DESCRIPTION OF THE VAN HORN QUADRANGLE.

By G. B. Richardson.

NORTHERN TRANS-PECOS TEXAS.

Across the northern part of trans-Pecos Texas, in the midst of which the Van Horn quadrangle is situated, ran these belts of highland separated by parallel belts of lowland, all having a northwest-southeast trend. (See fig. 2.) Needles in order from west to east they are the Franklin Mountains, the Huco Bolson, the Diablo Plateau, Salt Flat, the Guadalupe-Delamar-Apache Mountains, and the Toyah Basin (Pecos Valley).

The Van Horn quadrangle is situated in El Paso and Culberson counties, Tex., about 100 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 Cordillera 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.)

The region is characterized by mountains and intermontane plains having a northwest trend. (See fig. 2.) In general the highlands lack continuity, consisting of isolated peaks, groups of peaks, plateaus, narrow ridges, and broad mesas, slopes, and intermontane plains are called bolsons, a term of Spanish origin, current in Mexico, which is being introduced into the southwestern part of the United States.

Bolsons are elongated plains that commonly occupy structural basins and have been built up by wash derived from the disintegration of the rocks of adjacent highlands. Their central parts are almost level, but their margins slope up toward the highlands. Some bolsons are closed basins, being entirely surrounded by a rim, but many have outlets, which, however, in this arid climate, are practically free from surface drainage, unless the bolson is crossed by one of the few perennial streams of the area. If the climate were more humid bolson plains would not be formed, for the diurnal, instead of accumulating, would be carried away by storms.

Climate—Many of the characteristic features of the trans-Pecos region are due to its arid climate. The annual precipitation on the greater part of the area is about 15 inches, and in places is less than 10 inches. The common type of rainfall is the occasional heavy local summer shower of short duration. Such showers give rise to local torrential floods but yield no permanent runoff, for the short-lived streams that gather in the highlands disappear by absorption and evaporation shortly after reaching the lowlands.

The utility of the climate is emphasized by the vegetation, which is sparse and of the shrub type, so that the general appearance of the country is barren. (See fig. 3, illustration sheet.) Desert provides like yuccas, beargrass, ocotillo, creosote bush, palo verde, and a variety of bunch grasses are common. Except a few stunted junipers and pinyons on some of the highlands there are no trees in the Van Horn quadrangle. Only the highest mountains of the trans-Pecos region, like the Sacramento Mountains in New Mexico, support a forest growth.

Meteorologic records that have been kept for more than 50 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 63.4°F, the mean monthly maximum ranging from 87°F in January to 96°F in June, and the mean monthly minimum from 35°F in January to 69°F in July. The average daily range of temperature for the year is about 3°F. The annual average wind velocity is about 10 miles an hour. The maximum velocity on record was 75 miles an hour for short periods are not uncommon.

Geology.—The sedimentary rocks of trans-Pecos Texas include representatives of almost all the systems from the Algonkian to the Quaternary and are intruded or overlain, in parts of the area, by a variety of igneous rocks, as stated under the heading "Descriptive geology" (p. 26). The sedimentary rocks of trans-Pecos Texas are represented by a variety of sandstones, siltstones, and shales, and by the massive Silurian beds in the Hueco-Bolson, the largest of the bolsons in this quadrangle. Only the highest mountains of the trans-Pecos region, like the Sacramento Mountains in New Mexico, support a forest growth. 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 63.4°F, the mean monthly maximum ranging from 87°F in January to 96°F in June, and the mean monthly minimum from 35°F in January to 69°F in July. The average daily range of temperature for the year is about 3°F. The annual average wind velocity is about 10 miles an hour. The maximum velocity on record was 75 miles an hour for short periods are not uncommon.

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about 2500 square miles. A general view of the plateau escarpment from the east is shown in Plate II. The surface includes level, flat areas and in general slopes gently outward in a westward and southward direction 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 them, the Sierra Diablo, at the southeast corner of the plateau, bounds an irregular quadrilateral area on the south by an east-west escarpment 20 miles long, by a north-south escarpment 25 miles long and on the northwest by a northeast-southwest escarpment 15 miles long. The lowest of the Diablo Plateau escarpment, consisting of a point 6020 feet above sea level. From the crest the general surface slopes gradually westward toward the center of the plateau. North of the Sierra Diablo, nearly to the State boundary, the northeast corner of the plateau is marked by the Cerros Mountains and the Sierra Tempi Fina, two groups of isolated peaks of igneous rock and lava-capped masses fanned by Pecos and Centurion streams. The western boundary of the plateau, the Pecos River, formed to the Texas & Pacific Railway, is known as the El Indio Mountains, and farther north, near the State boundary, as the Hecox Mountains, the two a few miles separated by a narrow plain of about 500 square miles.

The plateau is formed of horizontal or gently inclined strata of Carboniferous age, capped by plains of Cretaceous sediments, and underlain locally by older Pecosan strata that outcrop in places on the lower slopes of the escarpments. The strata of the southern mountains are at some places exposed by the erosion of massive limestones of Carboniferous. The strata of the western mountains are deformed into a rude dome and are extensively intruded by limestone. The groups of the western mountains are formed chiefly of rocks of pre-Cambrian and early Paleozoic age, which at the northern end of the Diablo Plateau are divided into two branches of the western mountains. The eastern side of the quadrangle is occupied by a part of the Diablo Plateau, and the western end of Apache Mountains. The eastern side of the quadrangle is occupied by the Sierra Diablo in the north and by the Carrizo and Apache Mountains in the south. The eroded escarpments of the quadrangle are 5000 feet above sea level. A peak 3J 3 miles southwest of Figure Two ranch, rises to the sea of 9000 feet above sea level. The area south of the railroad consists of relatively low hills and ridges known as the Carrizo Mountains. The plateau is formed of horizontal or gently inclined strata of Carboniferous age, capped by plains of Cretaceous sediments, and underlain locally by older Pecosan strata that outcrop in places on the lower slopes of the escarpments.

The central portion of the plateau is in general a nearly level surface underlain by fossiliferous sand from the mountains, in part eroded and redeposited by the wind. The surface of the plateau is crossed by many small alluvial fans, which have been covered by sand dunes. The western part of the plateau is crossed by the Salt Flat, in the northern part of the quadrangle, a small alluvial fan, which has been covered by sand dunes and is dissected by sparsely timbered stream channels. The southern part of the plateau is dissected by a number of cross faults.

Another large bolson of the trans-Pecos country lying in part between the Llano Estacado on the north and the Diablo Plateau on the east is the Salt Flat bolson. A peak 3J 3 miles southwest of Figure Two ranch, rises to the sea of 9000 feet above sea level. A peak 3J 3 miles southwest of Figure Two ranch, rises to the sea of 9000 feet above sea level. The area south of the railroad consists of relatively low hills and ridges known as the Carrizo Mountains. The plateau is formed of horizontal or gently inclined strata of Carboniferous age, capped by plains of Cretaceous sediments, and underlain locally by older Pecosan strata that outcrop in places on the lower slopes of the escarpments. The strata of the western mountains are deformed into a rude dome and are extensively intruded by limestone. The groups of the western mountains are formed chiefly of rocks of pre-Cambrian and early Paleozoic age, which at the northern end of the Diablo Plateau are divided into two branches of the western mountains. The eastern side of the quadrangle is occupied by a part of the Diablo Plateau, and the western end of Apache Mountains. The eastern side of the quadrangle is occupied by the Sierra Diablo in the north and by the Carrizo and Apache Mountains in the south. The eroded escarpments of the quadrangle are 5000 feet above sea level. A peak 3J 3 miles southwest of Figure Two ranch, rises to the sea of 9000 feet above sea level. The area south of the railroad consists of relatively low hills and ridges known as the Carrizo Mountains. The plateau is formed of horizontal or gently inclined strata of Carboniferous age, capped by plains of Cretaceous sediments, and underlain locally by older Pecosan strata that outcrop in places on the lower slopes of the escarpments.

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Baylor Mountains.—In the central part of the quadrangle is an isolated highland area, trending northeast-southwest and about 6 miles in greatest width, called the Baylor Mountains. Though lower and less rugged than Beech Mountain, the Baylor Mountains form one of the most striking topographic features of the quadrangle. They jut out into Salt Flat, from which they are separated by faults, rising abruptly from 1000 to 3000 feet above the level of the plains. The northern point, 5650 feet above sea level, is in the southeast part of the mountains, and the highest summits are in general near the east side of the range. The mountains are underlain by gneiss, mica schists, and associated altered igneous rocks, and the other, the Millican, consists of schists, quartzite, slates, and associated dated and unconsolidated sediments and of a few small igneous masses of the Fusselman limestone. The Silurian, Devonian, and lower Carboniferous (Mississippian) periods are, as far as known, not represented by sediments, and the overlying formations, the Housie limestone of Pennsylvanian age, which with its local basal conglomerate is more than 2500 feet thick, rests unconformably on all of the older formations of the quadrangle. It should be noted that in the absence of fossils it is difficult in all parts of the quadrangle to distinguish the El Paso, Monahos, and Housie limestones, and that it is quite possible that the definition of those formations on the map is not everywhere exact. It is also possible—though no Silurian fossils have been found in the area—that small outlying masses of the Fusselian limestone (Silurian) may be present between limestones carrying Housie and Monahos formations.

STRATIGRAPHY.

The rocks of the Van Horn quadrangle consist of consolidated and unconsolidated sediments and of a few small igneous masses. The consolidated rocks range in age from Algonkian (?) to Cretaceous, and the unconsolidated are in part at least Quaternary. 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 Algonkian (?) rocks which have been separated into two formations. One, the Cariaco, consists of schists, quartzite, slates, and phyllite. The other, the Millian, consists of gneiss, mica schists, and associated altered igneous rocks, and the lower, the Millian, consists of gneiss, mica schists, and associated altered igneous rocks, and the upper, the Millian, consists of gneiss, mica schists, and associated altered igneous rocks. The general stratigraphic relations of these two formations are concealed by the greater metamorphism which the Carrizo has undergone. On account of the differences in the compositions and the thicknesses of the different formations of the district, it is not possible to name a group of sandstones and shales.

A small part of the Carrizo formation consists of schists which proximally represent igneous rocks that were injected in thin layers between the sediments. Of these the chlorite-schists are the most common. Although some may be metamorphosed arkose sandstones, those which were found to extend slightly across the original bedding plane of the adjacent arkose are altered basic igneous rocks. The chlorite schists have a pronounced green color and are distinctly foliased though some show an approach to granular texture. They are composed of dominant chlorite and in small amounts of mica, quartz, and feldspar.

The quartz beds are composed essentially of quartz and feldspar, with chert, feldspar, phyllite, and quartzite, with chert, feldspar, phyllite, and quartzite, with chert, feldspar, phyllite, and quartzite, with chert, feldspar, phyllite, and quartzite. The quartzite is generally parallel to the schistosity. Different proportions of quartz and mica give rise to the varieties microcline, quartz-orthoclase, and quartz schist, which last grade into quartzite.

These rocks constitute the great mass of the Carrizo formation. They occur in alternating bands, to which the schistose structure is parallel, and their composition and occurrence destroy the apparent direction of the adjacent alkali schists. The Carrizo formation is an aggregate of sandstones and shales.

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The conglomerate consists of angular to rounded fragments of red sandstone, cherty limestone, and conglomerate. The fine-grained red sandstone was called the Diablo sandstone by Von Steyeren and the Hazel sandstone by Dehlutke, but it has been found impractical to separate it satisfactorily from the cherty limestone and conglomerate.

**Distribution.**—The formation occupies a considerable area in the southwestern part of the quadrangle, chiefly in the Carrizo Mountains, between the Pecos and Pacific Railways. It outcrops in disconnected areas separated by wash, and its extent, thickness, and relations are not exactly determined, as shown on the map.

The sandstone consists mostly of the underlying hill district consisting of the Mesaverde sandstone and extends along the southern flank of the Sierra Diablo. It outcrops in the area north of the Sierra Diablo, where it outcrops, and in the southeastern part of the quadrangle, south of the Sierra Diablo, where it occurs continuously. The formations expose large blocks of strata, above which the Heron limestone forms a prominent cliff.

The limestone and conglomerate of the Miocene formation exhibiting weathering better than the sandstone and occupy areas of greater extent. The sandstone outcrops chiefly in the hills west, south, and southeast of the formation in the hills north and in Beach Mountain, and they generally form knobs trending with the strike of the strata.

**Character.**—The sandstone is homogeneous, dark red, and so fine-grained that its components can be distinguished in few hand specimens. In some fragments all the components of quartz and clay are apparent. Under the microscope it is seen that the texture is characterized by sedimentary and that the rock is composed chiefly of subangular or rounded minute grains of quartz and siltstone, with occasional calcite, the sandstone being coated with a thin film of red pigment—ferric oxide—that gives the uniform color to the rock. The homogeneity of the rock is pronounced that bedding planes can rarely be distinguished, and it is practically impossible to determine the thickness of the beds. The sandstone is of the fine-grained, thin bedded, varicolored type, usually of the type prevailing in the upper 1000 feet of the Santa Fe formation in the vicinity of Beach Mountain and the Longhollow limestone of central Texas and with the Littleton limestone of the Crockett quadrangle, Arit.

**Age.**—The upper part of the Van Horn sandstone contains numerous ammonial boulders and fossil.-like remains, but no fossils have been found in the formation and its age is therefore undetermined. However, because of its relation to the Upper Cretaceous system, it is designated as the Miocene age, or possibly Eocene. This formation is characterized by a considerable thickness of limestone that has been divided into two formations, the El Paso and Montoya limestones. The former is Upper Eocene and the latter Upper Cretaceous.

**Definition.**—The El Paso limestone is a massive gray magnesium limestone containing a Beekmantown (Lower Ordovician) fauna. It is named from El Paso, Tex., its type locality being in the Franklin Mountains north of that place. Its thickness is about 100 feet.
**Fossil and age.**—The Montoya limestone contains an abun-
dant fauna, especially in the upper cherty beds. The follow-
ing species from the Van Horn quadrangle have been identified by
E. O. Ulrich:

- *Corbula whitfieldii*
- Dicentraria americana
- *Hastigerina exigua*
- *Nassatina carinata*
- *Streptangina jolyi*
- *Streptocardium obsidionale*

In the El Paso-fúliers Montoya limestone, on the authority of E. O. Ulrich, were described the following two distinct forms, one identified as *Galeria* and the other as *Richmondia*. 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 Richmond age, with which conclusion Mr. Ulrich now agrees.

This fauna has a widespread distribution. It occurs in the Highel delomatol of Wyoming, the Fisk Reeves delomar of northeastern Utah, the Fremont limestone of Colorado, and elsewhere.

**Carboneous System.**

The greater part of the exposed consolidated rocks in the Van Horn quadrangle belongs to the Pennsylvanian and Per-
imian series of the Carboniferous system. The beds are divided into the Hueco limestone, Delaware Mountain formation, Cas-
tile graywacke, and Buda limestone. The Hueco limestone is Pennsylvanian and the other three formations are referred to the Permian. The Castile graywacke and overlying Buda limestone are parts of the group of red beds of the Poacca Valley. In the Van Horn quadrangle the top of the Hueco Formation in the southern end of the Delaware Mountains in a fault block sepa-
ated from the main occurrence a few miles to the east.

**Penrose series.**

**STUDIO LIMESTONE.**

**Definition.**—The Hueco limestone is a phase of the Hueco formation which is widely distributed in the trans-Pecos region. It is assumed to have been derived from the Hueco limestone in the El Paso quadrangle. In several areas the formation consists mainly of limestones, but in others, notably in the Sacramento Mountains, N. Mex., it comprises also considerable sandstone and shale, including red beds, and in many places a basal conglomerate. In Texas the Hueco is at least 5000 feet thick, of which about 1800 feet is typically nonmagnesian, an analysis by Chase Palmer of E. O. Ulrich, was described as containing two distinct

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near the Van Horn quadrangle. In a number of outcrops on the Díáhíó plains an eroded surface of the limestone is directly overlain by Cretaceous strata, and in many places a basal conglomerate. In the Castile graywacke the overlying Buda limestone is a distinct forma-
tion, and is separated from the main mass of the formation by a fault.

**Distribution and characteristic.**—The Hueco limestone outcrops copiously in the Sierra Diablo, where it forms the entire sequence north of Victoria Peak and the crest of the escarp-
ment south of that peak; it also underlies the surface of a large part of the Díáhíó plains. It forms nearly the whole base of the Buda and Wylie mountains, makes up a large part of the edge rising north of the railroad between Van Horn and Oehren, and occurs in small outlying hills here and there in the western half of the quadrangle. Some of the cliffs it forms are shown in Plate II, VI, and VII.

In the Van Horn quadrangle the formation consists almost wholly of limestone, but in some places it includes thin beds of dark clay shale, gray quartzose sandstone, and a basal conglomerate. The limestones range from massive to thin banded, the transition being well shown in some of the cliffs along the Sierra Diablo. In some cases bedding planes are distinctly indistinct, but in others the limestone is distinctly banded and laminated. The limestones are typically nonmagnesian, an analysis by Chase Palmer of E. O. Ulrich, was described as containing two distinct

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tion, and is separated from the main mass of the formation by a fault.

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

"The formation of Pennsylvanian in age, but, owing to the peculiar Assemblage of forms in the hues and investigators of the Hueco limestone of the West, it is impossible at present to indicate its exact position in the typical Pennsylvanian section."
The Castile formation, consisting of massive gypsum, is named from Castile Spring, which is situated about 25 miles northeast of the Van Horn quadrangle. The main mass of the formation occupies several hundred square miles between the eastern base of the Delaware Mountains and the Rustler Hills. The gypsum is a massive white granular variety. A characteristic sample analyzed qualitatively by W. T. Schaller shows it to be an unusual composition. On the surface the gypsum is generally disintegrated and earthy and commonly associated with sandstone. A characteristic sample analyzed quantitatively by W. T. Schaller has its typical development. The series is divided into three general parts, to which are assigned the Comanche, Seminole, and Fredericksburg groups. The former is a diminutive Productus semireticulatus var. capitanensis. The latter is a small Myalina, the other being perhaps Schizodus and Anisopyge. Anisopyge perannulata. Spirifer mexicanus. The Fredericksburg and Wastihis groups are known north of the San Antonio area.

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Analysis of Rustler limestone.

The Rustler limestone caps a basement of arkose and shale, extending as far east as the Sierra Blanca. It is the lower member of the Fredericksburg group, forming a part of the lower part of Salt Flat. The formation is intercalated with the red beds of the Hueco formation in places where the Washita formation is immediately under the surface. It is exposed on the surface of the central part of Salt Flat, where it forms a part of the lower Bedder Clay, which is composed of unconsolidated gray and white sandstone with some lenses of conglomerate. One area is 7 miles west of Van Horn, where the beds cap the railroad, where the beds occur in several isolated areas.
of rhyolite. The surface is greatly weathered, but fresh exposures above a dense fine-grained greyish to reddish rock composed of small phenocrysts of quartz and orthoclase, and albite intergrown as microliths in a groundmass consisting of minute grains of interlocking quartz and feldspar, carrying spots of iron oxide. The phenocrysts are much broken, and the rock shows evidence of having been subjected to pressure. The rock is usually coarse grained, composed of plagioclase, biotite, and amphibole, with subordinate orthoclase and quartz. The outer portion is diorite, being composed of more calcic plagioclase (chiefly andesine) and augite, with no quartz.

STRUCTURE

The Van Horn quadrangle.

The dominant structure of the trans-Pecos region is expressed in the northwestern to northward trend of the highlands and intervening lowlands. The highlands are areas of relative uplift, and the lowlands are basins and valleys. Most of the highland areas are bounded by faults that strike in general with the main trend of the region, though some cut the trans­verse. In the lowland areas, the boundaries are usually related to the older folds. Most of the highland areas are generally paralleled, or arc inclined at greater or less angles that form, and on the central parts of the trans-Pecos Texas north of the Trans Pecos highway. The area between the Sierra Diablo and the Pecos River has a series of regional uplifts and subsidences and of slight local pre­

van Horn, which R. T. Hill and J. A. Udden consider to have been the mountain is composed, is in fault contact on the south and east by a fault. The Milliken formation, of which the mountain is composed, is in fault contact on the east and south of Van Horn, and the Van Horn and the Texas limestone are slightly offset. (See PL. III.) In the northern part of the mountain chert and limestone are exposed, in the south, 2.50 K., but in accordance with the plunge of the syncline at the west end of the mountain the strata are more褶皱 than the trend of the flank of the Sierra Diablo is concealed by the unconsolidated deposits in the southern part of the quadrangle.

One of the principal zones of displacement of the quadrangle is at the eastern base of the Sierra Diablo, along which the fault plane passes. The fault shows a displacement of about 1300 feet. An example of "dip" along the fault is shown about a mile north of the mouth of the Sierra Diablo, where beds dipping southeastward are offset 50° 20' west.

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In the Van Horn quadrangle the eastward extension is concealed by the unconsolidated deposits in the southern part of the quadrangle.

Delaware Mountains.—The Delaware Mountains are an east-west-trending 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 foothills, forming a downthrown block, in which the maximum dip of the strata is 10° SW. The rocks of the main Delaware Mountains dip 10° SW. At the eastern end of the range there are a number of smaller ridges and a low, east-west-trending mountain range. The rocks in this mountain range are diversified and a low, axial valley of small extent. The abruptness of the edge of the Apachian Mountains is concealed by the unconsolidated deposits in Salt Flat. The outcrops in this block are chiefly the Castle gypsum and the overlying Rustler limestones, which have been faulted down along the Delaware Mountain formation...
Triassic and Jurassic sediments deposited elsewhere. But to
not, as in other regions, accompanied by folding of the rocks.
marked by continental uplift, which, however, in this area was
given way with some alternations to shallower water and to local
emphasizes the variability of late Carboniferous stratigraphy
onous material was succeeded by the accumulation of the great
epoch was accompanied by profound erosion in the Van Horn
Hueco limestone.
were never deposited or were removed by erosion is not known.
do occur in the Van Horn quadrangle, but whether they
periods, when the Algonkian (?) rocks probably formed a land
face, possibly to form part of a mountain area, and were acted,
and water. The deposits were indurated to conglomerate,
known of the outline and extent of these early bodies of land
the present topography highland areas rising abruptly above
which in the trans-Pecos region so little is known, the area
of the deposits bear witness to the fact. Upper Cretaceous
of the deposits appear to have been laid down in water con-
derived westward instead of in their present some-
tributaries of the north fork of Victoria Canyon probably
instance, where great bodies of water, the best known of which
land an area of corresponding depression. During and sub-
sequent to these movements the Quaternary record is one of
highlands being areas of uplift and the low-
canyons and coalesce, scallop fashion, with the alluvial slopes
the wind. Alluvial fans, consisting of heterogeneous masses of
rare earths, clay, and gravel; and locally plentiful underground water.

COOPER AND SILVER.

Copper and silver have been found at several places in the Carrizo Mountains, but thus far only one paying mine, the Huaz, has been opened in the quadrangle—and the Huaz for many years has been unworked.

Hazel mine.—The Hazel mine is situated close to the southern base of the Sierra Diablo, 10 miles northwest of Van Horn. It is said to have been opened in 1892, and to have been worked for eight or ten years, after which, until 1912, it remained idle. It is reported to have yielded silver ore worth several hundred thousand dollars.

W. E. Von Strassen* described the Hazel mine in 1892. The property was worked from two shafts, 575 and 375 feet deep, situated 1800 feet apart, and numerous crosscuts made the workings rather extensive. The ore was found in veins and pods, and was impregnated with grey and iron rock, the principal minerals being copper sulphides and carbonates, with some gold and silver. The workings were extensive, but thus far no paying properties have been developed.

Recent development shows that mineralization has taken place in a zone of narrow faults between the larger displacements at the southern end of the Sierra Diablo. Surface stripings show three mineralized belts striking from N. 60° E. to N. 80° E., each consisting of a bed of country rock, the fine-grained sandstone of the Million formation, from 3 to 6 feet wide, which has been bleached to a buff or creamy tint. This bleaching has, however, been so thorough as to destroy the main vein which swell and pinch irregularly, the greatest thickness reported by the engineer in charge being 18 inches. In one place the main vein, there 2 to 4 inches thick, princi-
ally vertical, is bounded on one side by a slickensided fault
surface and branches on the other side into many minute inter-
connecting vehicles, the whole constituting a mineralized zone 3 to 5 feet thick. The most important minerals noted were chal-
copyrite, tetrahedrite, messeract, and azurite in a gangue con-
isting largely of basalt or andesite.

Prospects in the Carrizo Mountains.—Prospects at various places in the Carrizo Mountains, in the Million and Carrizo formations, show a rather widespread area of mineralization, but thus far no paying properties have been developed. The ore is contained in seams of black talc, in aggregate disseminated at various places, but, as at several localities in the Carrizo formation south of the Pacific Railway, the veins are in schist and slate along joints or parallel to the planes of laminations. Spreading of the ore is rather wide and
sporadic. The ore consists of copper minerals in different stages of oxidation. At the old Mahly prospect, 6 miles west of Van Horn, copper ore has been found. Ames are reported to show traces of silver and gold.

The yield of the old Hazel mine indicates the hope that profitable deposits may be found elsewhere. The disturbed character of the Algonkian (?) formations, the many faults by Sierra Diablo, 2J miles southwest of Figure Two ranch headquarters, have been removed by erosion. Samples show small tektite crystals of wollastonite with associated iron oxides. The material has not been found in any considerable quantity.

**TUNGSTEN.**

Tungsten deposits are reported from the eastern end of the Sierra Diablo, 2J miles southwest of Van Horn, and at the Knight (old Malheur) copper prospect a mile to the southwest. The chief occurrence is at the Hidden prospect, which was opened in search of the tungsten. The mineral forms a semi-soluble thin deposit on the floor of tin wire. In a fine-grained rock, probably altered rhyolite, in the Carrizo formation. The tungsten is of a good sky-blue or green-blue color, but very limited of it has yet been found.

**LIMESTONE AND MARBLE.**

The supply of limestones suitable for the various uses to which this rock is adapted is practically inexhaustible. The deposits, however, are not sufficient to meet the wants of 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 occurrence of the Sierra Diablo 5J miles southwest of Van Horn and at the Knight (old Malheur) copper prospect, a mile to the southwest. The chief occurrence is at the Hidden prospect, which was opened in search of the tungsten. The mineral forms a semi-soluble thin deposit on the floor of tin wire. In a fine-grained rock, probably altered rhyolite, in the Carrizo formation. The tungsten is of a good sky-blue or green-blue color, but very limited of it has yet been found.

The sandstone of the Millican formation is of exceptional quality for this part of the State. The analyses show that the water at Figure Two ranch well contains enough mineral matter to make it unsuitable for drinking purposes. The analyses of water from the Van Horn quadrangle, however, have been made by the U. S. Geological Survey, and are reported to yield 50,000 gallons a day.

### Analyses of water from the Van Horn quadrangle.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total solids at 180° C</td>
<td>ppm</td>
<td>482</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>ppm</td>
<td>27</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>ppm</td>
<td>23</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>ppm</td>
<td>938</td>
</tr>
<tr>
<td>Sodium and potassium (Na-K)</td>
<td>ppm</td>
<td>137</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>ppm</td>
<td>122</td>
</tr>
<tr>
<td>Sulfate (SO4)</td>
<td>ppm</td>
<td>14</td>
</tr>
<tr>
<td>Total hardness</td>
<td>ppm</td>
<td>90</td>
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The analyses show 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, 2J miles south of Van Horn, shows that the water is similar to the water at Figure Two ranch well.

### WATER RESOURCES.

There are no permanent streams in the area. During and shortly after heavy local showers storm water gathers in arroyos, but much of it disappears by absorption and evaporation. Some storm water is collected, however, in ravines known as "wells," where there have been built across drainage ways. Large quantities are thus intermittent for watering cattle. This is the most practical way of developing water in the highlands.

The main supply of water in the lowlands is derived from wells in unconsolidated deposits supplied by that part of the precipitation which is not lost through evaporation and percolation. The water percolates downward until it reaches the zone of saturation, the upper surface of which is known as the water table. In a large part of Salt Flat the water table is shown by numerous wells to be between 3500 and 3600 feet below sea level. The data are not sufficient, however, to show its exact position throughout the area. In the lower part of the basin it is within 10 feet of the surface, and over a wide area it can be reached within 200 feet, the depth increasing with the surface elevation. Adjacent to the margins of Salt Flat ground water lies at a considerable depth and a number of dry holes have been sunk. There are several wells on the margins of Salt Flat, but these are deep and yield large quantities of water. On the other hand, the Rods well in the extreme northeast corner of the quadrangle was sunk in 1905 to a depth of 916 feet, without finding water. Almost all mine districts being reported through limestones 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 general character. Toward the center of Salt Flat, where there are considerable accumulations of gypsum and other evaporites, much of the underground water is strongly impregnated with salts, but toward the periphery of the basin it is much less saline.

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A partial analysis of a sample of the water from Salt Lake, 2J miles south of Figure Two ranch headquarters, collected by J. M. Dougherty in June, 1912, shows it to be an ordinary brine, containing principally sodium chloride and calcium sulfate.

December, 1913.