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# SURFACE GEOLOGY OF THE PALO DURO AND DALHART BASINS, AREA, TEXAS

by

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## 3.2.1 Surface Geology

### Introduction

The Texas Panhandle includes primarily two physiographic provinces: the High Plains which overlies the Dalhart and most of the Palo Duro Basin and the Rolling Plains characterizing the eastern part of the Palo Duro Basin area (Fig. 1). These two provinces are separated by the Caprock Escarpment, a prominent erosional feature along which relief locally exceeds 1,500 ft (500 m) (Gustavson and others, 1980). The High Plains is developed on the Tertiary Ogallala Formation and forms a broad, flat plain having regional slope to the southeast of 8 to 10 ft per mile (Evans and Meade, 1944). The Rolling Plains was formed by erosion of the Ogallala Formation which exposed the varying lithologies of the underlying Permian and Triassic age units.

The easterly flowing Canadian River divides the High Plains into two sections: the Northern High Plains overlying the Dalhart Basin, and the Southern High Plains, or Llano Estacado, overlying the Palo Duro Basin. Prominent escarpments bounding the High Plains on the west, east, and along the Canadian River Valley are the result of Quaternary erosion. These escarpments provide most of the Tertiary and Triassic rock exposures. The flat surface of the High Plains is interrupted by numerous playas, dunes, and a surface drainage system composed of linear draws or channels. Pleistocene strata are exposed in some stream-cut channels and large playas on the High Plains surface. With the exception of the Canadian River drainage system and minor streams, major portions of the High Plains surface are without external drainage.

## Stratigraphy

Rocks and sediments which range in age from Permian to Recent (Fig. 2) are exposed in the Texas Panhandle. The distribution (outcrop) and general lithologic character of these rocks are illustrated by a series of geologic quadrangle maps ($1^{o}$ X $2^{o}$), which are available for the area (Barnes, 1981, 1977, 1974, 1970, 1968, 1967, and unpublished data).

The oldest unit exposed in the Palo Duro Basin area is the Upper Permian Blaine Formation. Blaine outcrops are found only along the eastern margin of the Palo Duro Basin (Cottle, Childress, and Collingsworth Counties) where they contain interbedded shale, siltstone, gypsum, and dolomite. The Blaine is identified in the subsurface of the Dalhart and Anadarko Basins. The subsurface equivalent of the Blaine Formation in the Palo Duro Basin is the San Andres Formation. This transition in nomenclature occurs where bedded salt is being removed from the Blaine in the salt dissolution zone. The Blaine Formation members include the Guthrie and Acme Dolomites (Fig. 2) that can be mapped individually from outcrops (Plainview, Lubbock, and Amarillo sheets), but are not identified in the subsurface of the Palo Duro Basin. The primary lithologic distinction between Permian age outcrop strata and their subsurface equivalents is that no salt occurs in outcrop.

Upper Permian strata that crop out along the eastern and northern margins of the Palo Duro Basin are, in ascending stratigraphic sequence, the Blaine, Whitehorse Sandstone, Cloud Chief Gypsum, Dozier Sandstone, Alibates, and Quartermaster Formations. Outcrops occur along the Canadian River Valley and east of the eastern escarpment in Potter, Carson, Donley, Floyd, Collingsworth, Randall, Armstrong, Briscoe, Hall, Childress, Motley, and Cottle Counties

(Lubbock, Plainview, and Amarillo sheets). The Whitehorse Sandstone, of Guadalupian and Ochoan age, consists of reddish-brown sandstone with exposures in Motley, Cottle, Collingsworth, Briscoe, Hall, Armstrong, and Donley Counties. The Cloud Chief Gypsum, of Late Ochoan age, is composed of irregular impure gypsum beds interbedded with gypsiferous shales, sand, and dolomite. The Whitehorse Sandstone and Cloud Chief Gypsum Formations are stratigraphic equivalents to the Artesia Group of the Palo Duro Basin subsurface. The Dozier Sandstone, also of Late Ochoan age, locally occurs in the eastern Palo Duro Basin, in Collingsworth County, as ledges of pink to red fossiliferous, calcareous sandstone (WTGS, 1976). The overlying Alibates dolomite, which is transitional to anhydrite (subsurface) and gypsum (surface) in many parts of the Panhandle and Palo Duro Basin area and contains minor amounts of shale and chert, is continuous and easily traceable into the subsurface. The Quartermaster Formation, which overlies the Alibates and is equivalent to the Dewey Lake Formation of the Palo Duro Basin subsurface, contains red sandstone, gypsiferous shales, and sandy dolomites locally. Mapped both separately and undivided with the Whitehorse Sandstone and Cloud Chief Gypsum, the Quartermaster crops out in Motley, Floyd, Briscoe, Armstrong, Randall, Donley, Collingsworth, and Potter Counties.

Permian strata are not exposed in the Dalhart Basin area. The lack of Permian outcrops results from both the absence of deeply eroded stream canyons, and a Quaternary surface cover of windblown sand dunes, sheets, and ridges in Hartley, Dallam, and southern Cimarron Counties.

Triassic rocks are exposed on the southern margin of the Dalhart Basin along the Hartley and Oldham county line (McGowen and others, 1979). In this area, southerly stream drainage to the Canadian River has eroded Quaternary and Tertiary strata exposing the Triassic Tecovas Formation, which consists of siltstone, shale, and fine- to coarse-grained, orange-brown to reddish-brown sandstone. In the Palo Duro Basin area, Triassic rocks are exposed along the eastern and western Caprock Escarpments, and on the southern side of the Canadian River Valley (Potter County), along the Tierra Blanca Creek (Deaf Smith and Randall Counties), and near Garcia Lake (Deaf Smith County). Surface geologic mapping has resulted in the subdivision of the Triassic strata into the Trujillo and Tecovas Formations in Oldham and Potter Counties. Elsewhere in the Palo Duro Basin area, the Triassic is mapped as the Dockum Group. The Trujillo Formation contains conglomerate, fine- to coarse-grained sandstone and shale. All subsurface Triassic strata in the Palo Duro and Dalhart Basins area are identified as the Dockum Group.

Jurassic rocks are not present on the surface in the Texas Panhandle. However, exposures of Jurassic rocks do occur in New Mexico outside of the basin margins. The Jurassic occurs in the subsurface in western Dallam and northwestern Hartley Counties of the Dalhart Basin as undifferentiated strata. Lithologies include pale-green calcareous shales, white to gray calcareous sandstones, and minor amounts of conglomerate and limestone.

In the area of the Dalhart Basin, the Cretaceous Dakota Group consists of conglomerate and fine- to coarse-grained sandstone with limited local outcrops in south-central Cimarron County, Oklahoma, along the North Canadian River. Beyond the basin margin, outcrops are found in northern Cimarron and central Texas Counties, Oklahoma, and in eastern Union County, New Mexico. The Cretaceous is not identified in the subsurface.

Isolated remnants of the Cretaceous Edwards Limestone, consisting of hard, light gray to yellow, thick bedded to massive, fine- to coarse-grained, fossiliferous limestone have been mapped in the Palo Duro Basin in Floyd County. The Cretaceous Duck Creek and Kiamichi Formations are exposed in the southwestern Palo Duro Basin area adjacent to large playas in Bailey and Lamb Counties and have been mapped both undivided and separately. The Duck Creek Formation contains moderate yellow shale and thin moderate yellowish-brown limestone with marine megafossils. The Kiamichi Formation consists of interbedded shale and limestone, gray and yellow limestone, and minor sandstone with marine megafossils.

The surface of the High Plains is developed on the Tertiary Ogallala Formation. Exposures of the Ogallala are limited to areas of Pleistocene and Recent erosion along the Caprock Escarpment and on the High Plains surface. In the Palo Duro Basin area, the Ogallala is exposed along the eastern and western caprock escarpments, in stream-cut canyons, and adjacent to the larger playas on the Southern High Plains surface. Quaternary deposits in the Dalhart Basin area are less eroded and provide fewer outcrops than in the Palo Duro Basin area. The Ogallala Formation, consisting of sand, silt, clay, gravel, and caliche, is exposed along the Rita Blanca and Punta de Aqua Creeks in Hartley County, in several minor stream channels, near numerous playas, and in deflated areas where the windblown cover sands have been removed. The Ogallala Formation is also identified in the subsurface in both the Palo Duro and the Dalhart Basins (Seni, 1980).

Quaternary sediments of the Palo Duro and Dalhart Basins were deposited in lacustrine, eolian, and fluvial environments. Lacustrine sand, silt, clay, gravel, and limestone deposits in the Palo Duro Basin area include deposits of the Blanco, Tule, Double Lakes, and Tahoka Formations and playa sediments on the Southern High Plains surface. Exposures of the Pleistocene Blanco, Tule, and Double Lakes Formations are found on canyon walls in Blanco Canyon, Tule Draw, and Blackwater Draw in Crosby, Swisher, Briscoe, Bailey, and Lamb Counties (Lubbock, Plainview, and Clovis sheets, respectively). The Tahoka Formation is exposed around large playas in Bailey, Lamb, and Roosevelt Counties (Clovis and Brownfield sheets). Both Recent and Pleistocene playas and pond deposits occur on the High Plains surface of the Palo Duro and Dalhart Basins. Recent and Pleistocene fluvial sediments in the Palo Duro and Dalhart Basins areas are identified as terrace deposits and floodplain alluvium. Numerous exposures of fluvial sediments are mapped along the escarpments, in stream channels and canyons, and near large playas. The Palo Duro and Dalhart Basins areas are widely covered by eolian deposits of both Recent and Pleistocene age. Mappable units are the Blackwater Draw Formation (formerly unnamed and referred to as Pleistocene windblown cover sands), loess deposits, and sand in sheets, dunes, dune ridges, and other eolian features. The Blackwater Draw Formation includes fine-to-medium sand, caliche nodules, and local soil profiles. Exposures are found in all counties in the Palo Duro and Dalhart Basins area. Deposits of windblown silt or loess, and calcareous, dark-brown to grayish-brown eolian sand deposits, derived from lacustrine, fluvial, and reworked eolian deposits, are extensive in both basins and mapped on all sheets.

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# Figure Captions

Figure 1. Physiographic units of the Palo Duro and Dalhart Basins area.

Figure 2. Stratigraphic chart of the surface geology and subsurface equivalents in the Palo Duro and Dalhart Basins area, Texas Panhandle. Map symbols are those used on the Geologic Atlas of Texas sheets. Modified after Presley (1981), Barnes (1981, 1977, 1974, 1970, 1968, 1967), WTGS (1976), and Brand (1933).

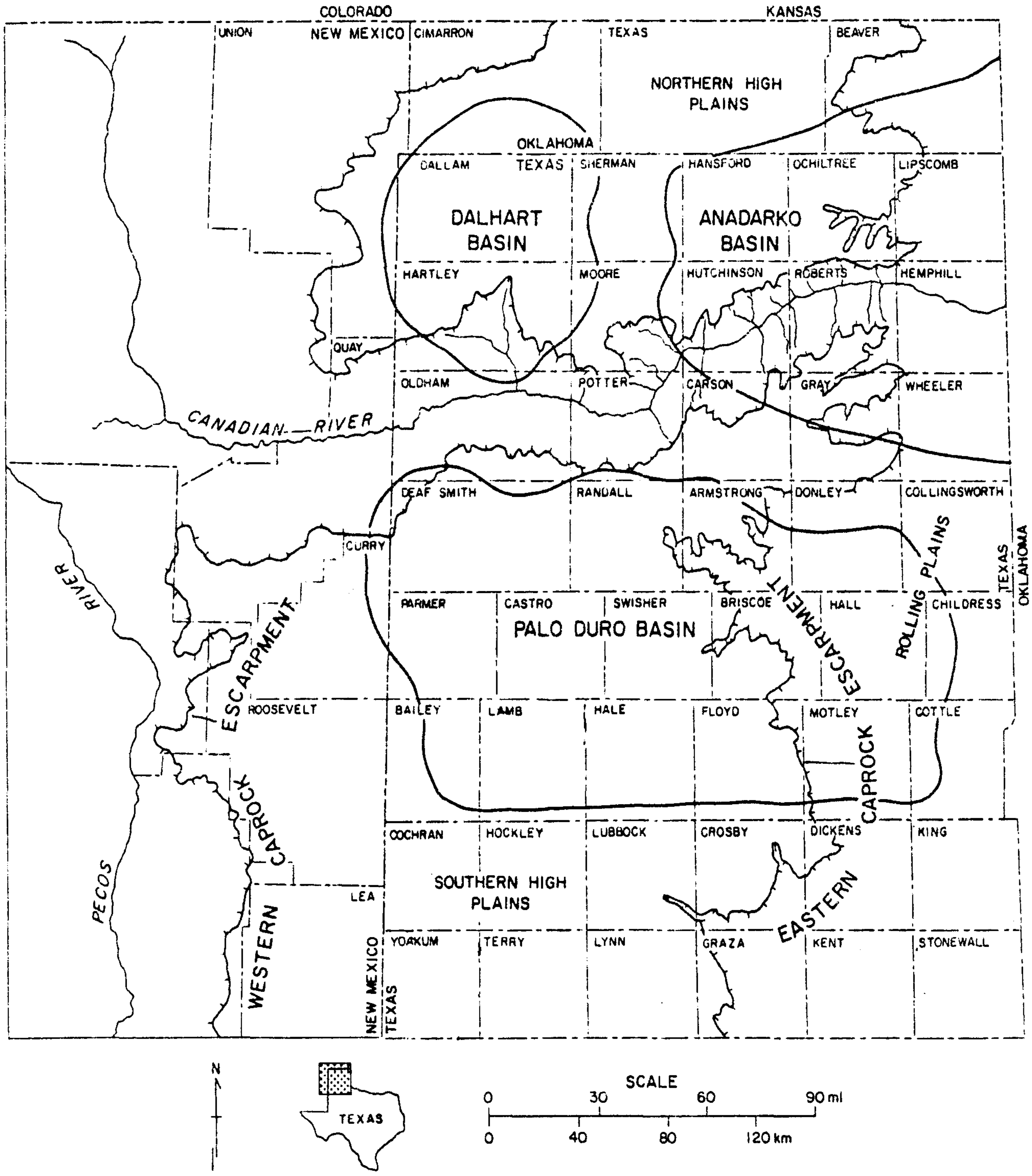


Figure 1. Physiographic units of the Palo Duro and Dalhart Basins area.

| SYSTEM | SERIES | GROUP | PALO DURO BASIN FORMATION | MAP SYMBOL | SUBSURFACE EQUIVALENTS | DALHART BASIN FORMATION | MAP SYMBOL | SUBSURFACE EQUIVALENTS |
|---|---|---|---|---|---|---|---|---|
| Quaternary | Recent | | Alluvium | Qal | | Alluvium | Qal | |
| | | | Eolian deposits | Qea | | Eolian dune sand | Qd | |
| | | | Windblown deposits | Qsd, Qs, Qsu | | Wind deposits | Qsd, Qs, | |
| | | | Playa and pond deposits | Qp, Qun | | Playa | Qp | |
| | Pleistocene | | Fluviatile terrace deposits | Qt | Undifferentiated | Fluviatile terrace deposits | Qt | Undifferentiated |
| | | | Playa and pond deposits | Qp, Qun | | Playa | Qp | |
| | | | Loess | Ql | | | | |
| | | | Tahoka | Qta | | | | |
| | | | Double Lakes (mapped only in southwestern Palo Duro Basin) | Qla | | | | |
| | | | Blackwater Draw and Windblown cover sands | Qcs | | Blackwater Draw and Windblown cover sands | Qcs | |
| | | | Tule | Qtu | | | | |
| | | | Blanco | Qb | | | | |
| Tertiary | Pliocene | | Ogallala | To | Ogallala | Ogallala | To | Ogallala |
| Cretaceous | | Washita | Duck Creek | Kdc | | Dakota Group | Kd | Undifferentiated |
| | Comanche | Fredericksburg | Duck Creek and Kiamichi (undivided) | Kdk | Undifferentiated | Dakota and Purgatoire (undivided)(mapped only on western margin in New Mexico) | Kdp | |
| | | | Kiamichi | Kk, K | | | | |
| | | | Edwards | Ke | | | | |
| Jurassic | Upper Jurassic | | Jurassic rocks undivided (mapped only on western escarpment along basin margin in New Mexico) | JR | Not present | Morrison (mapped only on western basin margin in New Mexico) | Jm | Undifferentiated |
| Triassic | Upper Triassic | Dockum | Dockum Group and Dockum Group (undivided) | TRd | Dockum Group | Tecovas (southern basin margin) | TRv | Dockum Group |
| | | | Trujillo | TRdj | | | | |
| | | | Tecovas | TRdv | | | | |
| Permian | Ochoa | | Quartermaster | Pq | Dewey Lake | | | |
| | | | Alibates | Pqwa | Alibates | | | |
| | Ochoa / Guadalupe | | Quartermaster, Dozier Sandstone, Cloud Chief Gypsum, and Whitehorse Sandstone | Pqw, Pqwd, Pwh | Artesia Group | | | |
| | Guadalupe | | Blaine | Pb | San Andres | | | |
| | | | Guthrie Dolomite, Acme Dolomite, unnamed dolomites | Pbg, Pbac, Pbdu | | | | |

Figure 2. Stratigraphic chart of the surface geology and subsurface equivalents in the Palo Duro and Dalhart Basins area, Texas Panhandle. Map symbols are those used on the Geologic Atlas of Texas sheets. Modified after Presley (1981), Barnes (1981, 1977, 1974, 1970, 1968, 1967), WTGS (1976), and Brand (1933).