes of chemical change of the rock debris, so that the unconsolidated material which underlies the highlands is but little decomposed.

The material derived from the disintegration of the rocks of the highlands is transported toward the lowlands by the wash of torrential rains, by the direct action of gravity, and by the wind. Alluvial fans, consisting of heterogeneous masses of bowlders, gravel, and sand, form about the mouths of the canyons and coulees, sculpitif form, with the alluvial slopes which accumulate along the base of the mountains between the array. The debris, composed of poorly rounded coarse material near its source, slopes steeply toward the lowlands near the mountains but flattens gradually toward the center, where it becomes almost flat. The material decreases in fineness with distance from the mountains, so that the lowlands are underlain chiefly by fine-textured deposits. The alluvial fans are important agents in transportation, keeping the highlands bare of fine debris and accumulating it about the vegetation in the lowlands or alluvial fans. Dust storms are common. Some material is even transported across the divide out of the basin by severe storms.

ECONOMIC GEOLOy.

The mineral resources of the Van Horn quadrangle include ores of copper, silver, and tungsten; terracotta in small amount; considerable marcasite; extensive quartzes of limestone, sandstone, gypseous, clay, and gravel; and locally plentiful underground water.

COPPER AND SILVER.

Copper and silver have been found at several places in the Carrion Mountains, but thus far only one mining mine, the Hazel, has been worked at the quadrangle—and the Hazel for many years lay unworked.

Hazel mine.—The Hazel mine is situated close to the south- 
ern base of the Sierra Diablo, 10 miles northwest of Van Horn. It is said to have been opened about 1855 and to have been worked for eight or ten years, after which, until 1912, it remained idle. It is reported to have yielded silver are worth several hundred thousand dollars.

W. H. von Simsonwitz described the Hazel mine in 1892. The mine worked from 1855 to 1868, the ore body having 1,200 feet of ore, but the mining has not been reerected. The main vein, extending along the east side of the Mission, is but 4 to 6 inches thick, and 3 feet high, and 300 feet long, and is composed of chalcopyrite, molybdenite, and talc. The talc is found in a gangue consisting largely of barite and calcite.

Prospects in the Carrion Mountains.—Prospects at various places in the Carrion Mountains and in the Van Horn quadrangle. Minor formation, show a rather wide area of mineralization, but thus far no paying properties have been developed. There are several minor veins or prospects in the Mission and Carrion formations, show a rather widespread area of mineralization, but thus far no paying properties have been developed. The country is not favorable for thorough exploration. The ore consists of two parts, known as the small veins or quartz veins, and the large veins, which are 2 miles southeast of the Hazel mine, the ore occurs in a fault zone. At other places, as in several localities in the Carrion and Finley quadrangles, the small veins are in schist and slate along joints or parallel to the planes of lamination. Sporadic occurrences are rather widespread. The ore consists of two parts, one of the different stages of oxidation. At the old Malby prospect, 6 miles west of Van Horn, copper arsenate was found. Assays are reported to show traces of silver and copper.

The yield of the old Hazel mine indicates the hope that profitable deposits may be found elsewhere. The disturbed character of the Alpengrund (7) formations, the many faults by which the rocks are traversed, and the presence of igneous rocks apparently afford favorable conditions for the circulation and metallization of underground solutions, and the widespread distribution of ore shows that some deposition has actually taken place. But whether ore has been deposited in commercial quantity elsewhere than in the Hazel mine has not been demonstrated and can be determined only by prospecting and development. It should be borne in mind, however, that considerable prospecting has been done and that, although the rocks are well exposed, valuable deposits outside of the Hazel mine have yet been found.

TURQUOISE

Turquoise deposits are reported from the eastern end of the Sierra Diablo, 25 miles southeast of Figure Two ranch headquarters. Samples show small tabular crystals of wolframite with associated iron oxides. The material has not been found in any considerable quantity.

LUMINITE AND MARLITE

The supply of limonite suitable for the various uses to which that rock is adapted is practically inexhaustible. The deposits, however, are too distant from commercial centers to merit special attention in the near future. There is, however, an occurrence of marble which on account of its high grade is of present importance, the chief deterrent factor in its development being its distance from the railroad. It occurs in the escarpment of the Sierra Diablo 25 miles southwest of Figure Two ranch headquarters and 27 miles in an air line north of Van Horn. The marble is part of the Huco limestone, which has been metamorphosed by an igneous intrusion. The original gray color has been changed to shades ranging from white to yellow by the alteration of the iron compounds and by the expulsion of the small quantities of carbon contained in the limestone. The extent to which this metamorphosis of the limestone has occurred is not known, but it must necessarily be limited to a relatively thin zone around the periphery of the intruded rock. The marble has not been critically tested nor extensively prospected, although enough work has been done to show the presence of a considerable mass of it.

There are also deposits of white and pink marble in the Carroso Mountains southeast of the Texas & Pacific Railway pumping station.

SANDSTONE

The sandstone of the Million formation is worthy of attention as a possible source of raw materials for building stone. It is a compact fine-grained homogeneous red sandstone which will take a good polish and occurs in great volume within a few miles of the railroad. One drawback to its use is that in places it is traversed by many joint planes, but it is possible that development will reveal masses that are in every way suitable for building stone. Selected beds of medium to fine grained Van Horn sandstone, particularly the more limonite-laden varieties, furnish desirable building stone. The Culberson County court house at Van Horn is built of this sandstone.

GYPSUM

Rock gypsum and less pure unconsolidated gypsum occur in considerable quantities and are available for local use in making plaster. A view, however, of the great amount of Mood was kept. Water was found at 515 feet and stands in the well to a depth of 400 feet.

Several wells have been sunk in unconsolidated deposits in valleys outside of Salt Flat. At Bond’s ranch, near the western margin of the quadrangle, there are several wells less than 100 feet deep in the valley of Deer Creek. At Mill’s ranch there are two shallow wells; and in the same valley, about 25 miles north of the railroad, the Texas & Pacific Railway has a pumping station, drawing from six wells, the depth of which is 70 feet. These wells are connected by tunnels and are reported to yield 60,000 gallons a day.

Although the main supply of underground water in the quadrangle is derived from unconsolidated deposits of sand and gravel, small amounts are obtained from bedrock. The chief source at present is the fine-grained red sandstone of the Million formation, which yields a number of feasible springs (see topographic map) and which supplies a shallow well at the Hall-Cannon ranch. The sandstone is much broken and is traversed by many joints, so that the location of successful wells is uncertain. A diabase dike, too small to be shown on the map, cuts across the valley below the Hall-Cannon ranch and seems to be the effective agent in impounding the underground water.

Limestone, being in general more compact and less porous than sandstone, is a relatively poor source of underground water. Water occurs in all rocks, nevertheless, however dense, and limestones that are much jointed or fissured are traversed by solution channels, and the more porous magnesian limestones, those which contain considerable admixtures of sand, often yield important quantities of water. Among successful wells in limestone are those sunk by the Lander brothers in the Huco limestone on the Diablo Flats about 40 miles north of Sierra Blanca, between 30 and 40 miles northwest of the Van Horn quadrangle. These wells are between 900 and 1000 feet deep and yield large quantities of water. On the other hand, the Aden well in the extreme northeastern corner of the quadrangle was sunk in 1902 to a depth of 216 feet, without finding water, almost the entire distance being reported through limestone of the Delaware Mountain formation.

The following analyses of water in the Van Horn quadrangle, one from the railroad well at Van Horn and the other from a well about 30 feet deep at the headquarters of Figure Two ranch show its varied character. Toward the center of Salt Flat, where there are considerable accumulations of gypsum and other evaporation products, the underground water is strongly impregnated with salts, but toward the periphery of the basin it is much less saline.

Analyses of water from the Van Horn quadrangle. (In parts per million. K. E. Ellis, Chase Hospital, and W. D. Collins, analyses.)

<table>
<thead>
<tr>
<th>Water from</th>
<th>Dissolved Solids in ppm</th>
<th>Total Solids in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Flat</td>
<td>165 (Na, K)</td>
<td>485</td>
</tr>
<tr>
<td>Cottonwood L</td>
<td>1,020 (Na, K)</td>
<td>1,020</td>
</tr>
<tr>
<td>Magnesium L</td>
<td>1,470 (Na, K)</td>
<td>1,470</td>
</tr>
<tr>
<td>Sodium and Potassium (Na, K)</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Carbonate (CO₃⁻)</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Chloride (Cl⁻)</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Sulfate (SO₄²⁻)</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Chloride (Cl⁻)</td>
<td>31</td>
<td>31</td>
</tr>
</tbody>
</table>

The analyses show that the water at Figure Two ranch carries more than five times as much dissolved salts as the Van Horn water. The former is notably high in sulfates and chlorides and is very hard; the latter is essentially a carbonate water with minor amounts of sulfates and chlorides. Water from the Figure Two ranch well contains enough mineral matter to give it a distinct and somewhat disagreeable taste.

A partial analysis of a sample of the water from Salt Lake, 4 miles south of Figure Two ranch headquarters, collected by J. M. Daugherty in June, 1912, shows it to be an ordinary brine, containing principally sodium chloride and sodium carbonate.
and still smaller crescent shapes. The age of a rock is expressed by the name of the time interval in which it was formed.

The sedimentary formations deposited during a period are grouped together into a system. The principal divisions of a system are called series. Any aggregate of formations less than a series is called a group.

Inasmuch as sedimentary deposits accumulate successively the younger rest on those that are older, and their relative ages may be determined by observing their positions in many regions of extreme distance, however, the beds have been overturned by folding or superposed by faulting, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossil, if present, may indicate which of two or more formations is the oldest.

The oldest of rocks contain fossils, the remains of plants and animals which, at the time the strata were deposited, lived in beds of water or were washed into them, or were brought to the surface by the deposits on the rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simplest 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 are 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. Where two sedimentary formations are remote from each 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 in the strata of different areas, prove, and continue to be the most important means for determining local histories in a general earth history.

It is in many places difficult or impossible to determine the age of an igneous rock, but the relative age of some can be obtained by geologic mapping. The age of the earth as a whole can be determined by meteoric rocks which are found in each of the original minerals and not that of the metamorphosed.

Symbols, colors, and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern and is labeled by a specific letter symbol. Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and other formations. Patterns of triangles and dots are used for igneous formations. Metamorphic rocks of unknown origin are represented by short lines irregularly placed in the rock. If the rock is slate, the slaty cleavage may be seen as a linear feature on the map.

The symbols consist of two or more letters. The letter A of a formation is known as the symbol includes the system, which is a capital letter or monogram; otherwise the symbols are composed of small letters.

The names of the systems and of series that have been given distinctive names, in order from youngest to oldest, with the color and symbol assigned to each system, are given in the subjoined table.

**Surface forms.**

Hills, valleys, and all other surface forms have been produced by geologic processes through the combination of erosion of the earth by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams and in cooperation with currents, build up and spits and bars. Topographic forms are composed of the record of the history of the earth. The hooked spits shown in figure 2 are an illustration. To this class belong alluvial plains, braided streams, drumlins (smooth oval hills composed of ground moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion.

The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and pedal plains. The making of a stream terrace an alluvial plain is first built and afterward partially eroded away. The shaping of a moraine or drumlin terrace is usually a double process, hills being worn away (degraded) and valleys filled up (aggraded).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and wear away the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried beyond the sea, and the sea is therefore called the base-level of erosion. Lakes or large rivers may determine local base-levels for certain regions. When a large tract is for a long time disturbed by uplift or subsidence it is degraded nearly to base-level, and the fairly even surface thus produced is called a pediplain. If the tract is afterward uplifted, the elevated pediplain becomes a record of the former close relation of the tract to base-level.

**Angular gravel sheets.**

The maps showing the areas occupied by the various formations is called an angular map. The map is a legend, which is the key to the map. The legend is arranged in the following order: the move meaning of any color or pattern and its letter symbol. The reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. It is intended to find any particular formation, its name should be sought in the legend and its color and pattern noted; then the areas on the map corresponding in color and pattern to the area of unknown origin are selected. If nothing is known of unknown origin and within each group they are placed in the order of age, so far as known, from the young to the ancient.

**Economic geology map.**—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the economic geology map is termed the economic geology map. The formations that are on the area geology map are shown on this map by lighter color patterns and the areas of productive formations are emphasized by stronger colors. A mine symbol is shown the location of an area of unknown origin and within each group they are placed in the order of age, so far as known, from the young to the ancient.

**Structural-geologic map.**—In cliffs, canyons, slabs, and other natural and artificial cuttings the relations of different beds to one another may be seen. Any cuttings that exhibits these relations in a column, such as the top flat surface of a sandstone or slate exposure, is called a structure section. The geologist is not limited, however, to natural and artificial cuttings for his information concerning the earth's structure. In the study of rocks and OMano I have traced the relations among the beds on the surface, he can not only determine the positions above them but can also determine the structure to a considerable depth. Such a section is illustrated in figure 2.

**Figure 2.—Sketch of a vertical section at the front and a landscape beyond.**

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so that the upper and lower underground relations of the rocks. The kinds of rock are shown by appropriate patterns of lines, dots, and dashes. This pattern is shown in figure 3. These patterns are used in figure 2 to represent the common kinds of rocks.

**Figure 3.—Sketch of a vertical section at the front and a landscape beyond.**

The rock, which is cut off sharply in the foreground on a vertical plane, so that the upper and lower underground relations of the rocks. The kinds of rock are shown by appropriate patterns of lines, dots, and dashes. This pattern is shown in figure 3. These patterns are used in figure 2 to represent the common kinds of rocks.

The problem shown at the top of figure 2 shows two points on the map, the shape of the rock and the distance from any mineral-producing or water-bearing stratum that appears in the section may be measured by using the scale of the map.

**Collector’s section.**—The geological section is usually shown by a collector’s section, which contains a concise description of the sedimentary formations that occur in the quadrangle. It presents a vertical cross section relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characteristics and depositional conditions are indicated graphically and by the word “unconformity.”

**GEORGE OTIS SMITH, May, 1883.**

Director.