AREAL GEOLOGY OF PAINTHORSE QUADRANGLE

CULBERSON COUNTY, TEXAS

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CULBERSON COUNTY, TEXAS

by

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THESIS

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ABSTRACT

Painthorse quadrangle is structurally high on an eastward-sloping homoclinal flexure of the Delaware Mountains. This quadrangle is divided into two major lithic units; the gypseous Castile is the bedrock formation of the eastern half of the quadrangle, the limestones and sandstones of the Delaware Mountain group comprising the western half.

The western half of the quadrangle is an area of low, rolling hills and flat, broad valleys. The soil is extremely fertile. Paleontological evidence supports the presence of the Manzanita limestone member of the Cherry Canyon. The South Wells member could be present. The Lamar member of the Bell Canyon formation is exposed as a westward-facing cuesta.

The weathering characteristics of the Castile gypsum directly control the topography of the eastern half of the quadrangle; the result is a karst topography. The soil derived from the Castile is almost sterile and the plants growing in it are especially adapted to its chemical make-up. The Rustler formation is found only as caps on the highest hills. The Cretaceous Cox sandstone unconformably overlies the Permian Pierce Canyon redbeds. Conglomerates composed of various ratios of Cox, Pierce Canyon and Rustler pebbles occur as sinkhole deposits throughout the area.

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ILLUSTRATIONS

INTRODUCTION

Painthorse quadrangle has within its boundaries the surface expression of a very thick deposit of anhydrite on the eastward-sloping homocline of the Delaware Mountains. The Castile-Lamar contact which extends diagonally across the quadrangle delineates the boundary between the gypsiferous Castile formation to the east and the calcareous limestone members of the Delaware Mountains to the west. The areal geology of Painthorse quadrangle cannot be fully understood unless both of these areas are considered. This is the first paper to report the areal geology in detail, and the accompanying maps (pl. I and II) are the first detailed geologic maps.

The purposes of this paper are to present data on stratigraphy, structure, paleontology, and areal distribution of the formations, and their extant flora, and to interpret the areal geology by consideration of these features.

As shown by the index map (pl. III) the Delaware Mountains are in central Culberson County, Texas; they are east of the Salt Basin. They extend northward, in line with the Guadalupe Mountains, to the Texas-New Mexico border. Their southern extremity is marked by Seven Heart Gap.

Painthorse quadrangle is just north of Seven Heart Gap on the eastern slope of the southern Delaware Mountains. It is an area of approximately 64 square miles bounded by the parallels N 31° 22' 30" and 31° 30' and the meridians 104° 22' 30" and 104° 30' W. It is NE of Van Horn, W of Pecos, and W by N of Toyah. These Texas towns are on U. S. Highway 80 and are served by the Texas and Pacific Railway. The United States Coast and Geodetic Survey's triangulation station, Paint (31° 27' 10.339"; 104° 26' 07.884") is located within the quadrangle; its name as well as the name of the quadrangle were derived from Painthorse Draw whose physiographic features dominate the topography and control the drainage of the central part of the quadrangle. Parts of the Looney Ranch, the Jones Ranch, the Foster Ranch, the Rainey Ranch and the Owens Ranch are included in the quadrangle.

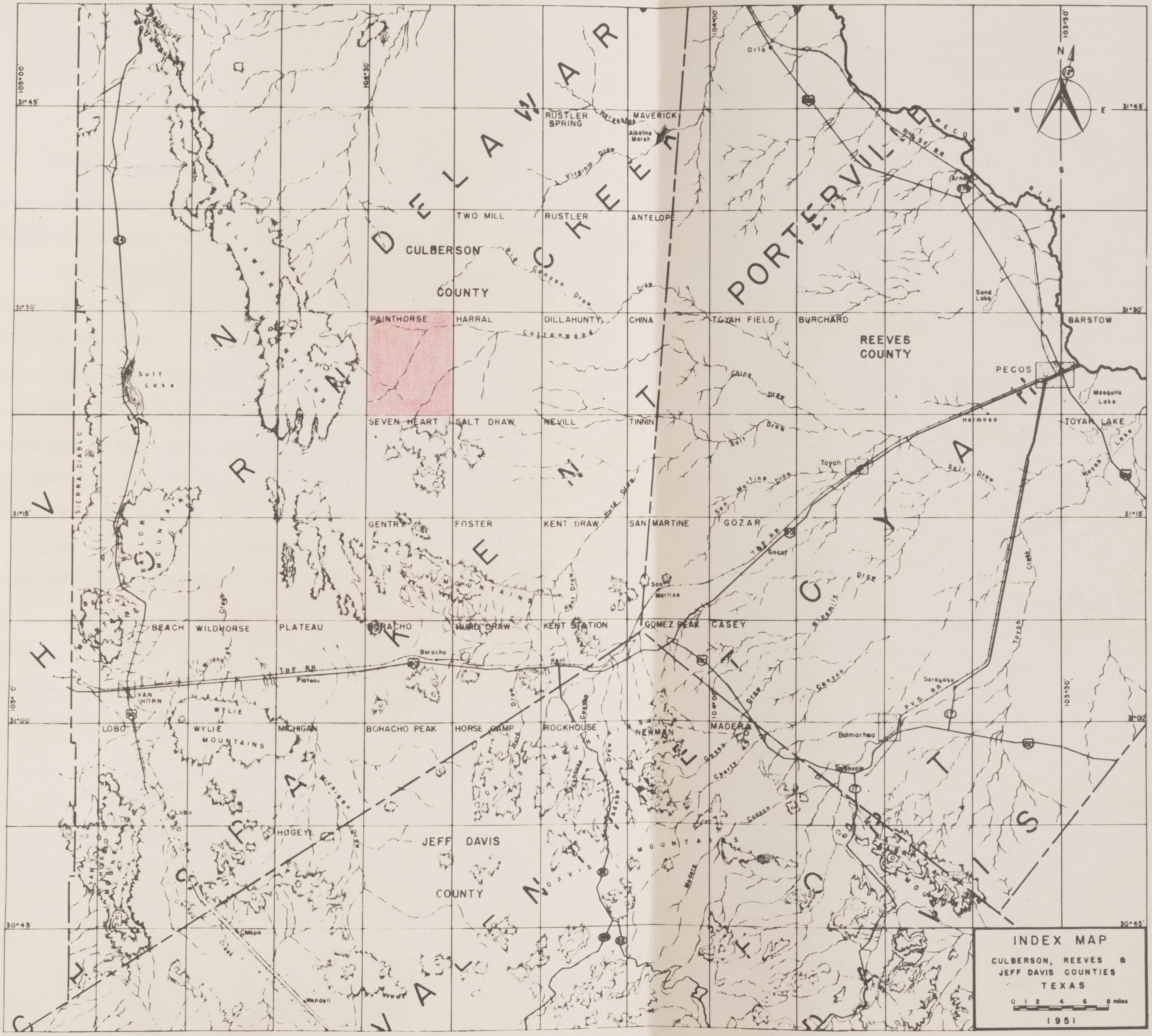
There is one county road which runs through the middle of the quadrangle bifurcating near the northern border. The western arm extends through the Owens Ranch to U.S. Highway 62 and 180; the eastern fork continues to the city of Pecos via Toyah. The county road runs S until it joins Highway 80, 8 miles east of Van Horn. This road is not improved. It is blighted by deep holes and ruts, outcrops of indurated bedrock, and during periods of heavy rainfall is, in some locations, completely submerged. Only specially equipped vehicles can travel this road after a heavy rainfall.

G. B. Richardson's (1904) reconnaissance map of Northern

Trans-Pecos, Texas, and P. B. King's recent (1949) regional map are the only published works on the Painthorse quadrangle.

A period of eight weeks of field investigation was required to complete the mapping. This was accomplished during the months of July, August, and September 1951. Edgar Tobin Aerial Surveys of San Antonio, Texas, made available the aerial mosaic used. Continental Oil Company of Midland, Texas, generously loaned copies of aerial photos which proved to be invaluable aids in mapping the area. The scale of the mosaic is one inch equals 2000 feet; this scale shows detail remarkably well. The photos with a larger scale, one inch equals 1650 feet, indicated the presence of even the smallest structure or physiographic feature. The finely detailed characteristics of the map were obtained by an incalculable number of observations made possible only by traveling by foot over the terrain. The Brunton compass and steel tape were the only field instruments used.

The procurement of supplies presented a problem. A limited quantity of food was brought from Austin in order to combat the prevailing higher prices in the area, and to prevent frequent trips to Van Horn, the nearest town, 44 miles from the quadrangle. Gasoline was purchased in Van Horn and carried in five gallon drums to the living quarters where it was stored. Cistern water for drinking and cooking was available and was generously shared by the rancher who supplied the living quarters. "Gyp" water was used in the cooling system of the always overheated jeep, which served as transportation on the trails.


INDEX MAP
CULBERSON, REEVES & JEFF DAVIS COUNTIES TEXAS
0 1 2 4 6 8 miles
1951
CULBERSON COUNTY
REEVES COUNTY
JEFF DAVIS COUNTY
DELAWARE
PORTERVILLE
RUSTLER SPRING
MAVERICK
TWO MILL
RUSTLER
ANTELOPE
PAINTHORSE
HARRAL
DILLAHUNTY
CHINA
TOYAH FIELD
BURCHARD
BARSTOW
PECOS
SEVEN HEART
SALT DRAW
NEVILL
TINNIN
TOYAH LAKE
GENTRY
FOSTER
KENT DRAW
SAN MARTINE
GOZAR
BEACH
WILDHORSE
PLATEAU
BORACHO
HURD DRAW
KENT STATION
GOMEZ PEAK
CASEY
LOBO
MICHIGAN
BORACHO PEAK
HORSE CAMP
ROCKHOUSE
NEWMAN
MADERA
HOGEYE
VAN HORN
Salt Lake
Sand Lake
Mosquito Lake
Toyah
Balmorhea
Saragosa
Orla
Arno
Hermosa
Boracho
Kent
Plateau
Lobo
Chispa
Wendell
T&P RR
P.V.S. RR
SIERRA DIABLO
WYLIE MOUNTAINS
DAVIS MOUNTAINS
31°45'
31°30'
31°15'
31°00'
30°45'
105°00'
104°30'
104°00'
103°30'
N
S
E
W

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To George Sealy, the writer is most deeply indebted. His willingness to work, his thirst for true knowledge, and his unlimited capabilities aided greatly in obtaining the successful results described in this paper. Special gratitude must be expressed to Professor R. K. DeFord for field supervision and editing and to Professor F. M. Bullard for editorial suggestions which made this paper possible in its final form. Grateful acknowledgement is also made to Professor B. C. Tharp whose broad knowledge of botany aided in solving diverse problems of plant ecology.

Finally, the writer is deeply grateful to Messrs. Jap Foster, Frank and Clyde Jones, Bob Owens, W. A. Rainey, K. P. Looney, and especially to Mr. and Mrs. E. F. Whitehead for hospitality and permission to work in this area.

REGIONAL STRUCTURE

The most important structure reflected in the Permian formations is the Delaware Basin. The formations dip gently ($1/2^{\circ}$-1°) eastward on a homoclinal flexure toward the center of the basin. The rim of the basin is formed by peripheral limestone deposits; the clastic calcareous silicate rocks within the basin grade into the marginal limestone; the lower part of the overlying evaporites abuts against the limestone and wedges out; the upper part oversteps the rim. A number of Tertiary normal faults which almost coincide with the present northwest-trending western boundary of the basin are present; the original boundary of the basin was farther west.

LOCAL STRUCTURE

Syncline.- In the southeastern corner of this quadrangle is a small syncline, the axis of which trends S 65° E. The southwest flanks dip 20°-25°, N 35° E and the northeast flank dips 18°-25°, S 35° W. Field observations indicate that this structure was formed by solution. The oldest formation within the syncline is the Permian Castile. This structural feature probably was formed in late Tertiary time, but a definite age determination of solution-formed structures is extremely difficult to make.

Fig. 1- Secondary calcite filling in the zone of a fault plane. Viewed toward the E in the $NE\frac{1}{4}$ $SE\frac{1}{4}$ $NE\frac{1}{4}$ of Sec. 13, Blk. 100 PSL.

Fig. 2- General view of the topography of the SE$\frac{1}{4}$ SW$\frac{1}{4}$ of Sec. 3, Blk. 92 PSL. Viewed toward the E, showing Rustler Hills in the background.

Anticline.- A large anticline plunging S 85°E is in the northwest corner of the area. The northwestern flanks dip N 20°E, and the southwestern flanks dip S 25°E.

Faults.- The area discussed in this paper is crossed by several faults. Evidences of movement of the earth's crust can easily be seen; strata have been extensively displaced; secondary calcite has filled in the zone of some fault planes. The longest fault in the quadrangle is approximately 3 miles long, and trends N 80° W. Although most of the faults follow this direction in the SE¼ of Sec. 12, Blk. 100 and the SW¼, Sec. 8, Blk. 101 PSL, there are three faults which trend approximately N 45° W.

PERMIAN SYSTEM

G U A D A L U P I A N   S E R I E S

Cherry Canyon formation

Manzanita limestone member.- The Manzanita member is named for Manzanita Spring, near the Frijole Post Office, 38 miles NNW of the Painthorse quadrangle (King, 1942, p. 581). At its type locality, it is separated from the top of the formation by a few feet of fine-grained limestone. It is a brownish black (5 YR 2/1); (Goddard, et. al., 1948) micrograined to paurograined limestone, and is very resistant to weathering. *Waagernoceras*, *Parafusulina*, and *Leella* sp. are present in this member in the Painthorse quadrangle.

Fig. 3- General view of measured section B, NW$\frac{1}{4}$ SE$\frac{1}{4}$ of Sec. 9, Blk. 100 PSL, viewed toward the E.

South Wells (?) limestone member.- The South Wells limestone is named for the South Wells of the D Ranch, 11 miles southeast of Guadalupe Peak, 35 miles NNW of the Painthorse quadrangle. A correlation of this member and a limestone unit observed in Painthorse quadrangle is doubtful. Nevertheless, structural and lithological evidence indicate that the South Wells could be present in the area studied. The South Wells (?) limestone member is medium dark gray (N 4) and is micrograined to paurograined. This member, like the Manzanita, contains Parafusulina and Leella sp.

Bell Canyon formation

The upper formation of the Delaware Mountain group is named for Bell Canyon, which is 40 miles N of Painthorse quadrangle (King, 1942, p. 581). Within the Bell Canyon formation, four persistent limestone beds have been set off as members, but of these four, only one, the Lamar, is exposed in Painthorse quadrangle. Some sandstone layers in the Bell Canyon are exposed; like those in the Cherry Canyon, they are very fine-grained.

Lamar limestone member.- W. B. Lang (1935, p. 262) named the Lamar limestone member of the Bell Canyon formation; its top is the top of the Delaware Mountain group. The type locality of the Lamar is 15 miles E of Guadalupe Peak, near Lamar

Canyon; 35 miles N by E of Painthorse quadrangle. Although it is 100 feet thick (Owen, 1951, p. 17) in the Seven Heart quadrangle (pl. III) 8 miles to the S, it is only 10 feet thick in the Painthorse quadrangle, where it forms a low, westward facing cuesta. In the northern Delaware Mountains, a layer of slabby sandstone, which is the top of the Bell Canyon, separates the Lamar from the overlying Castile (King, 1942, p. 586). In Painthorse quadrangle the sandstone is absent and the Castile lies directly on the Lamar. The Lamar member, in the area studied, is a medium dark gray (N 4) paurograined limestone, which when exposed to weathering becomes platy and fissile, and pale yellowish orange. Weathering has stained the member with limonite. Near the top it is finely laminated. The laminae are approximately 0.3 mm. thick and appear as alternating black and white layers. Both kinds of laminae are calcium carbonate. The darker layers are more heavily impregnated with bituminous material, which imparts the darker color.

Several specimens of "highly fossiliferous" material were collected from the Lamar member in the field; but upon examination under laboratory conditions, these specimens revealed no fossils whatsoever. The "fossils" appeared to be cherty or calcitic concretions approximately the size of small coral or fusulindae, and were very misleading.

Fig. 4- Bell Canyon sandstones below the Lamar limestone member which caps the hill. Viewed SSE in the NE$\frac{1}{4}$ SW$\frac{1}{4}$ of Sec. 1, Blk. 96 PSL, at fossiliferous locality no. 5.

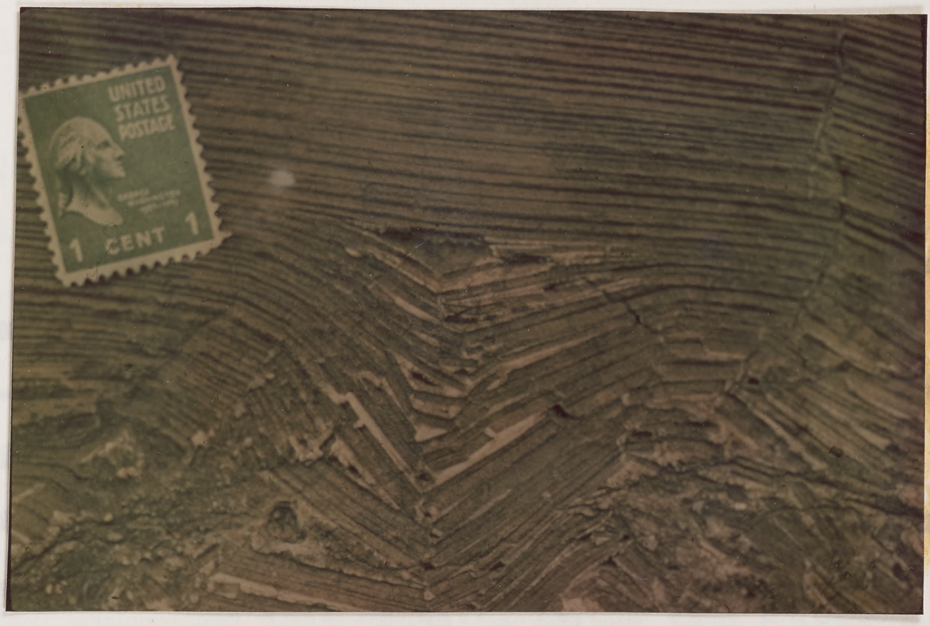

Fig. 5- Laminations in the Lamar limestone member of the Bell Canyon showing slippage or slumping. Viewed toward the E in NW¼ SW¼ NE¼ of Sec. 14, Blk. 96 PSL.

That part of the Bell Canyon which is below the Lamar is composed of grayish orange (10 YR 7.5/4) limestone and sandstone. Outcrops were few in number; for the most part, they appeared as narrow, linear belts at the base of hills capped by Gozar gravel.

O C H O A N   S E R I E S

Castile gypsum

Definition.- Richardson (1904, p. 43) named the Castile gypsum after Castile Spring which is about 12 miles S of the Texas-New Mexico border in central Culberson County, 40 miles ENE of the Painthorse quadrangle. He also measured a section in Cottonwood Draw and stated the rock to be "considerably cracked and joined" (sic).

Lithology.- For the most part the outcrops are composed of gypsum which alters to gypsite; at some places samples of anhydrite are located on the surface, but are usually limited to the subsurface. In the subsurface, the main constituent of the formation is calcite-banded anhydrite, composed of alternating bands of calcite and white (N 9) coarse paurograined anhydrite. There is enough bituminous material in the calcite laminae to stain these carbonate layers dark brown. The anhydrite layers are 3 to 4 mm. thick, four times as thick as the calcite veins which average 0.75 mm. There seems to be no regularity in band size or arrangement as core samples of this formation taken at various depths show wide differences in laminal width and pattern. Nevertheless, as the base of the formation is approached, the laminae seem to become thinner, and the grains of the anhydrite become much finer (DeFord, oral communication, August 1951).

For some time past, a few authors have chosen to designate thin layers of highly bituminous calcite as the "petroliferous Castile." Such layers were found at several locations in the area studied. An especially good exposure of the "petroliferous Castile" is in the NE$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$ of Sec. 21, Blk. 96, PSL.

Painthorse limestone member. - In Painthorse quadrangle, the basal portion of the Castile formation has a distinctive lithology. The bottom bed of this formation seems to be formed from the coalesced thin calcitic layers that appear in higher levels of the Castile. The result is the formation of a gray granular limestone which exhibits some strange characteristics. As a tentative proposal for field use, this limestone is herein designated as the Painthorse limestone member of the Castile formation (pl. II). The Painthorse member appears to lie conformably on the Lamar member of the Bell Canyon formation. Because the Painthorse weathers readily, it forms low round mounds.

"Ripple-marks".- In the Painthorse limestone member of the Castile, some unusual structural elements occur. Upon

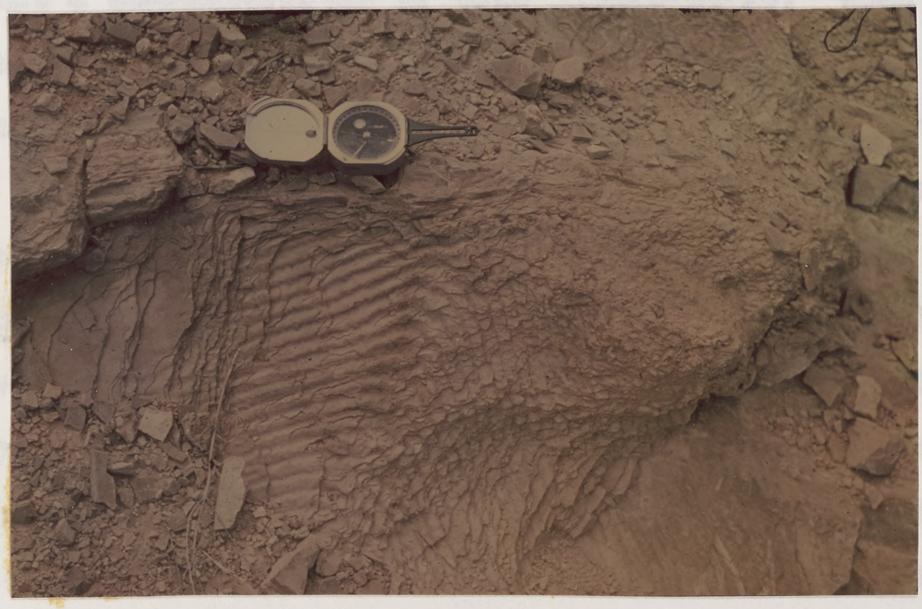

Fig. 6- Pseudo ripple marks in the Painthorse limestone member of the Castile formation. Viewed WNW in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ of Sec. 12, Blk. 96 PSL. The pointer of the Brunton compass points due N.

casual observation, these elements appeared to be ripple-marks, but more careful investigation revealed that these structures are actually pseudo ripple-marks. Photographs of these "ripple-marks" show that they exhibit right-angle convolutions (pl. IX). This is not a characteristic of true ripple-marks. When a specimen was cut perpendicular to the axis of the plications, a series of distinct layers were revealed. Each layer followed evenly and smoothly the surface of the underlying crenulation. This also is not characteristic of true ripple-marks (Ingerson, 1942, p. 568).

Characteristics of weathering.- Half the topography of Painthorse quadrangle is directly determined by the weathering characteristics of the Castile gypsum. This formation, under the impact of seasonal torrential rains, goes into solution very readily; in the presence of meteoric water the original anhydrite alters to hydrous calcium sulphate or gypsum, which in turn disintergrates without change of composition into an aggregate of loose uncemented grains, that is, into gypsite. The high rate of solubility causes the formation of subterranean caverns and sinkholes into which most of the rainfall disappears. The writer observed openings which are several feet in diameter. For the most part, these solution cavities are in old stream beds or in minor draws which control the local drainage. The stream beds are very deep; yet several of them are only three feet wide. The end result is the production of karst topography.

As the water dissolves the underlying beds, the surface layer of the formation slumps; thus sinkholes of varying sizes are formed. In some places a crust is formed on the surface that produces a hollow sound when struck with a hammer. Under the thin crust is a dry powdery gypsum.

Areal distribution.- The Delaware Mountains to the west and the Rustler Hills to the east are the boundaries which border the belt of Castile that runs NNE through Culberson County, Texas. In the area studied, the Castile-Lamar contact trends NE-ward so as to divide the rectangular quadrangle in half. This areal distribution serves to heighten the lithic contrast between the Castile formation and the Delaware Mountain group.

Structure.- R.H. King (1947, p. 477) suggested that the lamination of the anhydrite in the Castile should be ascribed to seasonal variations in temperature and resultant variations in relative solubility of anhydrite and calcite, rather than to cyclical interruption of deposition. The laminae are different widths at different locations.

Udden (1924, pl. 7) graphically pointed out that fracturing, waving of the laminae, and slipping are characteristic of this formation.

Considering the Salado halite, which unconformably overlies the Castile in the deeper part of the Delaware Basin, the writer believes that the Salado was never deposited in the

Fig. 7- Typical U-shaped valley cut in the Castile gypsum. Viewed toward the N in the NW¼ SW¼ of Sec. 8, Blk. 93 PSL.

Painthorse quadrangle; or, if deposited, it was completely eroded before deposition of the Rustler. The Castile in the Painthorse quadrangle is overlain unconformably by the Rustler, which, owing to truncation, rests on successively older beds of the Castile as it extends westward. It is generally accepted that a period of erosion took place during pre-Rustler time. Furthermore, the area studied is also topographically and structurally high on the eastward sloping homocline of the Delaware Mountains; although this position was attained in Tertiary time, it is possible the western side of the Delaware Basin was already positive enough in late Permian time so that this area was never submerged by the water from which the Salado precipitated.

Rustler formation

The Rustler formation was also described by Richardson (1904, p. 44) and named from exposures in the Rustler Hills in eastern Culberson County, Texas.

In the Painthorse quadrangle, the Rustler is a hard pale yellowish brown (10 YR 5/2), massively bedded, micrograined to paurograined limestone. At some places, this limestone lentil is overlain by grayish orange (10 YR 7/4) siltstone. In the region of the syncline described above, differential weathering of these two lentils has caused a distinct bench to be formed, because the upper siltstone lentil weathers more easily. The Rustler in the Painthorse quadrangle is thought to be lower Screwbean in age. Screwbean is a tentative field name for the lower member of the Rustler formation (DeFord, 1951, p. 3).

The Rustler is found only in the eastern portion of the Painthorse quadrangle as caps on the higher hills. No Rustler fossils have been found in the Painthorse quadrangle.

Pierce Canyon redbeds

Lang (1935, p. 264) named the Pierce Canyon redbeds after a favorable exposure in the vicinity of Pierce Canyon, southeast of Loving, New Mexico. On account of an unconformity between this formation and the underlying Rustler, Lang also assigned this formation to the Triassic. DeFord (oral communication, December, 1951) discounted the existence of this unconformity, stating that there is a definite unconformity between the top of the Pierce Canyon and overlying Dockum beds which are upper Triassic in age; furthermore, the age of this "favorable exposure" is Pleistocene. It is suggested, therefore, that until a more complete concept is obtained, either by paleontological discoveries or a more absolute stratigraphic relationship, that this formation be considered as Permian in age. To date the Pierce Canyon has yielded no fossils.

The Pierce Canyon redbeds exhibit pale yellowish orange

Fig. 8- General view of the Pierce Canyon redbeds. Viewed WNW in NW$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ of Sec. 5, Blk. 91 PSL.

(10 YR 8/2) spots which average about two millimeters in diameter. The Pierce Canyon redbeds are pale reddish brown (10 R 4.5/4). The formatinn is thinly bedded.

Using a Whipple disk to determine the grain size of the particles, it was found that about 90 per cent of the particles were silt size, and the remaining 10 per cent were within the size range of very fine sand. By texture alone, this formation would be considered a sandy siltstone. The cementing material is calcareous and responds moderately to hydrochloric acid. The residue seems to be well sorted quartz grains and mica flakes.

The largest outcrop of the formation in the Painthorse quadrangle is in the SW¼ SE¼ NW¼ of Sec. 5, Blk. 91, PSL. Here it is overlain unconformably by the Cretaceous Cox sandstone. It is also found in the SW¼ SW¼ of Sec. 13, Blk. 93, PSL. The westernmost outcrop was discovered in the NW¼ NW¼ NW¼ of Sec. 3, Blk. 92, PSL. At that place the Pierce Canyon is part of a brecciated sinkhole-filling composed of Pierce Canyon redbeds, Cox sandstone, and Rustler limestone. These fillings are resistive elements of topographic relief which form low steep mounds. The mixture was formed in a sinkhole in the Castile gypsum; later erosion removed the surrounding Castile leaving the resistive filling as a positive relief feature. This Pierce Canyon outcrop is approximately 4 miles farther W than any previously known; its discovery is a small aid in the determination of the western limit. As more discoveries are made, a more definite shoreline may be determined.

The Pierce Canyon redbeds are water lain. According to a classification devised by Krynine (1949), they would fall in the category of redbeds which have been produced by deposition within the basin of sedimentation. The accompanying map does not indicate the depositional conditions under which the Pierce Canyon was laid down; therefore, further explanation is necessary. Post-Permian weathering and erosion completely removed the redbeds in many locations, leaving isolated patches of the formation as erosional remnants. The exposure in the SW¼ SE¼ NW¼ of Sec. 5, Blk. 91 is one of these isolated patches. It is probable that the formation is present at other places to the E under the Cox sandstone, but without many more subsurface data it is not possible to determine the limits of such a distribution, if it does exist.

CRETACEOUS SYSTEM

Cox sandstone.- The Cox is a medium to coarse grained pale yellowish brown (10 YR 6/2) sandstone. It is calcareous and effervesces readily with hydrochloric acid. The Cox sandstone in Painthorse quadrangle is a shallow water deposit. The largest outcrop of this formation was found in the SW¼ SE¼ NW¼ Sec. 5, Blk. 91, PSL, where it unconformably overlies the Pierce

Canyon redbeds. This was the only place in the quadrangle where the base of the Cox was observed. Everywhere else it occurs as a sinkhole filling in association with the Pierce Canyon and the Rustler formation.

UG conglomerate.- In the NE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ of Sec. 9, Blk. 101, PSL, is an unusual conglomerate, shown on the map (pl. I) by the symbol UG. A true age determination has not been made, and the conglomerate was observed in only one place; thus information concerning this conglomerate is incomplete. It is very coarse; some particles are 30 cm. long and 10 cm. wide. It is a moderate yellowish brown (10 YR 6/2). Pieces of banded Castile anhydrite are embedded within the sandy matrix, as are small pieces of material that exhibit the characteristic red color of the Pierce Canyon. The pale light brown (5 YR 6/2) limestone fragments, which make up part of the conglomerate, contain Permian fossils. This conglomerate could be Tertiary in age. The presense of well-rounded pebbles discredits the hypothesis that it is a slump breccia, and the well preserved fragments of banded anhydrite indicate that the formation of the conglomerate took place locally; yet it is composed, in part, of particles which have traveled great distances, viz., the smooth, well-rounded pebbles. This conglomerate is topographically higher than the surrounding bedrock formations, thus it must be younger, but it is not possible at the present time to determine a definite age for it.

Fig. 9- General view of the coarse angular conglomerate designated as UG on Pl. I. Viewed toward the N in the $NW\frac{1}{4}$ $NW\frac{1}{4}$ $SW\frac{1}{4}$ of Sec. 10, Blk. 101 PSL.

GU conglomerate.- In the SW¼ NW¼ of Sec. 14, Blk. 93, PSL, is another unusual conglomerate. It is shown on the map (pl. I) by the symbol GU. This conglomerate was observed in only one place, where it appeared as a sinkhole filling in the Castile formation. The particles composing it are not so coarse as those of the UG conglomerate. For the most part, they are about 4 cm. long and 2 cm. wide. The color is a pale grayish orange (10 YR 7/2). The age of this conglomerate could be as early as Triassic or as late as Quaternary. Fragments of oolitic limestone, typical of back-reef facies, are embedded in it; these fragments could have been transported to their present site before the pre-Cretaceous penaplanation of the region surrounding Painthorse quadrangle. Nevertheless, a definite age determination of this conglomerate is, at this time, impossible.

QUATERNARY SYSTEM

DeFord (1951) proposed a revision of his "precursory classification" of Trans-Pecos Quaternary formations. The following extract lists only those formations which are found in Painthorse quadrangle.

Tentative Name	Symbol	Description
Calamity formation	Qc	Alluvium, grey, organic; present in stream channels.

Tentative Name	Symbol	Description
Neville formation	Qn	Older, orange, fill; contains caliche pebbles.
Gozar formation	Qgo	Well cemented in places; in exposures surrounded by Neville or benches above Neville.
Ninemile gravel	Qnm	Benches above Ninemile forming divides between draws.

Ninemile gravel.- The oldest Quaternary formation in Painthorse quandrangle is the Ninemile gravel. It is found in only two places in the quadrangle; at both locations the older Ninemile is topographically higher than the younger Gozar. The younger formation surrounds the base of the hills composed of Ninemile gravel.

Gozar formation.- The Gozar formation is younger than the Ninemile gravel and in Painthorse quadrangle shows two distinct facies. Where the source of the material is Castile bedrock the Gozar formation is a soft, earthy, white gypsite, which forms terraces. To the west, where the bedrock is the Delaware Mountain group, the terraces are composed of smooth water-transported pebbles and cobbles; these are moderate olive brown (5 Y 4/2) to dusky yellow (5 Y 6/2), and are derived from the limestones and

Fig. 10- Neville formation filling a cut in the Castile formation. Viewed toward the S in SW¼ SW¼ SW¼ of Sec. 8, Blk. 93 PSL.

Fig. 11- General view of the Neville formation filling a deep cut in the Castile formation. Viewed toward the S in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$ of Sec. 8, Blk. 93 PSL.

Fig. 12- General view of a platy conglomerate in the Neville formation. Viewed NNW in the NW¼ NW¼ of Sec. 22, Blk. 101 PSL.

sandstones of the Delaware Mountains. They are coated with a thin white layer of calcium carbonate, that is, with caliche.

Neville formation.- The Neville formation forms a terrace level that is immediately younger than the Gozar. For the most part, it is a silty sandy, grayish orange (10 YR 7/2) gypsite, but in many places appears as a dark yellowish orange (10 YR 6/2) sand. In many places, it forms cliffs 30 to 40 feet high.

Calamity formation.- The youngest Quaternary formation in the Painthorse quadrangle is the Calamity. It is a light to dark grey alluvium, and is the soil in which the majority of the flood plain plants are rooted. It has a well developed A zone of the soil profile, and is limited horizontally to the stream channels.

PHYSICAL GEOGRAPHY

The topography of Painthorse quadrangle bears the impression of both Guadalupian and Ochoan stratigraphy plus later diastrophism, deposition and erosion. In middle Permian time, the limestone and sandstone strata of the Delaware Mountains were deposited; in Ochoan time the area, still a part of the Delaware Basin, received thick deposits of evaporites which crop out as the Castile gypsum. The Rustler limestones, the Pierce Canyon redbeds, and the Cretaceous sandstone were the succeeding bedrock formations which were laid down.

Drainage.- The uplift of the Delaware Mountains in late Tertiary time caused the general drainage of the area to be eastward. Within Painthorse quadrangle, the drainage is chiefly controlled by a large draw, Painthorse Draw, which extends NW-ward through the central portion of the quadrangle until it joins the larger Cottonwood Draw in the northeast corner. The drainage into Painthorse Draw is predominately SE, on the western side of the draw, and NW from the eastern side. The result is inundation of the adjacent areas after heavy rainfall. In contrast to this condition, the high gradient of the Delaware Mountains causes rapid runoff into the many intermittent streams of the region.

The Castile formation, being relatively soluble, exhibits an unusual drainage pattern. The stream channels have become highly entrenched so that many of them are 30 feet deep, but only a few feet across. The formation has slumped in many places into subterranean caverns; into the openings so formed, thousands of gallons of water disappear.

Rustler Hills.- The topography of the eastern half of the quadrangle is dominated by the Rustler Hills. Almost without exception, the higher hills are capped by the Rustler formation. For the most part, the smaller hills are the low, rolling gypsite terraces whose bedrock formation is the Castile; a few positive relief features are formed of the resistant "plugs" of stratigraphic sinks which are composed of Cretaceous conglomerate.

Castile outcrop.- The Castile presents an unusual topography. Its deep, entrenched stream beds and numerous sink holes are the features which comprise this karst-dominated region. These characteristics, with the blinding white dust derived from the soluble bed rock and the sparse desert vegetation, impart to this area the appearance of wasteland.

Delaware Mountains.- In Painthorse quadrangle the topography of the Delaware Mountains is one of low, rolling hills and flat valleys. In only a few places is the relief more than 300 feet, and as an average the hills stand only 150 feet above the flood plain. A Quaternary gravel caps the areas of highest relief; a rich orange fill, the Quaternary Neville, fills the valleys and stream beds.

Climate and soils.- Geographers refer to the climate of areas where temperature extremes are wide because of a lack of oceanic influence as continental climates (Daubenmire, 1947, p. 183). This definition describes Painthorse quadrangle very well. The average date of the first killing frost is November 1; the average date of the last killing frost is April 1, and the mean average temperature is 62°F (Carter, et al, 1928). Yet the mean annual temperature as well as the mean annual rainfall (10-14 inches in Painthorse quadrangle) is an almost worthless statistic in a consideration of plant ecology, for a severe continental climate can have the same mean as a mild oceanic climate. It is best then to consider climate as a local phenomenon rather than treat it in so broad a manner. Most of the rainfall in Painthorse quadrangle occurs during the months of July and August. The mean annual precipitation at Kent, approximately 50 miles SE of Painthorse quadrangle, is 12.73 inches. The evaporation station closest to Painthorse quadrangle is located in Pecos, Texas, 65 miles E of Painthorse quadrangle. The mean evaporation in July is 10.17 inches; in August the mean evaporation is 9.14 inches (1942, National Resources Planning Board, p. 21).

The first step in the genesis of soil is the accumulation or exposure of the fragments of bedrock. The interstices between these particles are filled with gas and water. The introduction of living organisms and the products of their decay begins the constructive phases of the soil-forming process. As the processes operate upon the rock materials, changes are slowly brought about in the surface layers, which if allowed to continue for a long time, will make these layers very different from the parent material. This changed portion is regarded as true soil. The characteristics and thickness of the soil thus formed depends upon the intensity of the soil-forming processes, the time during which they have acted, and the resistance of the parent material to change. It is evident that the outstanding element in the formation of soils, and one of paramount importance, is the nature of the bedrock from which the soil was formed. The soils derived from the limestones and the siltstones of the Delaware Mountains are much more fertile than that derived from the gypsum of the Castile. Only in the stream beds and the valleys which are coated with a veneer of Quaternary sediments does the Castile seem to support any vegetation not especially adapted to its particular chemical composition.

PHYTOGEOGRAPHY

<u>Regional setting</u>.- The high degree of aridity is the major controlling factor in the distribution of the flora of the area studied. An examination of a rainfall map of the United States reveals that the precipitation patterns arrange themselves in a series of linear, concentric belts parallel to the highest topographic relief. It should also be remarked that the region of least rainfall is the area which lies beyond a mountain range from the source of moisture. The east slope of the Delaware Mountains along the western border of the quadrangle intercepts the moisture-laden southeasterly (Gulf) winds and cause them to precipitate much of their moisture on that slope.

<u>Flood plain</u>.- The immediate effect of aridity on the soil

can best be seen in the more recent flood plain deposits. These Quaternary sediments consist for the most part of calcified alluvial fill in which the accumulation of carbonates at grass roots level has resulted from soluble calcium and magnesium having been leached to this depth before being precipitated (Reiche, 1945, p. 62). These flood plain soils are comparatively fertile, as the arid climate and high temperature of the region cause almost all of the water to be drawn up through the soil to the surface where it is evaporated. As evidence of fertility, as well as evidence of more plentiful water supply, the flood plain supports a dense stand of vegetation. The soil profiles in the Neville and Calamity formations show a low humus content, a minor amount of surface plant litter and widely-spaced roots. It has a pinkish tint, and, owing to an accumulation of carbonates, in many places exhibits thin layers of caliche. In some places this underlying caliche material is from 3 to 5 feet beneath the surface. Deep phase Reeves silty clay loam is the term by which pedologists refer to the soil found in Painthorse Draw. In all other locations within the quadrangle, soil derived from the Neville and Calamity is referred to as Reeves silty clay loam (Carter, et al, 1928, p. 27). Both phases of the soil are granular and crumble readily. On drying thoroughly, the surface soil packs into a fairly tight light gray mass, but it is readily broken into fine clods and grains. Some of the more conspicious members of the flora of the flood plain are as follows:

	Common Name
ANACARDEACEAE (Cashew family)	
Schmaltzia microphylla Engelm	sumac
ASCLEPIDACEAE (Milkweed family)	
Asclepias latifolia (Torr.) Raf.	milkweed
Asclepias brachystephana Engelm.	milkweed
ASTERACEAE (Aster family)	
Gutierrezia sp.	broomweed
BRASSICACEAE (Mustard family)	
Lepidium alyssoides A. Gray	pepper grass
MIMOSACEAE (Pea family)	
Acacia constricta Benth.	white-thorn
Prosopis glandulosa Torr.	mesquite
POACEAE (Grass family)	
Aristida spp.	needle grass
Bouteloua curtipendula (Michx.) Torr.	tall grama
Bouteloua eriopoda Torr.	black grama
Boutelous gracilis (H. B. K.) Lag.	blue grama
Hilaria mutica (Buckl.)	tobosa grass
Sporobolus wrightii (Munro)	sacaton
Triodia elongata (Scribn.) Buckl.	rough triodia
PINACEAE (Pine family)	
Juniperus monosperma Engelm	cherrystone juniper

Delaware Mountains.- A distinctive type of flora is supported by the interbedded limestone and sandstone of this region, with limestone the more abundant outcrop. Agave lechuguilla is the predominant plant. The soil of this region is the Ector stony loam. It is present in very small quantities and consists of a thin layer of light-brown calcareous loam or gritty clay loam from 2 to 10 inches thick. The underlying rocks have a slight coating of calcium carbonate, i.e. caliche. It can be seen from the following list that the vegetation of this area is quite similar to that found on the flood plain, but because the plants are more xerophytic than those of the flood plain, the flora of this sloping region is more restricted in number of species.

	Common Name
CACTACEAE (Cactus family)	
Opuntia spp.	prickly-pear
Echinocereus spp.	
KOEBERLINIACEAE (Junco family)	
Koeberlinia spinosa Zucc.	allthorn
DRACAENACEAE (Yucca family)	
Nolina spp.	nolina
Yucca spp.	yucca
ZYGOPHYLLACEAE	
Covillea glutinosa (Engelm.) Rydb.	creosote bush
(Larrea glutinosa Engelm.)	

Castile outcrop.- The flora listed above is in sharp contrast with that found on the Castile gypsum. Some authors advance the theory that it is the calcium component of a soil that controls the type of flora. Painthorse quadrangle is an area in which calcareous and gypsiferous soils abut one another; both are high in calcium; but in the Delaware Mountains the parent material is a carbonate whereas on the Castile outcrop, it is a sulphate. The vegetation of the Delaware Mountains is typical of the surrounding district, but the Castile outcrop presents a different flora adapted to the gypseous soil. Nevertheless, it was noticed that in some locations, due to the admixture of weathered gypseous bed rock and alluvial material brought in from weathered limestone of the Delaware Mountains or Rustler-capped hills, a soil profile has been built of such thickness and chemical composition as to admit species that are not obviously gyp tolerant, e.g., Agave lechuguilla.

Gypsophiles.- Plants which will grow on gypsite are gyp tolerants, gypsophiles or obligate gypsophiles. Obligate gypsophiles are limited to gypseous soils. Gypsophiles are plants which prefer gypseous soils, but will grow on non-gypseous soils. Gyp tolerants are those which will grow on gypseous soils, but prefer non-gypseous soils. The following gypsophiles and gyp tolerants were observed in Painthorse quadrangle.

	Common Name
ASCLEPIDACEAE (Milkweed family)	
Asclepias brachystephana Engelm.	milkweed
ASTERACEAE (Aster family)	
Aciphyllaea acerosa (D C.) A. Gray	
(Dysodia acerosa DC.)	
Psilostrophe villosa Rydb.	
Senecio (riddellii?) Torr. and Gray	groundsel
Thymophylla pentachaeta (DC.) Small	
BERBERIDACEAE (Barberry family)	
Berberis trifoliolata Moric.	threespine barberry
BORAGINACEAE (Borage family)	
Coldenia hispidissima Gray	gyp weed
Coldenia greggii (Torr.) A. Gray	
Cryptantha sp.	
Heliotropium confertifolium Torr.	heliotrope
BRASSICACEAE (Mustard family)	
Greggia camporum A. Gray	field mustard
Lepidium alyssoides A. Gray	pepper grass
CACTACEAE (Cactus family)	
Opuntia spp.	prickly pear
Echinocereus spp.	devil's head
KOEBERLINIACEAE (Junco family)	
Koeberlinia spinosa Zucc.	allthorn

	Common Name
CUCURBITACEAE (Gourd family)	
Ibervillea tenuisecta (A. Gray) Small	wild gourd
CUSCUTACEAE (Morning Glory family)	
Cuscuta sp. (a parasitic plant)	
DRACAENACEAE (Yucca family)	
Dasylirion texanum Scheele	sotol
Nolina spp.	nolina
Yucca spp.	yucca
MALVACEAE (Mallow family)	
Sphaeralcea hastulata Gray	globe mallow
MIMOSACEAE (Pea family)	
Acacia constricta Benth.	white-thorn
NYCTAGINACEAE (Four o'clock family)	
Anulocaulis gypsogenus Waterfall	four o'clock
Abronia nealleyi Standl.	sand verbena
Mirabilis multiflora (Torr.) Gray	sweet four o'clock
POACEAE (Grass family)	
Bouteloua breviseta Vasey	yeso grass
Hilaria mutica Buckl.	tobosa grass
PRIMULACEAE (Evening Primrose family)	
Galpinsia hartwegi (Benth.) Britton	
SOLANACEAE (Nightshade family)	
Lycium berlandieri Durnal	matrimony vine

<u>Covillea</u> <u>glutinosa</u> (Engelm) Rydb. creosote bush

(<u>Larrea</u> <u>glutinosa</u> Engelm)

The soil derived wholly from the Castile is called the Reeves chalk, a name misleading to a geologist. Although large areas are practically bare, much of the land supports a sparse vegetation, ranging from 10 to 20 percent of a complete coverage.

<u>Joint</u> <u>fir</u>.- <u>Ephedra</u> <u>nevadensis</u> S. Watts, commonly called joint-fir is an unusual desert plant. This non-succulent perennial belongs to the order Gnetales, of which members have been found dating back to the Devonian. In this xeric switch plant, blade reduction has progressed so far that the leaves are vestigial, thus relegating transpiration functions to the stems. The plant is erect, usually 2 to 10 feet tall, and usually solitary. The branches are pale or bluish green, and bear minute, scale-like, leaves in distinct sheathing whorls. These leaves are an eighth of an inch long. The flowers are dioecious in peduncled axillary clusters; the staminate flowers have a 2 to 4 lobed perianth, and bear 2 to 8 stamens united into a column; the pistilate flowers have an urceolate perianth including a naked ovule which develops into a nutlet.

<u>Rustler</u> <u>Hills</u>.- The most predominant vegetation observed on the Rustler formation is <u>Agave</u> <u>lechuguilla</u> Torr, <u>Fouguieria</u> <u>splendens</u> Engelm, <u>Dasylirion</u> <u>texanum</u> Scheele, and <u>Juniperus</u> <u>monosperma</u> Engelm.

The flora examined in Painthorse quadrangle is directly related to the topography and geology of the area. As shown in the following list, these two features determine the distribution and abundance of the species listed.

This list is intended to present an analysis of the distribution of the components of the flora of Painthorse quadrangle. Within limits, this list reveals not only the presence of the several species listed, but also their relative abundance and geological distribution. Nevertheless, to obtain a full concept of the area, one must first be acquainted with the topography of the area. The flood plain area, varying in width, lies back of the banks that form stream channels; the column designated as Delaware Mountains includes the slope areas. A suggestion on interpreting the list may be in order.

Fouquieria splendens, for example, is dominant only on the small, vestigial caps of Rustler on the highest hills. Hilaria mutica and Triodia elongata are dominant on the flood plain. There are some species which appear to be limited to the Castile formation. Anulocaulis gypsogenus is an example. This species is an obligate gypsophile. Mirabilis on the other hand, may grow on formations other than the Castile, but no such observations were made in Painthorse quadrangle. It is quite apparent that the Delaware Mountains support little vegetation, and the dominant species is Agave lechuguilla. Opuntia and Echinocereus are genera which are common to all formations and all types of soil.

Plants	Geologic Unit			
Analytical list of plants of Painthorse quadrangle	Flood Plain	Delaware Mountains	Castile outcrop	Rustler outcrop
Schmaltzia microphylla Engelm	4			
Asclepias latifolia (Torr.) Raf.	3	5	4	
Asclepias brachystephana Engelm	4	5	3	
Gutierrezia sp.	2	4	5	4
Lepidium alyssoides A. Gray	3	5	4	
Acacia constricta Benth.	3	5		
Prosopis glandulosa Torr.	2	4		5
Aristida spp.	4			
Bouteloua curtipendula (Michx.) Torr.	3	4		
Bouteloua eriopoda Torr.	3			
Bouteloua gracilis (H.B.K.) Lag.	4			
Bouteloua breviseta Vasey	5		2	
Hilaria mutica Buckl.	1	5		
Sporobolus wrightii Munro	2		5	
Triodia elongata (Scribn.) Buckl.	1	4		
Juniperus monosperma Engelm.	2		4	3
Opuntia spp.	3	3	4	3
Echinocereus spp.	3	3	4	3
Koeberlinia spinosa Zucc.	3	4	5	
Nolina spp.	2	3		4
Yucca spp.	2	3		4

Significance of numbers: 1- dominant; 2- frequent; 3- common; 4- infrequent; 5- rare

Plants	Geologic Unit			
Analytical list of plants of Painthorse quadrangle	Flood Plain	Delaware Mountains	Castile outcrop	Rustler outcrop
Covillea glutinosa (Engelm) Rydb.	3	4	5	4
Aciphyllaea acerosa (D.C.) A. Gray	4		3	
Psilostrophe villosa Rydb.	3		3	
Senecio (riddelli?) Torr. & Gray	2	4	3	5
Thymophylla pentachaeta (D.C.) Small	4		3	
Agave lechuguilla Torr.	3	1		2
Ephedra nevadensis S. Watts	3		5	
Fouquieria splendens Engelm	5	4	4	1
Dasylirion texanum Scheele	3	4	2	2
Berberis trifoliata Meric	3		4	
Coldenia hispidissima A. Gray			1	
Coldenia greggii (Torr.) A. Gray	4		1	
Cryptanthe sp.			4	
Heliotropium confertifolium Torr.	4		3	
Greggia camporum A. Gray	3	5	3	5
Ibervillea tenuisecta A. Gray	3		4	
Sphaeralcea hastulate A. Gray	3		4	
Anulocaulis gypsogenus Waterfall			3	
Abronia nealleyi Standl.	5		4	
Mirabilis multiflora (Torr.) Gray			4	
Galpinsia hartwegii (Benth.) Britton	4		4	
Lycium berlanderi Durnal	3	3	4	

Significance of numbers: 1- dominant; 2- frequent; 3- common; 4- infrequent; 5- rare

Floral succession.- As vegetation develops, beginning with a primary bare surface (either rock or water), the same area becomes successively occupied by different plant communities. This process is known as plant succession. In Painthorse quadrangle, three dominant factors influence floral succession. In order of their importance these factors are: quantity of available water, the characteristics of the soil, and topography. The characteristics of the soil are, in turn, almost entirely dependent upon the character of the bedrock from which the soil is derived. The three features mentioned above largely determine the character of the vegetation. In Painthorse quadrangle succession had resulted in substantial climax before intensive grazing materially altered the composition of the climax cover. These disturbances in the virgin cover have brought about the present day disclimax.

The most frequent examples of the disclimax result from the modification or replacement of the true climax, either wholly as by cultivation, or, in part, as a result of grazing. The disclimax in Painthorse quadrangle seems to be the result of the partial destruction of the climax brought about by grazing animals. An example of the modification has been the introduction and the increasing dominance of the Russian thistle in the flood plain area. Continuous overgrazing has also produced dominance of broomweed (Gutierrezia). Slight overgrazing produces a mixed weed and grass cover, which because of the large variety of palatable plants made possible by such grazing, is still of considerable value in sheep grazing. Thus, the intensity of grazing can affect the character of a disclimax.

The geology of the area indicates that the developmental processes resulting in the present soils began immediately after the Tertiary uplift of the Delaware Mountains. The initial and middle stages of plant succession are wanting. It must also be remembered that a unit of vegetation at any given time represents the condition of a segment in the dynamic flow of succession processes. Climatic changes have left relict desert shrub communities that bear a preclimax relation to the present day desert grassland. A recession of the last great dry phase in climate probably took place in early Quaternary time. These desert shrubs are located, for the most part, on the lower slopes of the hills, but almost never in the flood plain. Grasslands are located on the flood plain, and, to a diminishing extent, on the lowest slopes of the hills adjacent to the flood plain, where grasslands are predominant but bear patches of desert shrubs.

ZOOGEOGRAPHY

Domestic animals.- Aridity and sparse vegetation make conditions for profitable livestock raising extremely unfavorable. Because sheep can survive on the scanty browse that is available plus some limited amount of artificial feeding, they are the most profitable livestock commodity of the region.

The Brahma is the most popular breed of cattle because of its resistance to worms and adaptability to drouth conditions. The white-face Hereford is also bred, but with less success than the Brahma. The amount of rainfall is the determining factor in stock marketing. During the month of September 1951, in Painthorse quadrangle, 35,000 sheep were sold at an average loss of $5.00 per head due to lack of rainfall and the resultant loss of weight.

Native animals.- Painthorse quadrangle and the surrounding region abounds with many forms of wild life. There are quail, chicken hawk, screech owl, and the turkey buzzard. Two species of rabbit are very plentiful, and at times the rattlesnake seems always to be underfoot. Deer and antelope are present in limited numbers. The mountain lion, coyote, and wolf are a menace to livestock. Gophers and kangaroo rats are the most important burrowing animals of the region.

ECOLOGIC AND ECONOMIC EFFECTS OF OUTCROP PATTERN

Even the most casual observation of the accompanying areal geology map indicates that some rather unusual characteristics are present in this area. Painthorse quadrangle is divided into two major lithic units. East of the Lamar-Castile contact is the gypsiferous Castile; west of this contact are the limestone and calcareous sandstone of the Delaware Mountains. This contact is more than a geological boundary; it is the dividing line between two distinct economic and ecologic cultures. A consideration of each of these as an unit in itself will render the geologic pattern more significant.

The western part of the quadrangle, the Delaware Mountain region, is an area of low rolling hills and valleys. These valleys contain active stream channels and a veneer of Quaternary alluvium; thus there is provided a fertile soil for the usual dense stand of vegetation. The hills are composed of Quaternary gravel. The ranchers in this area were quick to take advantage of this hill and valley configuration. All the earth dams in the quadrangle, with one or two exceptions, are west of the Lamar-Castile contact. The hills serve as watersheds; when it rains the valleys become active stream channels carrying the water eastward, following the general dip of the formations. At the confluence of several of these streams, a dam is built, forming a reservoir in which water may be stored for livestock.

On each side of the stream channel is a flood plain in which most of the prolific vegetation and the more fertile soil occurs. This valley soil, in the western section of the quadrangle, is the greatest single asset to the rancher; for while not very deep nor extensive in areal distribution, it is extremely fertile. The Reeves silty clay loam supports all of the economically important vegetation. East of the contact, this type of soil is found only in Miller Draw and the southern part of Painthorse Draw. The Ector stony loam, a soil derived from the bedrock of the Delaware Mountains, supports some grasses and Agave. More than 80 percent of the surface is covered by vegetation. As a result of the fertility of the soil, the availability of dam sites and the dense stand of vegetation, the western half of the quadrangle is of great economic value to the ranchers who own land in this area. Sheep can be grazed profitably and with little supplementary feeding. The vast herds of sheep belonging to K. P. Looney and the large cattle herds of Bob Owens are indicative of the great extent to which bedrock geology and outcrop patterns can directly control the economy and ecology of a region. In the eastern half of Painthouse quadrangle the topography is directly controlled by the weathering characteristics of the Castile gypsum. This formation, except in Miller Draw, is the exposed bedrock. The western half of the quadrangle is a hill and valley region; the eastern half is an area of karst topography. This is a result of the high solubility of the Castile. It has only a 20 percent vegetation covering. The accompanying maps (pl. I) reveal that almost all of the windmills are located in this half of the quadrangle. This is an economic necessity, as the weathering characteristics of the Castile are not favorable for the divergence of streams nor the storage of water. These windmills are an attempt by the rancher to supply water to small herds of sheep which are grazed there. It is also necessary that more supplementary feeding be done in this half of the quadrangle. The flood plain region is not as extensive in area nor as productive of vegetation as that of the western half of the quadrangle. The soil derived from the Castile is the so-called Reeves chalk, which supports in abundance only yeso grass and cenizo (*Coldenia greggii*). This area is by no means as valuable as the western half of the quadrangle. Thus geology and climate have controlled ecology again; the result in this area is a wasteland.

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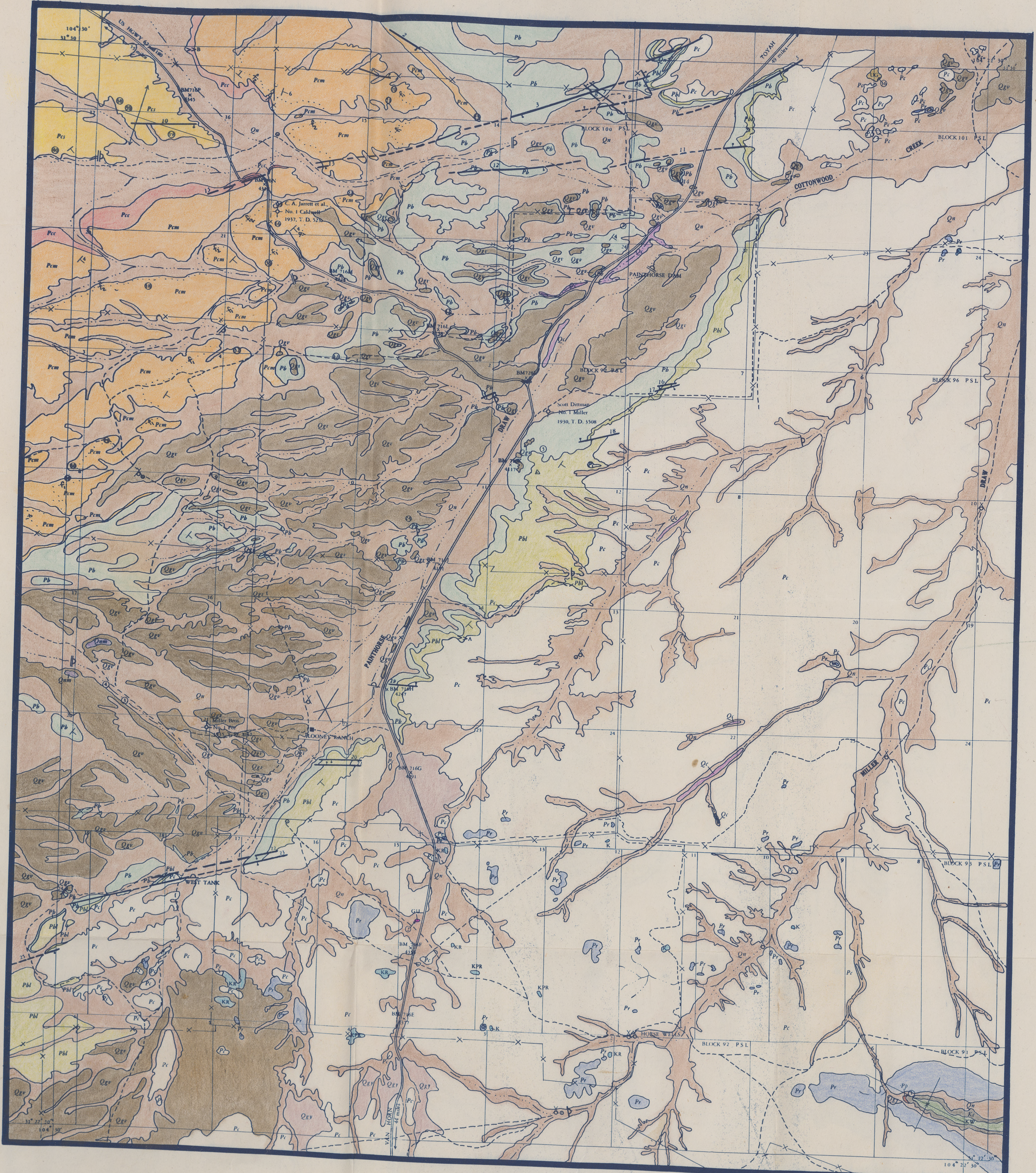


Plate I

QUATERNARY

- Qc — Calamity alluvium
- Qn — Neville alluvium
- Qgy/Qgv — Gozar formation; Qgy, gypsite member; Qgv, gravel member
- Qnm — Ninemile gravel

- UG — Conglomerate, brown, age undetermined; caps hill
- GU — Conglomerate, age undetermined
- K — Cretaceous conglomeratic sandstone
- P — Pierce Canyon redbeds
- R — Rustler dolomite

(GU, K, P, R:) components of brecciated sinkhole fill

CRETACEOUS

- KW — marl & sandstone of Washita age
- Kc — Cox sandstone

PERMIAN

OCHOAN

- Pp — Pierce Canyon redbeds
- Pr — Rustler formation
- Pc — Castile formation

GUADALUPIAN

- Pbl / Pb — Bell Canyon formation, Pb; Lamar limestone member, Pbl, at top.
- Pcm / Pcc / Pcs / Pcc — Cherry Canyon formation, Pcc; Manzanita limestone member, Pcm, at top; South Wells (?) limestone member, Pcs.

anticlinal axis	county road
synclinal axis	ranch road
«««« A measured section A	fence
BM 716E 4377 USC & GS benchmark No. 716E Elevation 4377 feet above sea level	3 observed fault No. 3
USC & GS triangulation station	concealed fault
landing strip	fault trace visible through Quaternary cover
buildings	windmill
earthen tank	water-storage tank
earthen dam	dry well (oil test)
fossiliferous locality No. 7	f1 fossiliferous bed No. 1

AREAL GEOLOGY PAINTHORSE QUADRANGLE

Culberson County, Texas

Cartography by

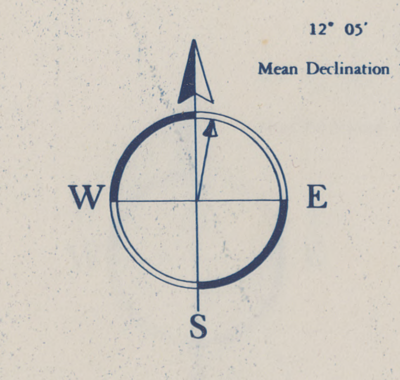
Asa L. Blankenship, Jr. George Sealy

Supervised by R. K. DeFord & J. A. Wilson

Department of Geology The University of Texas

FIELD WORK
SUMMER, 1951

MAP PRINTED
DECEMBER, 1951



BASE FROM EDGAR TOBIN
AERIAL MOSAIC

1 0 1 2

SCALE IN MILES

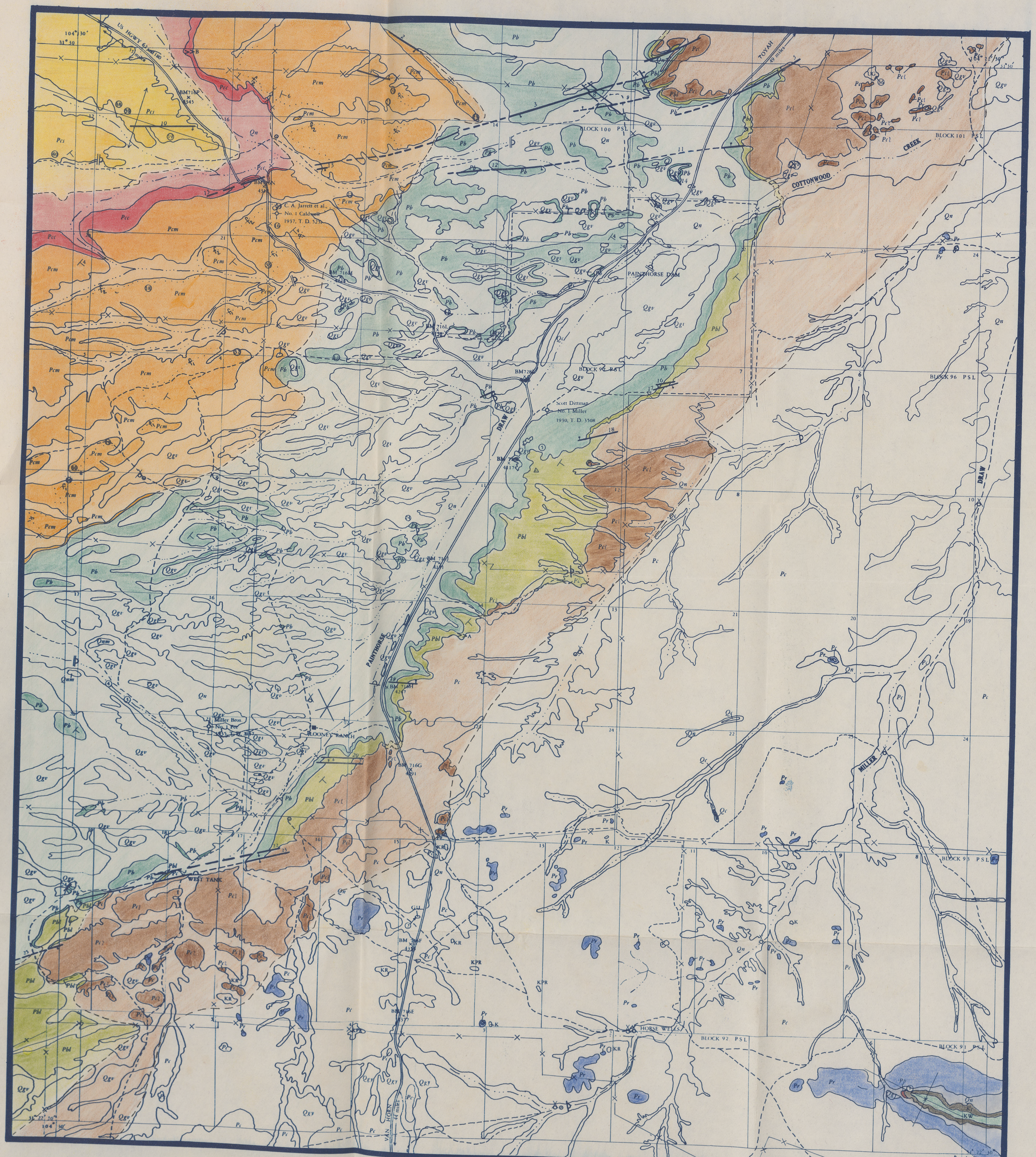


Plate II

QUATERNARY

Qc	Calamity alluvium
Qn	Neville alluvium
Qgy / Qgv	Gozar formation; Qgy, gypsite member; Qgv, gravel member
Qnm	Ninemile gravel

UG	Conglomerate, brown, age undetermined; caps hill	
GU	Conglomerate, age undetermined	components of brecciated sinkhole fill
K	Cretaceous conglomeratic sandstone	components of brecciated sinkhole fill
P	Pierce Canyon redbeds	components of brecciated sinkhole fill
R	Rustler dolomite	components of brecciated sinkhole fill

CRETACEOUS

KW	marl & sandstone of Washita age
Kc	Cox sandstone

PERMIAN

OCHOAN

Pp	Pierce Canyon redbeds
Pr	Rustler formation
Pc	Castile formation
Pcl	Painthorse limestone member

GUADALUPIAN

Pbl / Pb	Bell Canyon formation, Pb: Lamar limestone member, Pbl, at top.
Pcm / Pcc / Pcs / Pcc	Cherry Canyon formation, Pcc; Manzanita limestone member, Pcm, at top; South Wells (?) limestone member, Pcs.

anticlinal axis	county road
synclinal axis	ranch road
measured section A	fence
BM 716E 4377 — USC & GS benchmark No. 716E Elevation 4377 feet above sea level	observed fault No. 3
USC & GS triangulation station	concealed fault
landing strip	fault trace visible through Quaternary cover
buildings	windmill
earthen tank	water-storage tank
earthen dam	dry well (oil test)
fossiliferous locality No. 7	fossiliferous bed No. 1

BEDROCK & AREAL GEOLOGY PAINTHORSE QUADRANGLE

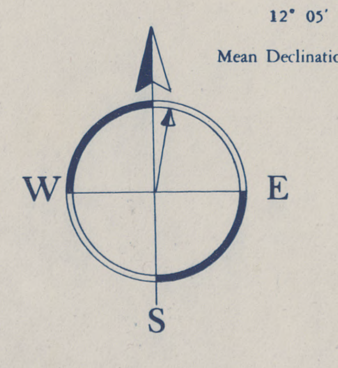
Culberson County, Texas

Cartography by
Asa L. Blankenship, Jr. George Sealy

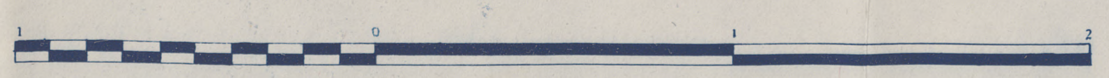
Supervised by R. K. DeFord & J. A. Wilson
Department of Geology The University of Texas

FIELD WORK
SUMMER, 1951

MAP PRINTED
DECEMBER, 1951



BASE FROM EDGAR TOBIN
AERIAL MOSAIC



SCALE IN MILES