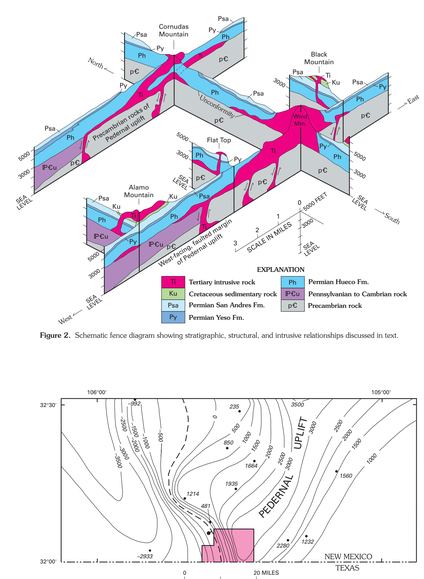


Figure 2. Schematic fence diagram showing stratigraphic, structural, and intrusive relationships discussed in text.

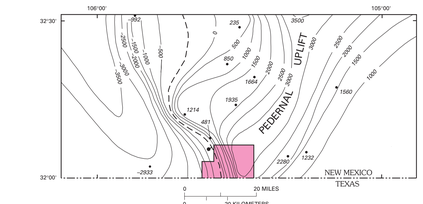
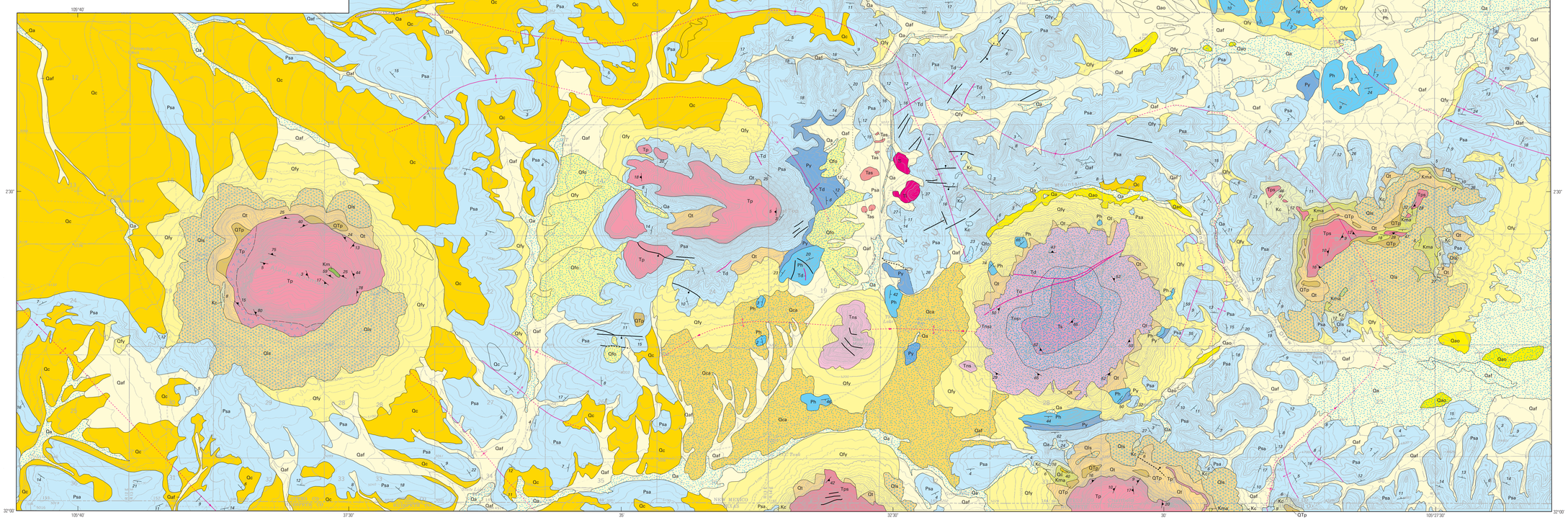


Figure 3. Structure contour map drawn on top of Precambrian basement showing location of buried Pedernal uplift with respect to Cornudas Mountains (pink). Contour interval 500 ft; datum is mean sea level. Dashed line, well; dot within circle, well, showing depth. Dashed line, fault; bar and ball on downthrown side. Modified from King and Harder (1985).



Base from U.S. Geological Survey, Alamo Mountain, Cornudas Mountain, 1975, McVeigh Hills, 1970.
Projection: Transverse Mercator (Alamo Mountain, Cornudas Mountain), Polyconic (McVeigh Hills).
1927 North American datum

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1998

MAP LOCATION

Geology by J. Michael O'Neill and Constance J. Nutt, 1996–1997; and Clabaugh (1941), Timm (1941), Zapp (1941), and McLemore and others (1996).
Geology digitized by Esther L. Castellano
Editing and digital cartography by Alessandro J. Donatich
Manuscript approved for publication March 26, 1998

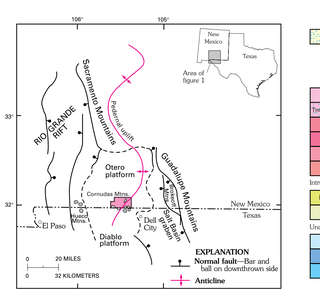


Figure 1. Index map showing regional physiographic setting of the Cornudas Mountains (map area shown in pink), south-central New Mexico and adjacent Texas.

CORRELATION OF MAP UNITS

Qa, Qaf, Qfy, Qt, Qc, Qca, Qfo, Qao, Qls, QTp — QUATERNARY (Holocene, Pleistocene, Pliocene)

Tns, Tns1, Tns2, Ts, Tps, Tqs, Tp, Tas — TERTIARY (Oligocene, Eocene)

Intrusive contact

Td, Ti, Kma, Km, Kc — CRETACEOUS (Lower Cretaceous)

Unconformity

Psa, Py, Ph — PERMIAN (Lower Permian)

DESCRIPTION OF MAP UNITS

SURFICIAL DESCRIPTIONS

Qa **Stream floodplain alluvium (Holocene)**—Sand, silt, and clay deposited in (1) broad, open stream valleys, (2) confined ephemeral stream channels, and (3) areas where drainage is partly blocked by man-made earthen dams. Where exposed, consists of upper zone of 1.5- to 2-ft- (0.45–0.6 m) thick, tan-brown, clay-and silt-rich sand enclosing isolated pebbles; a medial zone of 1-ft-thick (0.3 m) silty sand interlayered with yellow-white 2- to 4-in.-thick (5.1–10.2 cm) layers of calcium carbonate-rich silty sand, silt, and clay; and a lower zone of unknown thickness of clay, silt, and sand enclosing clasts ranging in size from pebbles to small boulders. Maximum exposed thickness about 10 ft (3 m)

Qaf **Alluvial and fluvial deposits (Holocene)**—Sand, silt, clay, and pebble to cobble gravel deposited in narrow stream channels and on broad alluvial slopes at base of low hills and mountain fronts. Generally less than 15 ft (4.5 m) thick

Qfy **Young alluvial fan deposits (Holocene)**—Poorly sorted silty sand and gravel deposited in small alluvial fans along valley margins and around hills and mountains; locally includes minor colluvium (Qc). Maximum thickness unknown

Qt **Talus deposits (Holocene)**—Unsorted, unstratified angular pebbles to boulders as wide as 30 ft (9.2 m); covers flanks of steep slopes of hills and mountains underlain by resistant bedrock

Qc **Colluvium (Holocene)**—Weakly to strongly cemented calche soil developed in residual deposits of sand, silt, clay, and angular pebbles and cobbles; most commonly mantles the San Andres Formation (Psa) in northwestern part of map area, which is drained by tributaries of Shiloh Draw to the north. Thickness generally less than 1–2 ft (0.3–0.6 m)

Qca **Colluvial and alluvial deposits, undivided (Holocene)**—Colluvium (Qc) that is partly reworked and dissected by intermittent streams infilled with young alluvium (Qa); restricted to south-central part of map area, which is drained by tributaries of Shiloh Draw to the south

Qao **Old alluvial fan deposits (Holocene and Pleistocene)**—Poorly sorted silty sand and gravel deposited in dissected, abandoned alluvial fans that no longer receive sediment. Dissection probably related to Pleistocene faulting to the east in the Salt Basin graben adjacent to Guadalupe Mountains. Maximum thickness unknown

Qfo **Old alluvium (Holocene and Pleistocene)**—Dissected terraces underlain by sand, silt, clay, and pebble to cobble gravel; preserved as small, isolated hills 3–10 ft (0.9–3 m) above active stream valley floors

Qls **Landslide deposits (Pleistocene)**—Angular fragments of bedrock mixed with soil, or heterogeneous mixtures of boulders and finer grained material derived from adjacent steep hillslopes; characterized by irregular-shaped, hummocky topography and numerous closed depressions. Landslides mainly confined to areas underlain by Cretaceous sedimentary rocks preserved adjacent to middle Tertiary igneous intrusions

QTp **Pediment alluvium (Pleistocene and Pliocene?)**—Angular boulder to cobble gravel set in finer grained matrix and deposited on gently sloping surfaces; preserved as isolated, flat-topped deposits on flanks of Alamo, Black, and Chatfield Mountains and Flat Top at elevations between 5,100 and 5,700 ft (1,530 and 1,710 m). Appears to be continuous with perched pediment gravels preserved 1 mi east of Chatfield Mountain at elevations near 4,900 ft (1,470 m)

IGNEOUS ROCKS

[Igneous rocks of the Cornudas Mountains have been described by Clabaugh (1941), Zapp (1941), Timm (1941), Barker and others (1977), Barker and Hodges (1977), McLemore and Gallegher (1993), McLemore and others (1996), and Schreiner (1994). The following descriptions are taken from their work. K-Ar age determinations reported below are from Barker and others (1977)]

Tns **Nepheline syenite (Oligocene)**—Medium- to light-gray, mostly coarse-grained, equigranular to slightly porphyritic nepheline syenite. Consists of anorthoclase, nepheline, clinopyroxene, arfvedsonite, biotite, and interstitial fayalite and red hornblende, and minor to trace amounts of biotite, apatite, zircon, and magnetite. Exposures on Wind and Deer Mountains range from weakly to strongly foliated. Wind Mountain units subdivided into medium grained (Tns$_2$) and coarse grained (Tns$_1$) after McLemore and others (1996); medium-grained units are most suitable for industrial use. K-Ar age of biotite from Deer Mountain is 31.6 Ma

Ts **Syenite porphyry (Oligocene)**—Syenite porphyry exposed in upper parts of Wind Mountain, as mapped by McLemore and others (1996). Fine grained; consists of potassium feldspar, albite, aegirine, sodic amphibole, biotite, analcime, and trace amounts of magnetite

Tps **Porphyritic nepheline syenite (Oligocene)**—Dark-gray-green, fine- to medium-grained, porphyritic nepheline syenite. Phenocrysts consist of euhedral anorthoclase as long as 1 in. (2.5 cm) in groundmass of anorthoclase, clinopyroxene, biotite, nepheline, and analcime. Well-foliated rocks characterize exposures on Black and San Antonio Mountains

Tqs **Quartz-bearing syenite (Oligocene)**—Medium-gray, weakly foliated, granoblastic to porphyritic syenite composed of tabular, euhedral anorthoclase, subhedral clinopyroxene, biotite, and interstitial quartz. Exposed at Cornudas Mountain. K-Ar age of biotite is 33.9 Ma

Tp **Phonolite (Oligocene)**—Medium-gray-green, aphanitic rock composed mainly of alkali feldspar, nepheline, clinopyroxene, and nepheline. Locally contains xenocrysts of olivine, clinopyroxene, and biotite. Phonolite of Chatfield Mountain, Flat Top, and Alamo Mountain shows well-developed flow foliation. K-Ar age of biotite from Alamo Mountain is 36 Ma. On western and southern Alamo Mountain unit Tp is phonolite with foliation dipping at a low angle to underlying sedimentary bedding (denoted by pattern)

Tas **Nepheline-bearing augite syenite (Oligocene and Eocene)**—Gray, medium-grained, equigranular nepheline-bearing augite syenite. Consists of anorthoclase, plagioclase mantled by anorthoclase, augite, biotite, and interstitial nepheline and analcite. Small body, in part covered by unit Qaf, in Chess Draw. K-Ar age of biotite is 36.8 Ma

Td, Ti **Dike (Oligocene and Eocene)**—Mafic dikes mainly restricted to the Chess Draw area

Tu **Intrusive breccia, undifferentiated (Oligocene and Eocene)**

SEDIMENTARY ROCKS

[Nomenclature for Permian sedimentary rocks exposed in the Cornudas Mountains follows the terminology used on the New Mexico State geologic map of Anderson (1994)]

Kma **Muleros and Mesilla Valley Formations, undivided (Lower Cretaceous)**—Yellowish-tan to light-gray, nodular, fossiliferous limestone and minor shale and siltstone (Muleros) overlain by poorly exposed brownish-tan to orangish-tan sandstone and siltstone (Mesilla Valley). Maximum exposed thickness about 100 ft (30.5 m)

Kc **Campagnarde Formation and Cox Sandstone, undivided (Lower Cretaceous)**—Yellowish-orange siltstone and minor cream-white, fine-grained limestone are the oldest Cretaceous rocks exposed in map area. The interbedded siltstone and limestone are no more than about 15 ft (4.5 m) thick and are present only on northwest side of Chatfield Mountain; these rocks are similar to those described by Kues and Lucas (1993) as the Campagnarde Formation on southeast flank of Chatfield Mountain. The Cox Sandstone overlies the Campagnarde at Chatfield Mountain, and elsewhere rests unconformably on the Permian San Andres Formation (Psa). The Cox Sandstone consists of a basal, rounded to angular chert-pebble conglomerate overlain by interbedded silty to sandy, light-gray, thin-bedded limestone and orange-tan to reddish-brown to cream-white, calcareous, quartz-rich, crossbedded sandstone; locally, channel-fill deposits of lithic pebble conglomerate are interlayered with sandstone. Maximum thickness of the Cox is about 100 ft (30.5 m)

Km **Metamorphosed calc-silicate rock (Lower Cretaceous)**—Yellow-white to pale-green, fine-grained metamorphosed calcareous rock that rests directly on Alamo Mountain sill. Less than 5 ft (1.5 m) thick

Psa **San Andres Formation (Lower Permian)**—Medium-gray to light-olive-gray dolomite and dolomitic limestone overlain by dark-gray limestone; lower dolomitic rocks are fine to medium grained and thin to massive bedded, and contain medium-gray chert nodules and stringers; sandstone and shale lenses are most abundant in middle part of dolomitic section. Basal dolomitic limestone is locally pisolitic and vuggy and contains layers of coquina and intraformational conglomerate. Dark-gray massive limestone, restricted to uppermost exposures in map area, is conspicuously fossiliferous. Formation forms erosion-resistant ledges and has a maximum exposed thickness of about 500 ft (150 m)

Py **Yeso Formation (Lower Permian)**—Interlayered gypsum-rich laminated claystone locally enclosing dark-gray gypsum nodules; yellow-white, sugary-textured limestone; coarse-grained gypsum; red to green shale and claystone; and orange-tan to red and red-brown, medium-grained quartz sandstone. Most exposures are restricted to top of unit where red to green shale directly underlie the San Andreas Formation (Psa). Maximum exposed thickness about 100 ft (30.5 m)

Ph **Hueco Formation (Lower Permian)**—Dark-gray, fine-grained, thin- to medium-bedded, fossiliferous limestone containing nodules and stringers of dark-gray to black chert nodules and stringers. Maximum exposed thickness less than 100 ft (30.5 m)

Contact—Dashed where approximately located; dotted where concealed

Fault or prominent fracture—Dotted where concealed. Bar and ball on downthrown side where relative movement known; displacement on the order of 15 ft (4.6 m) or less

Syncline—Showing direction of plunge where known. Dashed where approximately located; dotted where concealed. Synclines formed during intrusion of Tertiary igneous rocks

Anticline—Showing direction of plunge where known. Dashed where approximately located; dotted where concealed. Anticlines formed during intrusion of Tertiary igneous rocks

Strike and dip of bedding

Strike and dip of foliation

Platy phonolite (Tp) with foliation dipping at a low angle to underlying sedimentary bedding on western and southern Alamo Mountain

GEOLOGY

REGIONAL GEOLOGIC SETTING

The Cornudas Mountains are in the easternmost part of the Basin and Range province of southern New Mexico. The area is located near the Otero platform, which separates areas of Tertiary and Quaternary faulting of the Rio Grande rift on the west from the Salt Basin graben and the adjacent Guadalupe Mountains on the east (fig. 1). The Cornudas Mountains are underlain by Permian limestone and dolomite, Cretaceous sandstone and shale, and late Eocene to early Oligocene alkaline intrusive rocks. The intrusive rocks are part of the Tertiary Trans-Pecos magmatic belt (Barker and others, 1977) and form the major peaks of the Cornudas Mountains, which are, from east to west, Black, Cornudas, Wind, Chatfield, San Antonio, and Deer Mountains, Flat Top, and Alamo Mountain. The Cornudas Mountains lie above the faulted, western edge of the buried Pennsylvanian Pedernal uplift (Baltz, 1965), which apparently intruded along the pre-existing Precambrian faults and invaded Paleozoic sedimentary rocks (plug uncomformably on the uplifted Precambrian basement (Black, 1975).

SEDIMENTARY ROCKS

Permian sedimentary strata, the oldest exposed rocks in the study area, make up gently rolling hill and plain topography of this part of the Otero-Diablo platform. Three mappable Permian formations are exposed in the Cornudas Mountains. From oldest to youngest, they are: dark-gray, cherty limestone (Hueco Formation (Ph)); generally poorly exposed gypsum, shale, and limestone (Yeso Formation (Py)); and dolomite, dolomitic limestone, limestone, and minor clastic rocks (San Andres Formation (Psa)). Only the Yeso Formation, about 100 ft (30.5m) thick, is completely exposed in the map area. The base of the Hueco Formation is not exposed, and the upper part of the San Andres was removed by erosion prior to deposition of the overlying Cretaceous strata.

On the New Mexico State geologic map (Anderson, 1994), only two formations are shown in the Cornudas area: the gypsiferous Yeso Formation and the overlying San Andres Formation. On the Geologic Atlas of Texas map of the Van Horn-El Paso area directly south of the map area (Barnes, 1975), three Permian formations are mapped in the southernmost Cornudas Mountains: the lowermost Hueco Formation, the Permian Victorio Peak Formation, and the Permian undifferentiated Leonardian limestones. The Victorio Peak overlies the Hueco on the east; the undifferentiated Leonardian limestones overlie the Hueco on the south and west. The Hueco in Texas is correlative to the Hueco and Yeso combined in New Mexico. The Victorio Peak and Leonardian limestones in Texas are equivalent to the San Andres in New Mexico. Neither the Yeso nor San Andres Formations are recognized on the Texas geologic map.

The complex stratigraphic relationships between the various Permian formations of southern New Mexico are summarized by Kottlowski (1963); stratigraphic pinchouts, abrupt lateral lithologic gradations, and stratigraphic younging from west to east characterize the Permian section. The Yeso Formation in the southern Otero platform grades abruptly to the south into carbonate rocks of the Victorio Peak Formation, which in turn grade into the dark, organic-rich calcareous mud of the Bone Springs Formation (Black, 1975). The upper San Andres Formation of New Mexico becomes younger eastward into the Guadalupe Mountains where it pinches out southward into Delaware basin sediments (Pray, 1988); the lower part intertongues with the Victorio Peak as does the underlying Yeso (Black, 1975). The three distinct Permian units mapped in the Cornudas Mountains appear to conform best with nomenclature followed in New Mexico. The lowermost limestones exposed in the map area are likely equivalents of the Hueco Formation (Kottlowski, 1963). The Hueco is in sharp contact with the overlying, anomalously thin section of gypsum, green and red shale, and pale-gray limestone of the Yeso Formation. The Yeso has not been reported south of Cornudas and appears to pinch out abruptly southward. The Yeso is overlain by a marine, near-shore, shallow-water deposit of carbonate rocks and sandstone that grade upward into thin- to medium-bedded dolomitic limestone and dolomite which we correlate with the San Andres Formation. The San Andres in the western part of the map area grades laterally into Leonardian limestones, probably the Bone Springs Limestone (King, 1934) of the Diablo platform; on the east, the formation appears to grade into the Victorio Peak carbonates, the bank-ramp facies of the Capitan reef complex (Pray, 1988).

Cretaceous sedimentary rocks, also present in the map area, are exposed only where they are overlain by or adjacent to resistant igneous bodies at Alamo, San Antonio, Chatfield, and Black Mountains. Cretaceous rocks consist of basal conglomerate and associated sandstone, siltstone, and limestone and are remnants of a sedimentary section that once covered the area. The variable thickness of the lowermost Cretaceous Campagnarde Formation and Cox Sandstone (Kc) suggests that the pre-Cretaceous depositional surface was locally irregular. Areas of Cretaceous outcrop are coincident with landslide deposits (Qls) and suggest that during late Tertiary erosion of the southern Otero platform, the less resistant Cretaceous strata slumped along the edges of the more resistant igneous rocks.

Tertiary and Quaternary surficial deposits are common in the map area and consist mainly of calcium carbonate-cemented colluvium, alluvial and fluvial deposits, and ephemeral stream channel deposits. Perched gravels (QTp) of probable Pliocene-Pleistocene age are preserved adjacent to many of the peaks of the Cornudas Mountains.

IGNEOUS ROCKS

The intrusive bodies that form the peaks of the Cornudas Mountains represent a part of the north-northwest-trending mid-Tertiary calc-alkaline to alkaline Trans-Pecos magmatic belt of western Texas and New Mexico (McLemore and others, 1996). The predominantly alkaline intrusive rocks of the Cornudas Mountains give way to calc-alkaline intrusions of the Hueco Mountains, about 30 mi (50 km) to the west (fig. 1). The composition of the alkaline intrusive rocks of the Cornudas Mountains is predominantly syenite and phonolite. The most mafic rock is the poorly exposed nepheline-bearing augite syenite (Tas) of the Chess Draw area, the most felsic rock, quartz-bearing syenite (Tqs), underlies Cornudas Mountain (Barker and others, 1977) and forms