RECONNAISSANCE GEOLOGIC MAP OF THE QUEMADO 30 x 60 MINUTE QUADRANGLE, CATRON COUNTY, NEW MEXICO

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INTRODUCTION

The Quemado 30 x 60 minute quadrangle, hereafter referred to as the Quemado sheet, is located in northern Catron County in west-central New Mexico. US-60 is the main access route across the Quemado sheet and serves the communities of Quemado and Pie Town (Fig. 1).

Previous reconnaissance geologic maps covering the Quemado sheet (Fig. 2, Willard, 1957; and Willard and Weber, 1958) were made in the middle 1950s as part of a statewide mapping effort that culminated in the 1965 geologic map of New Mexico (Dane and Bachman, 1965). Our recent reconnaissance mapping of the Quemado sheet (1991–1993) was undertaken to provide new geologic data commensurate with that being used to prepare a digital geologic map of New Mexico (Anderson and Jones, 1994).

Reconnaissance geologic data acquired by Chamberlin, Cather and Anderson (Fig. 3) was primarily plotted on 7.5 minute quadrangles (Fig. 1) at a scale of 1:24,000. Jones digitized this 1:24,000 data set using GSMAP ver. 7.0 (developed by Gary Selner, USGS, Denver, CO); Jones then combined the 7.5 minute quadrangles at the 1:100,000 scale to produce a geologic map of the Quemado sheet. The digital printout of this geologic map, an explanatory lettering sheet, and the 1:100,000 USGS topographic base have been photographically combined to make the geologic map presented here. The original digital printout of the Quemado sheet used 4 point type for map unit symbols. To improve legibility of the final photographic composite, the unit symbols have been enlarged to 6 point type. The left (west) end of these larger symbols always lies within the designated outcrop area, but the right (east) end may extend outside the area (or overlap a leader). A colored copy of the Quemado sheet is available for inspection at the New Mexico Bureau of Mines and Mineral Resources. Areas of reconnaissance mapping responsibility are delineated on Figure 3. Some portions of the reconnaissance map have been generalized from, or modified after, existing detailed maps of Jones (1980), Guilinger (1982) and Roybal (1982); see Figure 2.

STRATIGRAPHY AND CORRELATION OF MAP UNITS

The general stratigraphic relationships of regional map units are schematically portrayed on Figure 4. A chronostratigraphic diagram showing the correlation of map units is presented as Figure 5. Age boundaries of Tertiary epochs (Fig. 5) are from Palmer (1983), except for the Eocene–Oligocene boundary which is from McIntosh et al. (1992). Some users of the Quemado sheet may want to color the map for better visualization of geologic patterns. In this case, it is recommended that largely correlative units be given the same color or similar shades of the same color. Groups of map units that could be given similar colors include: Qa + Qe + Qs, Qbt + Qb, QTsf + QTq, Tsf + Tfl + QTg, Tuau + Tual, Tsm + Tlrp + Tla, Ts + Tsl + Tsd, Kmho + Kcco + Kmh + Kcc, Ka + Kmha and Kmw + Kdtm. For the purpose of map coloring, short black lines across faults (tie lines) indicate that the same map unit is present on both sides of the fault at that location.

Detailed descriptions of map units are listed in Table 1. Symbols for map units on the Quemado sheet mostly represent generalized nomenclature established for the state map of Anderson and Jones. On Figure 4, symbols shown in parentheses represent individual formation names that are included as part of state map units, or that are equivalent to state map units. The description of map units (Table 1) references both sets of symbols as shown on Figure 4. The stratigraphic nomenclature applied to upper Cenozoic alluvial deposits and their relationship to major drainage divides is shown on Figure 6.

STRUCTURE

Regional strike and dip data are shown on the reconnaissance map. Indicated dips include direct observations and estimates (to nearest 0.5 degree) calculated from local variation in the elevations of topographically defined contacts. Regional and local structures are identified on Figure 7. Stratigraphic throws of normal faults (Fig. 7) are locally estimated from elevation differences of gently dipping contacts, from sketched cross sections, and from juxtaposition of formations of known thickness.

The dominant structural pattern consists of mostly NNE-trending high-angle normal faults of Neogene age and gently (1–3°) SSE-dipping middle Tertiary strata. A regional seismic reflection profile in the Red Flats–Alegres Mountain–Wallace Mesa area (Armstrong and Chamberlin, 1994) indicates that Mesozoic strata were gently tilted to the north or northeast prior to deposition of the Baca Formation. This seismic line also indicates that the Alegres Mountain fault zone (AMF) was a Laramide reverse fault, downthrown to the north prior to Baca deposition. Regional thickness trends for the Baca Formation (cf. Fig. 4) and structural patterns about the Zuni uplift (e.g. Chamberlin and Anderson, 1989) suggest that the Hickman fault zone (HF) was a right-lateral reverse fault in late Laramide time. Both fault zones (HF and AMF) are now expressed as high-angle normal faults. These relationships support the general interpretation that Neogene normal faults commonly represent collapsed (extended) Laramide transpressional fault zones (Cather, 1989). A few observations of striated fault surfaces along the Hickman fault zone (e.g. Maxwell et al., 1989, p. 20–24) and the Red Lake fault zone north of Datil (R. M. Chamberlin, unpublished data), suggests that the NNE-trending Neogene normal faults are essentially dip-slip faults. The Lehew dike north of Tres Lagunas shows an apparent cumulative left offset of about 400 ft, where it is cut by three strands of the Hickman fault zone. A pure dip-slip displacement of about 1200 ft on the Hickman fault zone could produce the observed lateral offset. This estimated dip slip is somewhat larger than the estimated stratigraphic throw (700 ft + 200 ft + 100 ft; Fig. 7) at Lehew, and suggests some of the apparent left offset could be attributed to a minor sinistral component for the Hickman zone (e.g. a 70° rake angle of net slip; Chamberlin, 1993).

Northwest of Pie Town, Fence Lake strata define an asymmetric synclinal basin (Omega syncline) on the downthrown western side of the Hickman fault zone. The Hickman fault zone locally has the character of an asymmetric anticline near Pie Town. Small northwest-trending anticlines near Adams Diggings (AA and TA, Fig. 7) are apparently of late Laramide age, since the Baca Formation is locally absent on their crests.

The regional southerly dip in the Quemado region (Mogollon slope) may be attributed to loading of the southern margin of the Colorado Plateau by as much as 4000–7000 ft of early and middle Tertiary strata (Chamberlin and Cather, 1994; Chamberlin, 1994).

Regional Hydrostratigraphic Units

Myers (1992) presented hydrologic data pertinent to Mesozoic strata in the Quemado–Zuni Salt Lake region of the Quemado sheet. Newcomer (1994) briefly discussed the hydrogeology and ground water quality in the Largo Creek basin between Quemado and Pie Town. Morgan (1980) presented hydrogeochemical data for well waters in the Pie Town region.

These hydrologic data sets in combination with regional stratigraphic relationships (Fig. 4, Table 1) suggest that the Cenozoic stratigraphic section may be divided into four regional hydrostratigraphic units. From oldest to youngest these units are: (1) Paleogene sedimentary rocks (Tps, 600–2000 ft thick), (2) lower Spears Group (Tsd + Tsl, 1300–2000 ft thick), (3) middle and upper Spears Group plus intercalated volcanic rocks of the Datil and Mogollon groups (Tsm + Tlrp + Tla + Tsu + Turp + Tuau, 2000–2500 ft thick), and (4) late Cenozoic surficial alluvial deposits (Tfl + QTq + Qa; mostly 0–200 ft thick, possibly 800 ft thick along Omega syncline, Fig. 7).

Unit 1 contains belt-like aquifers of fluvial channel sandstone and conglomerate within overbank mudstones of the Baca and Eagar formations. Sandstones appear to be thickest and most continuous near the middle of this unit (Cather and Johnson, 1984; Broadhead and Chamberlin, 1994). Paleocurrent data (Cather and Johnson, 1984) indicate that these river-deposited sandstone belts generally trend to the east. In the Hunt Oil Co. No. 1-16 well, west of Wallace Mesa, potential aquifer sandstones of the medial Baca Formation are present at a depth of 1830 to 2710 ft (Broadhead and Chamberlin, 1994). Unit 1 is a semi-confined to confined aquifer capped by relatively impermeable beds of the lower Spears Group. Well waters from the Baca Formation commonly contain elevated concentrations of uranium (Morgan, 1980; Newcomer, 1994)

Unit 2 appears to act as a regional aquitard or thick confining bed in the area south and east of Omega. The argillaceous matrix of andesitic sandstones (Tsl) and debris-flow deposits (Tsd) in this region makes these rocks relatively impermeable. Electrical logs for the Hunt Oil Co. No. 1-16 well indicate high resistivity and low permeability for the 1370 ft of lower Spears Formation intersected in the upper part of this well (Broadhead and Chamberlin, 1994). Several springs along the west side of the Omega synclinal basin (Nutria Spring, San Ignacio Spring and Rito Spring; Quemado 7.5-minute quadrangle) issue from the base of the Fence Lake and Quemado formations where these alluvial aquifers rest on relatively impermeable andesitic sandstones of the lower Spears Group (Tsl). Andesitic sandstones of the lower Spears Group (Tsl and Ts) generally become better sorted and less argillaceous in the west half of the Quemado sheet. Shallow wells along Rito Creek valley, just east of Quemado, apparently draw minor amounts of water from these andesitic sandstones. East of Quemado, this low-yield aquifer produces water with anomalously high concentrations of arsenic and selenium (Newcomer, 1994), both of which can be harmful to animals and humans. More work is appropriate to test groundwaters in the Rito Creek Valley and determine their potential health hazard. Tsl and Ts west of Quemado may also have the character of a low-yield aquifer possibly with elevated concentrations of arsenic and selenium.

Unit 3 appears to represent a thick regional unconfined aquifer above confining beds of the lower Spears Group. This hydrologic unit consists primarily of moderately indurated conglomeratic sandstones of fluvial origin (Tsm, Tlrp) and well sorted sandstones of eolian origin (Tsu). Fractured volcanic rocks that cap Unit 3 (Tuau, Turp, Tual), form resistant highlands that act as local recharge areas to this unconfined aquifer. Numerous springs that issue from the flanks of Alegres, Mangas, Escondido, Gallo, and Fox mountains are the most obvious expression of this unconfined aquifer. These waters are apparently fresh; no data are available concerning their metal content.

Unit 4 consists of mostly thin surficial alluvial deposits that generally stand above the regional water table. Lower portions of alluvial valley fill deposits (Qa and QTq) may be perennially or intermittently saturated with ground water, especially where they overlie relatively impermeable beds of the lower Spears Group. The lower Fence Lake Formation (Tfl) is locally saturated along the Omega basin syncline, where it may be as much as 800 ft thick. The lower half of a 200-ft-thick Fence Lake paleocanyon fill near Quemado Lake dam is a significant perennial fresh-water aquifer that serves a local water system at Quemado Lake Estates (Chamberlin et al., 1994, p. 42–43).

Acknowledgments

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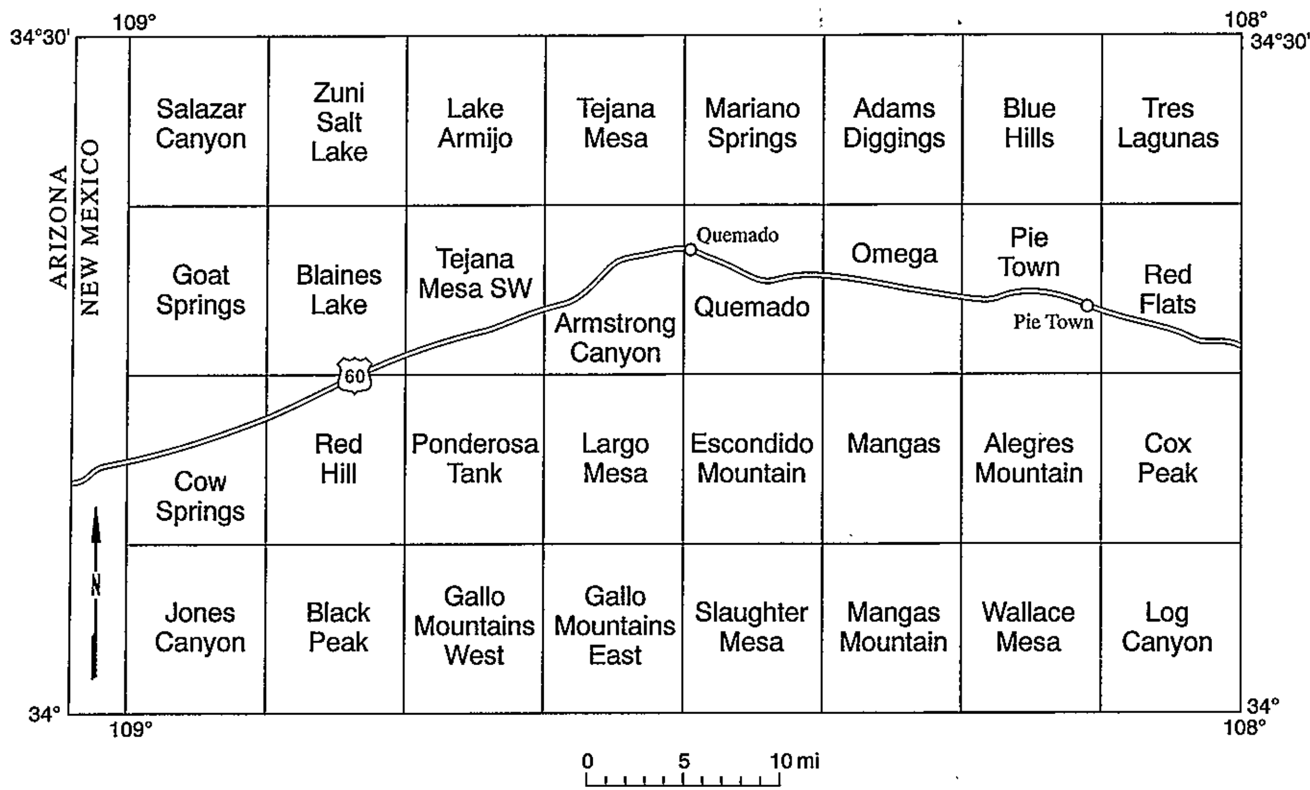


Figure 1. Communities, primary access route, and 7.5 minute quadrangles in the Quemado 30 x 60 minute quadrangle.

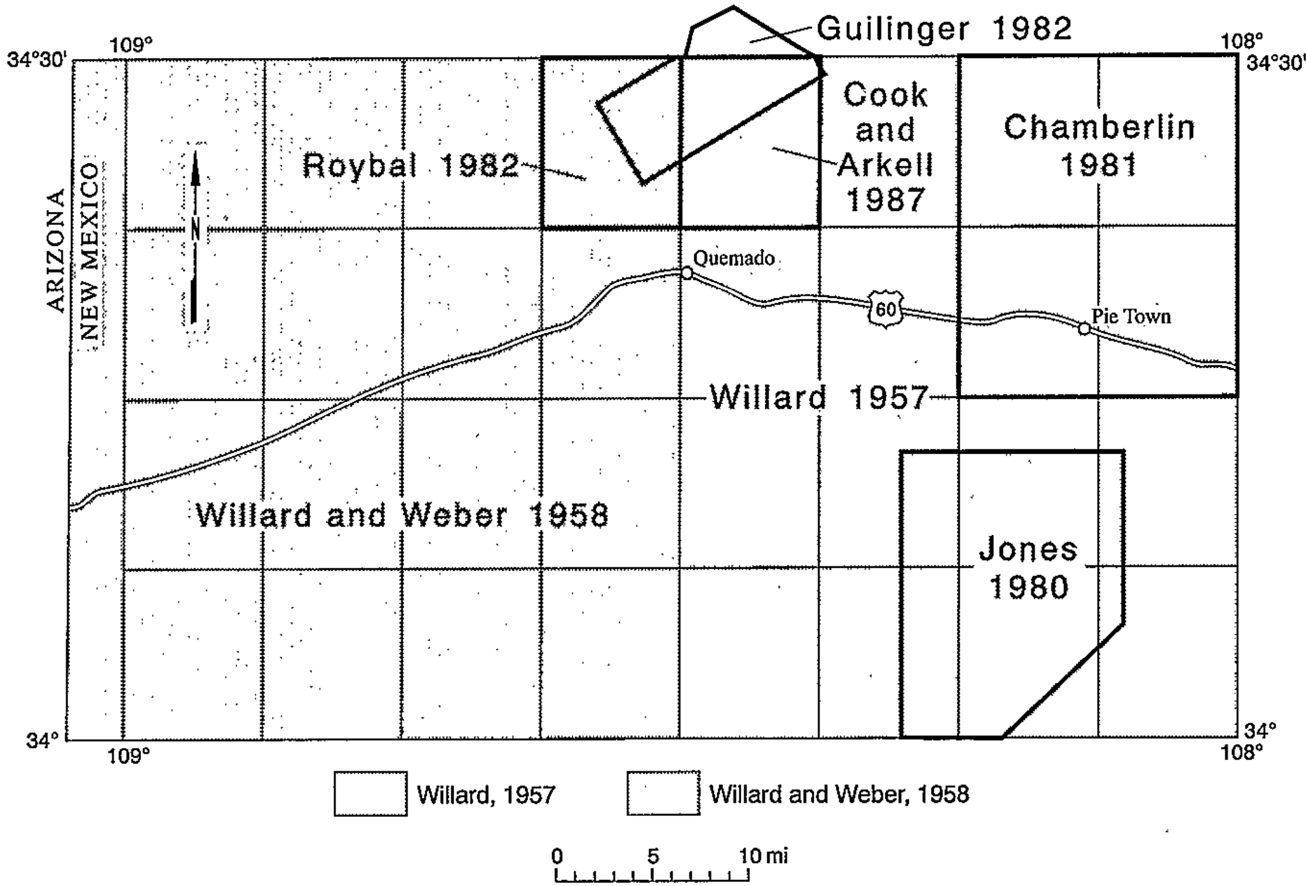


Figure 2. Geologic maps of prior investigations in the Quemado 30 x 60 minute quadrangle.

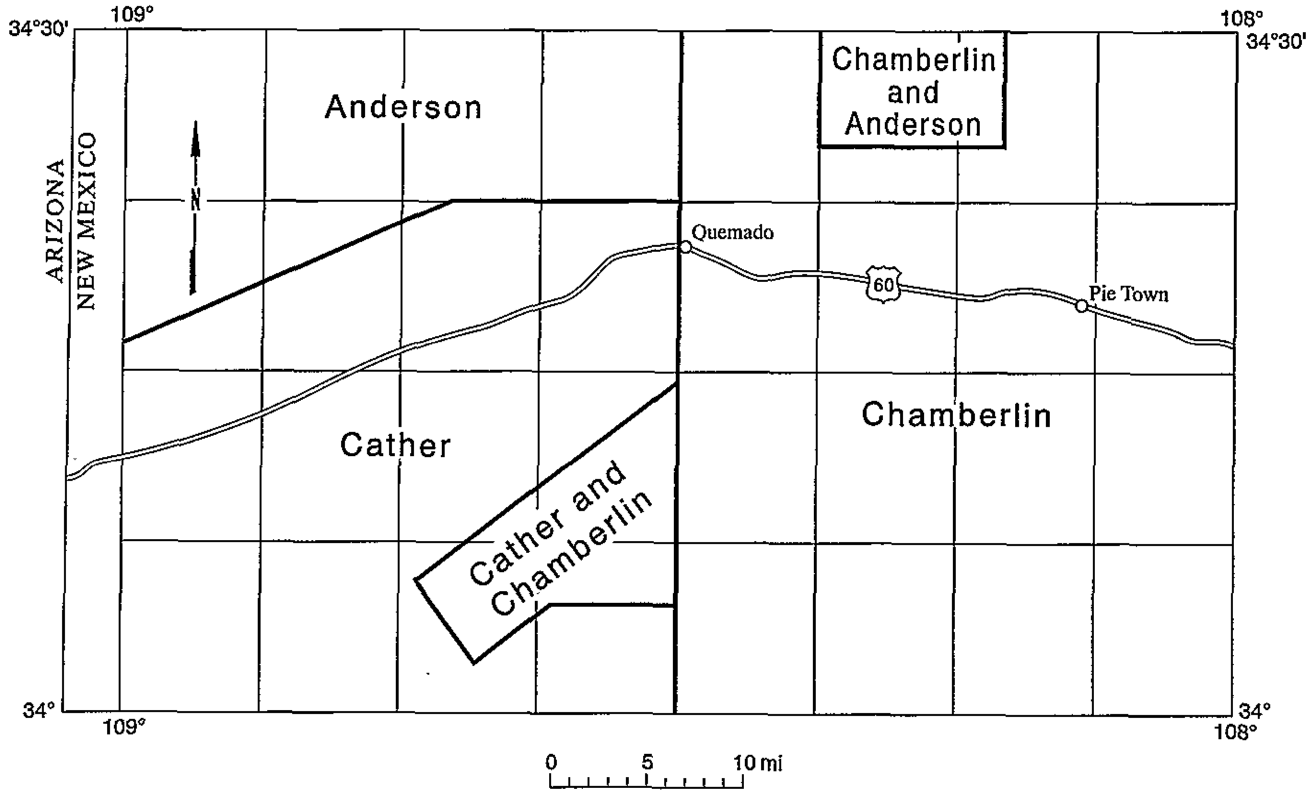


Figure 3. Reconnaissance mapping responsibilities for the Quemado 30 x 60 minute quadrangle.

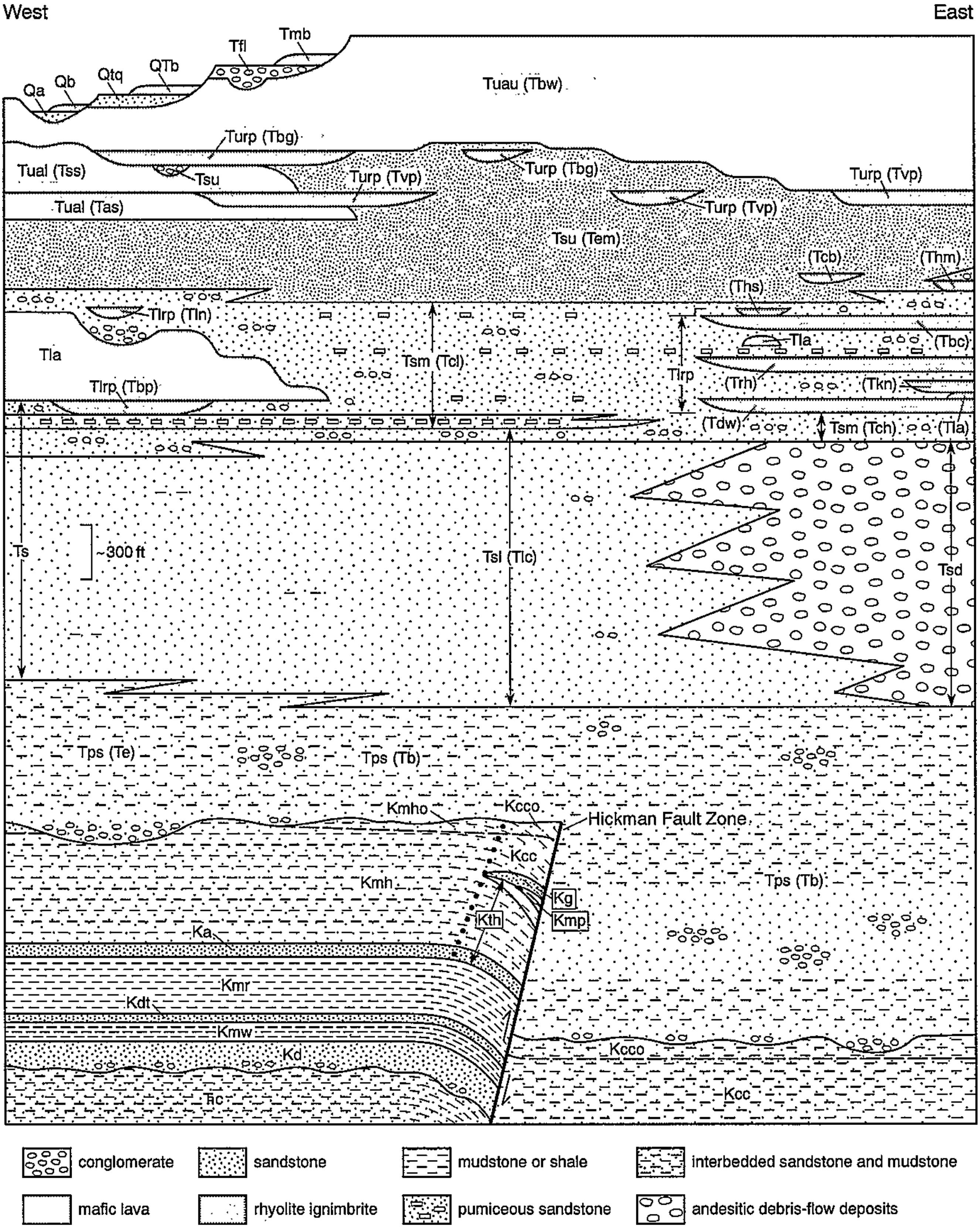


Figure 4. Schematic stratigraphic diagram for the Quemado 30 x 60 minute quadrangle. See Table 1 for explanation of symbols and detailed lithologic descriptions of map units. Symbols in parentheses represent formation names equivalent to map units or included as part of map units. Symbols in boxes indicate formations not exposed in map area: Kg = Gallup Sandstone; Kmp = Pescado tongue of Mancos Shale; Kth = Tres Hermanos Formation. Heavy dotted line shows locus of nomenclature change. Thickness of thin units is exaggerated for clarity.

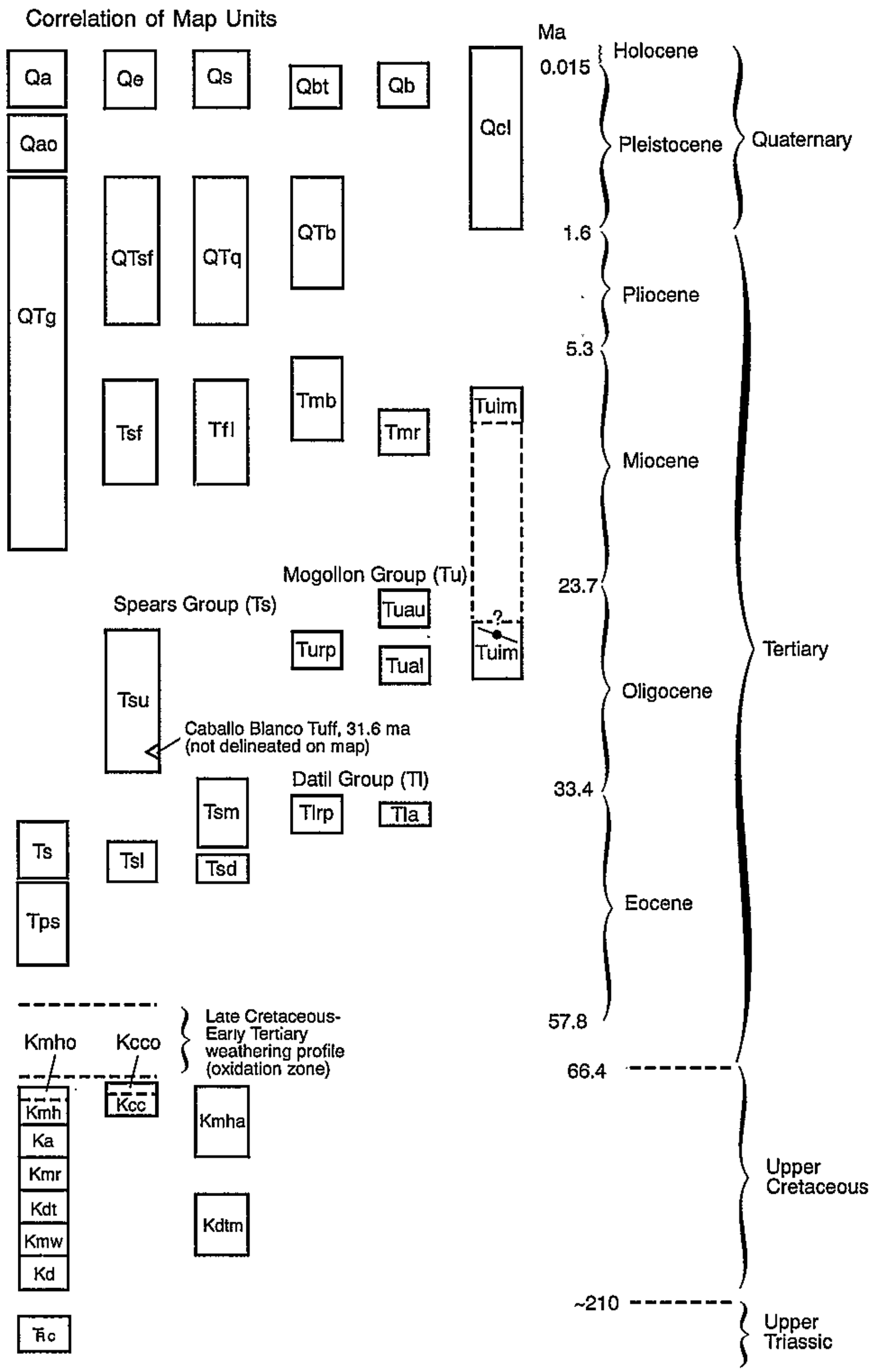


Figure 5. Correlation of map units for the Quemado 30x60 minute quadrangle.. Age of epoch boundaries from Palmer (1983) and McIntosh et al (1992). Ma=mega annum (million years).

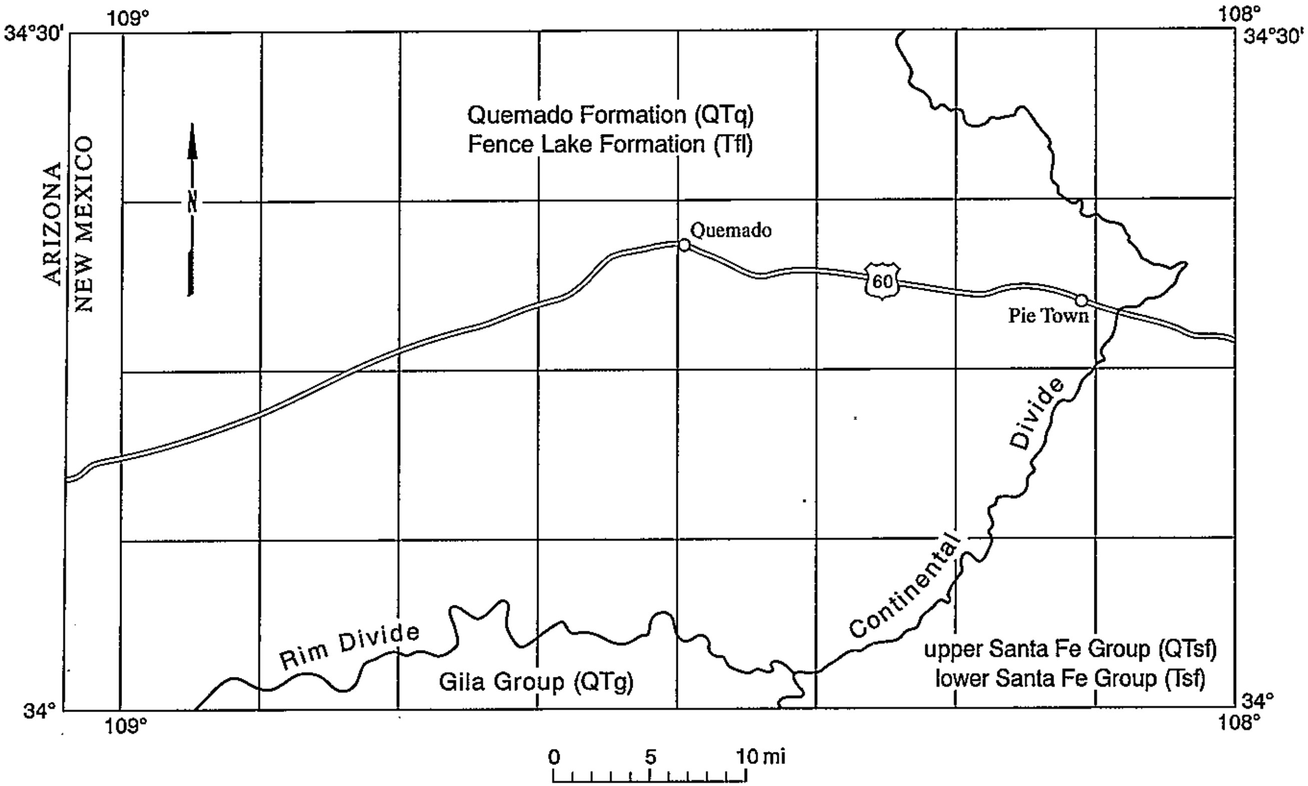
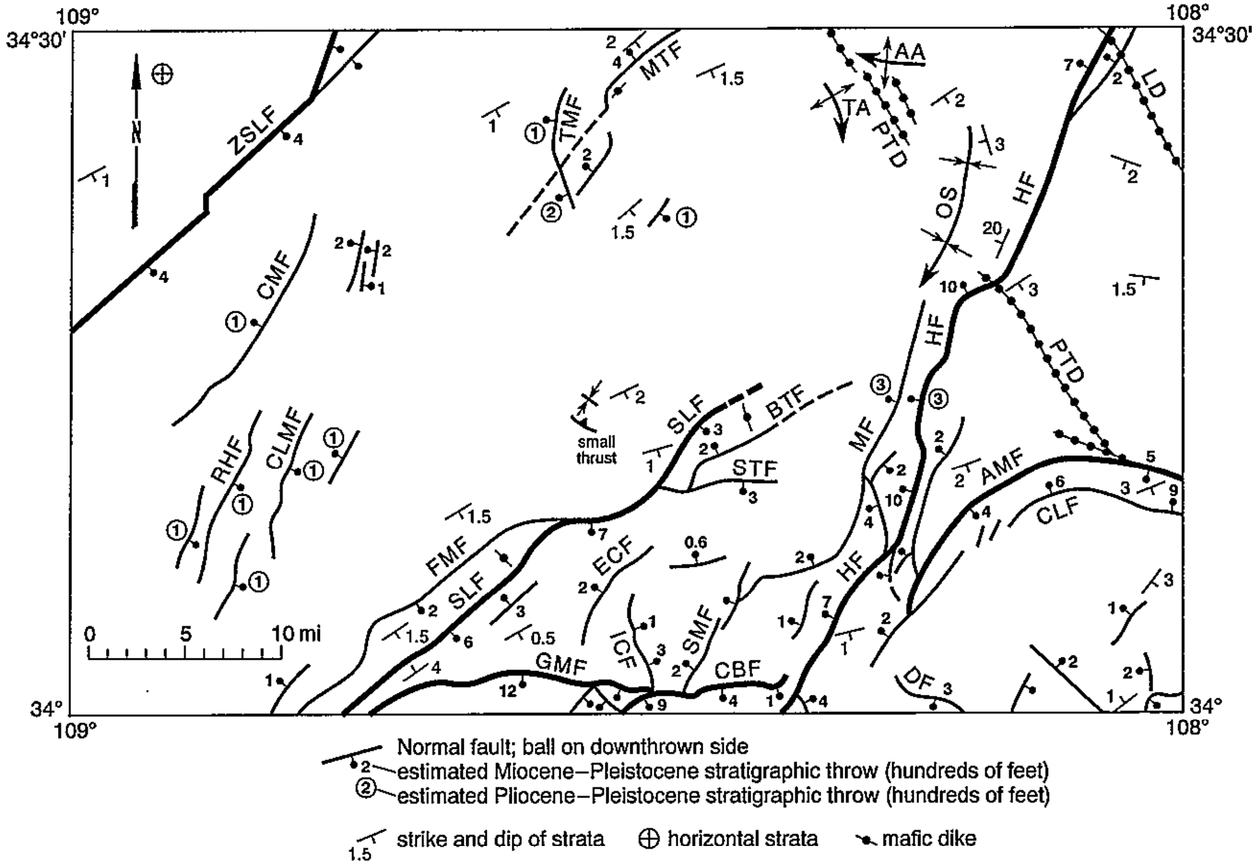


Figure 6. Major drainage divides and nomenclature of upper Cenozoic surficial deposits (after Cather et al., 1994).



Regional Faults (bold)	
HF	Hickman
AMF	Allegres Mtn.
SLF	Spur Lake
GMF	Gallo Mtn.
CBF	Cañon del Buey
ZSLF	Zuni Salt Lake

Local Faults			
CLF	Cox Lake	BTF	Baca Tank
DF	Dutch Oven Pass	FMF	Fox Mtn.
MF	Mangas	CLMF	Cerro la Mula
SMF	Slaughter Mesa	RHF	Red Hill
ICF	Indio Canyon	CMF	Cimarron Mesa
ECF	El Caso	TMF	Tejana Mesa
STF	Slaughter Tank	MTF	Mesa Tinaja

Anticlines	
AA	Adams Diggings
TA	Toms Rock
Syncline	
OS	Omega
Dikes	
PTD	Pie Town
LD	Lehew

Figure 7. Structural index map of the Quemado 30 x 60 minute quadrangle

Table 1. Description of Map Units

Qa — Alluvium (Holocene to upper Pleistocene)
Mostly stream channel and floodplain deposits; includes numerous closed-basin deposits, alluvial-fan deposits and minor colluvium. Consists of sand, silt, clay and gravels. Contacts approximately located. Thickness probably less than 100 ft in most areas.

Qe — Eolian deposits (Holocene to upper Pleistocene)
Dune sands commonly forming elongate mounds that trend ENE. Thickness less than 100 ft. Restricted to North Plains area (Blue Hills and Tres Lagunas 7.5′ quadrangles).

Qs — Salt deposits (Holocene to upper Pleistocene)
Evaporitic salt deposits and muds in Zuni Salt Lake maar. Thickness less than 30 ft.

Qbt — Basaltic tephra deposits (upper Pleistocene, 0.07–0.21 Ma)
Basaltic cinder cones and tephra deposits associated with volcanic vents at Red Hill, Quemado Crater (sec. 16, T1S, R19W), Cerro Pomo and Zuni Salt Lake (McIntosh and Cather, 1994). Thickness 0–300 ft.

Qb — Basaltic lava flows (upper Pleistocene, 0.07–0.21 Ma)
Basaltic lava flows at Red Hill, near Blaines Lake, and at Cerro Pomo. Thickness 0–100 ft.

Qao — Older alluvium (middle Pleistocene)
Mostly alluvial-fan deposits and alluvial-valley-fill deposits. Consist of sand, silt, mud and gravel; moderately developed calcic soils locally present. Thickness 0–100 ft.

Qcl — Colluvium and landslide deposits (Pleistocene)
Coarse slope wash, talus and minor slump blocks on moderate to steep slopes. Colluvial deposits that commonly mask parts of the Spears Group (Tsu and Tsl) are generally not shown on the map. Thickness 0–30 ft.

QTb — Basaltic lavas and tephra (lower Pleistocene to Pliocene, 0.86–2.46 Ma)
Basaltic lava flows and tephra cones near vents (asterisks); locally intercalated with the Quemado Formation in the Red Hill area (McIntosh and Cather, 1994). Thickness 0–300 ft.

QTq — Quemado Formation (lower Pleistocene to Pliocene)
Poorly consolidated alluvial-valley-fill and arroyo-fill deposits locally intercalated with basaltic lava flows ranging from 2.46–0.97 Ma (Cather and McIntosh, 1994). Consists of light-brown friable sandstone and gravels; volcanic clasts are largely reworked from adjacent exposures of the Fence Lake Formation and well-rounded

siliceous clasts (e.g. quartzite) are locally derived from adjacent outcrops of the Baca Formation. Calcic paleosols are common within the formation. Thickness 0–120 ft.

QTsf Upper Santa Fe Group (lower Pleistocene to Pliocene)
Poorly to moderately consolidated piedmont-slope deposits similar to the Quemado Formation but occurring east of the Continental Divide. Gravels contain abundant clasts of Oligocene basaltic andesite (from Tuau and Tual) and Eocene hornblende andesite (from Tsd) reflecting local source areas in the Mangas Mountains and Sawtooth Mountains. Gravels in the Blue Hills quadrangle were mostly derived from the Fence Lake Formation, just west of the Continental Divide. Thickness 0–100 ft.

QTg Gila Group (lower Pleistocene to Miocene)
Poorly consolidated to well-indurated piedmont-slope conglomerates and sandstones west of the Continental Divide and south of the Rim Divide. Epiclastic conglomerates contain abundant clasts of Oligocene basaltic andesite (Tuau), coarsely porphyritic basaltic andesite (Tual) and minor ignimbrite (Turp) derived from source areas in the Mangas, Gallo and Fox Mountains. Thickness 0–300 ft.

Tmb Basaltic lava flows and tephra deposits (upper Miocene)
Medium gray to black basaltic lava flows, commonly with sparse fine-grained olivine phenocrysts. Reddish tephra cones and agglomerates are common near vents (marked by asterisk symbols). Coarse-grained syenitic veins and sill-like segregations locally occur in thick (near vent) phonolitic lavas at El Porticito (Tejana Mesa) and in the Tejana Mesa SW quadrangle (sec. 12, T1N, R18W). $^{40}Ar/^{39}Ar$ ages range from 7.92–5.20 Ma (McIntosh and Cather, 1994). Basaltic flows northwest of Red Hill are locally interbedded in the Fence Lake Formation. An ENE-trending feeder dike (Tuim) for the basaltic flow capping Mesa Tinaja has yielded a K-Ar whole rock age of 9.07 ± 0.22 Ma (M. J. Aldrich, written commun. 1984). Basaltic flows in the Log Canyon quadrangle may be associated with an early eruptive phase of the Horse Mountain volcano (ca. 13.6 Ma; Ratté et al., 1994, p. 109). Thickness 0–200 ft.

Tmr Rhyodacite lava flows (upper Miocene)
Gray to reddish, flow banded, rhyodacite lava flows on the north flank of Horse Mountain volcano. Small hornblende phenocrysts are locally present. Hornblende from a down-faulted block of rhyodacite lava on the east foot of Horse Mountain has yielded an $^{40}Ar/^{39}Ar$ age of 12.64 ± 0.06 Ma (W. C. McIntosh, unpublished data; Ratté et al., 1994, p. 109). Thickness ranges from 500 ft on flank of volcano to 2000 ft at crest.

Tsf Lower Santa Fe Group (Miocene)
Moderately indurated piedmont-slope conglomerates and conglomeratic sandstones at 200–300 ft above modern drainages in the area east of the Continental Divide. Clast compositions reflect source areas in the Sawtooth, Alegres and Mangas Mountains. Poorly exposed lower Santa Fe conglomerates (not shown on map) locally underlie

Miocene basaltic lavas (Tmb) in the Log Canyon quadrangle north of Nester Draw. Thickness less than 100 ft.

Tfl Fence Lake Formation (Miocene)
Moderate to well indurated fluviatile conglomerate and conglomeratic sandstones north of the Rim Divide and west of the Continental Divide. Represent early stream deposits of the ancestral Little Colorado River system. Boulder to pebble conglomerates contain abundant basaltic andesite clasts derived from Alegres, Mangas, Escondido and Gallo Mountains. Medium-grained andesite porphyry clasts from the Fox Mountain area (Tla) are common in the Fence Lake Formation north of Red Hill (Goat Springs quadrangle). Hornblende andesite clasts in the Fence Lake Formation northwest of Pie Town were derived from the Sawtooth-Datil Mountains area. Well-rounded quartzite clasts typical of the Baca Formation (Tps) are locally present in Fence Lake exposures north of the Baca outcrop belt. Laminar petrocalcic soils locally cap the Fence Lake Formation northwest of Pie Town and west of Quemado (Armstrong Canyon quadrangle). Observed thickness ranges from 0–200 feet, average thickness 60 ft; may be as much as 800 ft thick along Tres Lagunas Draw northwest of Pie Town. Late Miocene basaltic lavas (Tmb) commonly cap the Fence Lake Formation on mesas west of Quemado. A fossil mammal bone collected from the basal Fence Lake Formation northeast of Fox Mountain (Ponderosa Tank quadrangle) locally indicates the flat-lying conglomerates here are not older than 14.5 Ma (Lucas and Anderson, 1994). Tilted Fence Lake beds northwest of Pie Town may be older, possibly in the range of 15–20 Ma. Lower Fence Lake beds locally form a fresh water aquifer along the Omega syncline (Fig. 7) and north of Quemado Lake dam (Newcomer, 1994).

Tuau Bearwallow Mountain Andesite (Tbw, upper Oligocene)
Thick pile of thin basaltic andesite lava flows and minor tephra deposits. Dark gray to reddish lavas with fine-grained phenocrysts of olivine, or iddingsite after olivine, and clinopyroxene. Vesicular and autobrecciated zones commonly define tops and bottoms of flows about 20–30 ft thick. A stacked sequence of thin flows is locally well exposed on the west slope of Escondido Mountain. Average thickness of formation is 400 to 600 ft; maximum thickness at primary vent area near Mangas Mountain is 1100 ft. Near vent agglomerates and flow-banded spatter deposits are locally well exposed along Forest Road 13 near Cañon del Buey Vista (Slaughter Mesa quadrangle). A basal Bearwallow flow north of Slaughter Mesa has yielded a $^{40}Ar/^{39}Ar$ whole-rock isochron age of 26.1 ± 0.1 Ma (McIntosh and Chamberlin, 1994). Bearwallow flows in the Reserve area yield K-Ar ages of 23–27 Ma (Marvin et al., 1987).

Turp Rhyolitic pyroclastic rocks—Bloodgood Canyon Tuff and Vicks Peak Tuff (upper Oligocene)
Light gray, moderately phenocryst-rich Bloodgood Canyon Tuff (Tbg) is a high-silica rhyolite ignimbrite erupted from the Bursum caldera in the Mogollon Mountains to

the south (Ratté et al., 1984). Contains about 10–20 percent medium-grained phenocrysts of sanidine (blue moonstone common) and quartz with minor sphene, biotite and plagioclase. Thickness from 0–150 ft, moderately welded in thicker outcrops. Ancient colluvial breccias derived from Bloodgood Canyon Tuff locally form the "Turp" outcrop along FR 93 (sec. 10, T3S, R16W) west of Slaughter Mesa. Vicks Peak Tuff (Tvp) is a light gray, nonwelded, phenocryst-poor high-silica rhyolite ignimbrite erupted from the Nogal caldera in the southern San Mateo Mountains (Osburn and Chapin, 1983). Contains 1–3 percent medium-grained phenocrysts of sanidine, quartz, and plagioclase and moderately abundant (3–5%), small (0.1–1 cm), friable pumice lapilli. Both tuffs locally fill paleotopographic lows in underlying dune sands (Tsu); Bloodgood Canyon Tuff locally fills paleovalleys cut in underlying Squirrel Springs Canyon Andesite (upper Tual). Vicks Peak Tuff is locally intercalated with Tual. Bloodgood Canyon Tuff forms several lenticular outcrops on the east flank of Escondido Mountain. $^{40}Ar/^{39}Ar$ sanidine ages of Bloodgood Canyon Tuff and Vicks Peak Tuff are 28.0 and 28.5 Ma, respectively (McIntosh and Chamberlin, 1994).

Tual Squirrel Springs Canyon Andesite and andesite of San Antone Canyon (upper Oligocene)
Squirrel Springs Canyon Andesite (Tss) of Rhodes and Smith (1976) consists of medium gray to purplish gray, coarsely porphyritic, basaltic andesite lava flows characterized by abundant tabular plagioclase phenocrysts (1–3 cm) and sparse medium-grained pyroxene. Dark gray, flow-foliated lavas of the andesite of San Antone Canyon (Tas, informal new name, Cather et al., 1994, p. 52) consist of aphanitic basaltic andesite. The Squirrel Springs Canyon Andesite generally thickens to the southwest and ranges from 0–600 ft. The andesite of San Antone Canyon thickens to the south or southwest and ranges from 0–200 ft. Individual flows in both units are generally 20–60 ft thick. $^{40}Ar/^{39}Ar$ isochron ages of the Squirrel Springs Canyon Andesite and andesite of San Antone Canyon are 28.8 ± 0.1 Ma and 29.2 ± 0.1 Ma, respectively (McIntosh and Chamberlin, 1994).

Tuim Mafic dikes, plugs and sill (upper Miocene and upper Oligocene)
Mafic dikes (–•—), small plugs and a sill of basaltic andesite to basaltic composition. Textures range from fine-grained diabase near Lehew (Tres Lagunas quadrangle) to vesicular aphanitic basalt south of Cox Peak. ENE-trending basaltic dike at Mesa Tinaja is of late Miocene age (ca. 9.1 Ma) and NNW-trending dikes at Pie Town and Lehew are of late Oligocene age (ca. 27–28 Ma; Laughlin et al., 1983). Small basaltic plugs and a south-dipping sill are present near Adams Diggings.

Tsu Upper Spears Group—sandstone of Escondido Mountain (Oligocene)
Yellowish brown, well sorted, fine- to medium-grained, volcaniclastic sandstone characterized by high-angle crossbedding and less common planar bedding. The sandstone of Escondido Mountain (Tem, Chamberlin and Harris, 1994) is interpreted as an eolian deposit transported by prevailing westerly winds. Crossbed sets, as much

as 30 ft high, commonly dip steeply to the east (southeast to northeast). Weathered outcrops are commonly littered with small (½ inch) yellow brown sandstone concretions. Lenticular ignimbrite outcrops of 28.1 Ma Bloodgood Canyon Tuff, 28.6 Ma Vicks Peak Tuff and 31.6 Ma Caballo Blanco Tuff (Tcb) locally fill paleotopographic lows within the dune deposits; and occur respectively, at Cañon del Macho (sec. 27, T1S, R15W), at Killion Canyon (NE¼ sec. 3, T3S, R14W), and the low hills east of Mangas (sec. 35, T1S, R14W). Tsu (Tem) is widely masked by colluvial deposits that are generally not shown on the reconnaissance map. Thickness ranges from about 600 ft on Alegres Mountain to 800 ft on the north flank of Escondido Mountain; Tem thins to the south.

Tsm Middle Spears Group (upper Eocene)
Includes the volcaniclastic unit of Cañon del Leon (Tcl, Chamberlin and Harris, 1994) in the area west of the Hickman fault; and the lower Chavez Canyon Formation (Tch, Osburn and Chapin, 1983) in the area east of the Hickman fault. The base of Tcl is defined by a cliff-forming marker bed of tuffaceous sandstone and pumiceous mudstone as much as 60 ft thick. Most of Tcl consists of light-brownish gray to bluish green andesitic conglomeratic sandstone with widely spaced thin beds of light gray tuffaceous sandstone and pale red pumiceous mudstones. Tcl is about 600 ft thick on the north flank of Escondido Mountain. Sanidine and plagioclase phenocrysts picked from pumice in the syneruptive pumiceous mudstones yield $^{40}Ar/^{39}Ar$ ages of 35.3 to 33.2 Ma, which is considered to be the approximate age of deposition for Tcl (McIntosh and Chamberlin, 1994). Tcl also includes as much as 200 ft of brownish gray andesitic conglomeratic sandstones that fill a north-northeast-trending paleovalley cut in Tla west of Agua Fria Mountain (Largo Mesa 7.5′ quadrangle).

The lower Chavez Canyon Formation (Tch) consists of light gray to reddish brown andesitic conglomeratic sandstones and minor mudstones of fluvial origin; it is about 200 ft thick. In the area northeast of Alegres Mountain, the lower Chavez Canyon Formation disconformably overlies Tsd and Tsl. The lower Chavez Canyon Formation is conformably overlain by the 35.0 Ma Datil Well Tuff (Tdw), which defines the base of Tlrp east of the Hickman fault.

Tla Andesite of Dry Leggett Canyon (upper Eocene)
Medium gray, reddish gray, and greenish gray porphyritic andesite lavas (~58% SiO_2; Ratté, 1989) containing about 20–30% fine- to medium-grained phenocrysts of plagioclase and pyroxene. Thick stack of lava flows in the Fox Mountain area (Gallo Mountains West quadrangle) is as much as 600 ft thick. Greenish gray propylitically altered lavas that commonly contain banded agates (Luna agate) as cavity and fracture fillings are widespread on the lower flanks of Fox Mountain. Tla thins rapidly to the northeast of Fox Mountain; it is absent on the north flank of Escondido Mountain. The age of Tla is bracketed by the underlying 34.8 Ma Tuff of Bishop Peak (Tlrp) and the overlying 33.4 Ma Tuff of Luna (Tlrp) in the Fox Mountain area (McIntosh and Chamberlin, 1994). Small exposures of andesite lava within Tlrp in the Mangas Mountain quadrangle (sec. 25, T2S, R14W) and Log Canyon quadrangle (sec. 14,

T3S, R12W; not delineated) are tentatively correlated with Tla (see. Fig. 4). Tla is a widespread unit in the region west of Reserve (Ratté, 1989).

Tlrp Rhyolitic pyroclastic rocks (lower Oligocene to upper Eocene)
Composite unit east of the Hickman fault consists of thin distal ignimbrites of the Datil Group (Cather et al., 1994) and intercalated volcaniclastic sedimentary rocks of the upper Chavez Canyon Formation and the Rincon Windmill Formation (Osburn and Chapin, 1983; Cather et al., 1994). Total thickness of this composite unit is 500–700 ft. From oldest to youngest these ledge-forming ignimbrites consist of the Datil Well Tuff (Tdw), Kneeling Nun Tuff and tuff of Lebya Well (Tkn), Rock House Canyon Tuff (Trh), Blue Canyon Tuff (Tbc) and Hells Mesa Tuff (Thm); which are, respectively, dated at 35.0, 34.9, 34.2, 33.7, and 32.1 Ma (McIntosh et al., 1991; McIntosh and Chamberlin, 1994). The ignimbrites are poorly to densely welded, phenocryst-poor to rich, and light gray to pale red; medium-grained phenocrysts of sanidine, plagioclase, quartz, and biotite are common. For detailed descriptions of each ignimbrite see Osburn and Chapin, (1983) or Ratté et al. (1991). Individual ignimbrites are usually 10–60 ft thick. Pumice-breccia flows of the Horse Springs dacite (Ths, Ratté et al., 1994) locally overlie the Blue Canyon Tuff and define the top of Tlrp along the east flank of Mangas Mountain. Blue Canyon Tuff locally defines the top of Tlrp in the Alegres Mountain and Cox Peak quadrangles. Hells Mesa Tuff is generally absent in the Quemado 30 x 60 minute quadrangle; it is present only in sec. 8, T2S, R11W of the Cox Peak quadrangle. Rock House Canyon Tuff and Hells Mesa Tuff locally wedge out against splays of the Alegres Mountain fault zone; thus indicating that this normal fault zone was active 34.2 to 32.1 million years ago (Chamberlin et al., 1994, p. 28; Lopez and Bornhorst, 1979). Andesitic to rhyolitic conglomeratic sandstones, sandstones and minor mudstones of the upper Chavez Canyon Formation and Rincon Windmill Formation are generally not well exposed in slopes between the ledge-forming ignimbrites. The tuff of Bishop Peak (Tbp, 34.8 Ma) and the tuff of Luna (Tln, 33.4 Ma) are locally delineated, respectively, below and above the andesite of Dry Leggett Canyon (Tla) in the Fox Mountain area (McIntosh and Chamberlin, 1994).

Tsl Lower Spears Group (upper Eocene)
Equivalent to the volcaniclastic unit of Largo Creek (Tlc, Chamberlin and Harris, 1994) in the Quemado-Pie Town region. Consists of predominantly light gray andesitic sandstones and red mudstones of fluvial origin; conglomeratic sandstones are also locally present and thin debris-flow deposits are rarely observed. Andesitic sandstones are quartz poor and contain abundant grains of plagioclase, hornblende, biotite, and Fe-Ti oxides. Andesitic sandstones in the Pie Town area are more poorly sorted (argillaceous matrix) and better indurated than in the Quemado area. These argillaceous sandstones grade southeastward into debris-flow deposits of the Dog Springs Formation (Tsd) in the Sawtooth Mountains-Cox Peak area. Tlc sandstones locally exhibit unusually steep dips, broad open folds, and small thrust faults (Fig. 7), which may be associated with late Laramide crustal shortening or regional soft-

sediment deformation of late Eocene age (Chamberlin et al., 1994, p. 29–31 and p. 40–41). Probably 900–1200 ft thick in the Quemado region, but could be as much as 1800 ft thick. Tlc is considered to be age equivalent to the Dog Springs Formation (Tsd). Tsl (Tlc) is widely masked by colluvial deposits (not shown on map) derived from the overlying Fence Lake Formation in the Quemado-Escondido Mountain area; numerous landslide scars locally provide good exposures of Tlc. Thin beds of Baca-like sandstone (quartz–microcline rich) and reddish-orange mudstone locally occur in the uppermost Tlc (Tsl and Ts) southwest of Quemado (Chamberlin and Harris, 1994; sec. 15, T1S, R16W and sec. 18, T2S, R17W, respectively).

Ts Lower and lower–middle Spears Group undifferentiated (upper Eocene).
Includes volcaniclastic unit of Largo Creek (Tlc, or Tsl) and lower volcaniclastic unit of Cañon del Leon (Tcl, or Tsm) both of which underlie the andesite of Dry Leggett Canyon (Tla) in the area north and west of Fox Mountain (Gallo Mountains West, Ponderosa Tank, Black Peak and Jones Canyon quadrangles). See descriptions of Tsl and Tsm. Thickness probably 1200–1500 ft.

Tsd Dog Springs Formation of lower Spears Group (upper Eocene).
Thick sequence of coarse andesitic to dacitic (58–64% SiO_2) debris-flow deposits and breccias with abundant rounded to angular clasts of gray phenocryst-rich porphyry (Osburn and Chapin, 1983; Cather et al., 1987 and 1994). In decreasing order of abundance, the medium-grained phenocrysts are plagioclase, hornblende, biotite and Fe-Ti oxides. "Tsl-type" argillaceous andesitic sandstones are common near the base of the formation in the Sawtooth Mountains and Cox Peak area (Red Flats and Cox Peak quadrangles). Variably folded beds and clastic dikes are common and reflect regional soft sediment deformation of late Eocene age (Cather and Chapin, 1989). Dog Springs debris-flows and breccias are interpreted as syneruptive volcaniclastic sedimentary deposits derived from a late Eocene volcanic center now buried under the south-central San Agustin Plains (Cather et al., 1987; Chamberlin and Harris, 1994). Drill-hole intercepts (Broadhead and Chamberlin, 1994; Chamberlin et al., 1994, p. 15) and estimates from cross sections (Cather et al., 1987) indicate a thickness of 1300 to 2000 ft for the Dog Springs Formation in the Wallace Mesa-Datil region. Isotopic ages of Dog Springs volcaniclastic rocks range from 39.6 ± 1.5 Ma (Osburn and Chapin, 1983; Cather et al., 1987) to 36.94 ± 0.07 Ma (McIntosh and Chamberlin, 1994).

Tps Paleogene sedimentary rocks (middle to upper Eocene).
Includes the Baca Formation (Tb) of Wilpolt et al. (1946) east of Cimarron Mesa (Blaines Lake quadrangle) and the Eagar Formation (Te) of Sirrine (1956) west of Cimarron Mesa (Cather et al., 1994, fig. 1). Pale yellowish brown to pale red sandstones, conglomeratic sandstones, and red to reddish orange mudstones of fluvial origin comprise the bulk of the Baca and Eagar formations. Cobble to boulder gravels and conglomerates locally define a major fluvial axis near the base of the Eagar Formation west and north of Cimarron Mesa (Cow Springs, Goat Springs and Blaines

Lake quadrangles). Well-rounded cobbles and pebbles of quartzite, chert, plutonic rocks and metarhyolite are common in conglomeratic beds of both formations. Sparse to moderately abundant clasts of andesite porphyry occur in Eagar conglomerates, but are typically absent in Baca conglomerates east of Cimarron Mesa. A regional unconformity at the base of the Baca-Eagar formations is best defined by a sharp decrease in grain size; e.g. from coarse-grained conglomeratic sandstones of Eocene age, to fine- to medium-grained sandstones and shales of Late Cretaceous age (Chamberlin, 1981; Cather, 1994). Sparse mammalian fossils of middle to late Eocene age (Bridgerian to Duchesnean) have been recovered from the Baca Formation in Catron County (Lucas, 1983). The thickness of the Baca Formation appears to have been strongly controlled by late Laramide down-to-the-east displacement along the Hickman fault zone (Fig. 4). The Baca Formation is as much as 2000 ft thick east of the Hickman fault in the Pie Town area (Armstrong and Chamberlin, 1994). West of the Hickman fault zone the Baca Formation is about 600 ft thick (Guilinger, 1982). The Baca Formation locally wedges out over the crest of Laramide anticlines in the Adams Diggings quadrangle. West of Adams Diggings, a thin east-trending tongue of siliceous Baca sandstone (about 60 ft thick and ¾ mi wide) locally overlies about 40 ft of andesitic sandstone near the base of the lower Spears Group (Tsl).

Kcco Late Cretaceous to early Tertiary weathering profile (oxidation zone) developed on the Crevasse Canyon Formation (mostly Paleocene?).
Oxidized (reddened) and bleached Crevasse Canyon sandstones and shales; small uranium deposits locally occur along basal redox boundary (Chamberlin, 1981). Light purplish gray, light gray and maroon shales often mottled with yellowish brown; interbedded with white, light gray, bluish gray, lavender, and pale red to brick red sandstones. Sandstones are fine- to medium-grained and locally contain small concretions of hematite (after early diagenetic iron sulfide concretions). Sandstones commonly exhibit large low-angle crossbeds and locally contain silicified logs. Banded iron oxides occur sporadically as nodules in the altered rocks and as thin layers along sandstone-shale contacts. Basal redox front (dashed contact) locally cuts across bedding and is commonly defined by greenish-gray (chloritic) sandstones and radiometric anomalies. This regional stratiform zone of altered rocks about 100–200 ft thick is interpreted as the subsolum of a pre-Baca lateritic soil (Chamberlin, 1981).

Kmho Late Cretaceous to early Tertiary weathering profile (oxidation zone) developed on the Moreno Hill Formation (mostly Paleocene?).
Oxidized (reddened) and altered Moreno Hill Formation sandstones and shales; small uranium deposits locally occur along basal redox boundary (Guilinger, 1982). Varicolored sandstones and shales are similar to Kcco and represent westward continuation of the same ancient oxidation zone on another Late Cretaceous formation. Hematite concretions are very rare and basal redox boundary lacks chloritic sandstones observed in Tres Lagunas quadrangle (Kcco). Kmho is 50–100 ft thick in area east of Tejana Mesa. Kmho is locally present west of Tejana Mesa (Lake Armijo quadrangle), but it is generally too thin to map (<20 ft). Kmho appears to be

locally truncated by erosion at base of Eagar Formation gravels north of Cimarron Mesa (Blaines lake quadrangle); however, the ancient oxidation zone reappears along Coyote Creek in eastern Arizona (Cather, 1994).

Kcc Crevasse Canyon Formation (Upper Cretaceous; upper Turonian, Coniacian and Santonian?).
Below the ancient oxidation zone in the top of the Crevasse Canyon Formation (Kcco), typical Crevasse Canyon beds (Kcc) consist of yellowish brown fine- to medium-grained, feldspathic sandstones interbedded with yellowish brown shales, dark gray carbonaceous shales, gray siltstones and thin coal seams. Sandstones commonly contain coalified wood and leaf debris, small iron sulfide concretions (partially to completely oxidized to limonite), large dark brown iron-carbonate concretions and clay galls. Base not exposed in map area; as much as 1100 ft thick in the D-Cross Mountain area east of the Quemado sheet.

Kmh Moreno Hill Formation (Upper Cretaceous; upper Turonian).
Below the ancient oxidation zone (Kmho), typical Moreno Hill beds consist of light yellowish gray to light gray, fine- to medium-grained feldspathic sandstones, gray siltstones, brown mudstones and thin to moderately thick (3–7 ft) coal beds (Hoffman, 1994). Pale reddish, medium- to coarse-grained feldspathic sandstones about 60 ft thick locally define a middle member. Coals are thicker and more continuous near the base of the lower member. Approximately 500 ft thick in the Tejana Mesa area. Coal beds as much as 13 ft thick are locally present in the lower Moreno Hill Formation just north of the Quemado sheet near Cerro Prieto (Rodgers, 1994). The Moreno Hill Formation is laterally continuous with the lower Crevasse Canyon Formation. Crevasse Canyon beds overlie the Gallup Sandstone; the nomenclature change to Moreno Hill Formation occurs southwest of the pinchout of the Gallup Sandstone (Fig. 4).

Ka Atarque Sandstone (Upper Cretaceous; Turonian)
Very fine- to fine-grained, very pale orange to grayish orange quartzose sandstone; coarsens upward in a general way. Flat bedded in lower part; crossbedding, both low and high angle, in thin to moderate sets, is present in upper part. A molluscan faunal assemblage collected from a structurally disturbed block on the northwest rim of Zuni Salt Lake maar (sec. 30 T3N, R18W) includes *ostrea* sp., *Trigonarca* sp., *Phelopteria* sp., *Inoceramus* sp., *Plicatula ferryi* coquand, *Crassatella excavata* Stanton, *Pleurocardia pauperculum* (Meek), Gyrodes depressa Meek, and *Rostellinda* sp. (Anderson, 1994). Thickness approximately 45 ft.

Kmha Moreno Hill Formation and Atarque Sandstone undivided (Upper Cretaceous; Turonian).

Kmr Rio Salado Tongue of Mancos Shale (Upper Cretaceous; upper Cenomanian and Turonian).

Shale and silty shale, medium gray. Calcareous concretions in upper part. Lower part normally has nodular to platy limestone beds in a zone about 25 ft above the top of the Twowells Tongue of Dakota sandstone. These limestone beds represent the local expression of the Bridge Creek Member of Greenhorn Formation. Abundant specimens of *Pycnodonte newberryi* are commonly associated with the limestone beds. Rio Salado Tongue is as much as 300 ft thick.

Kdt Twowells Tongue of Dakota Sandstone (Upper Cretaceous; upper Cenomanian). Very fine to fine grained, yellowish gray to pale olive, quartzose sandstone, coarsens upward and uppermost portion is locally lower-medium grained. Lower part is commonly bioturbated; upper part is crossbedded with numerous, moderate to large diameter burrows (up to 1 inch diameter) and horizontal feeding trails, tracks, and burrows (an excellent ichnofauna). Bivalves *Exogyra levis* and *Pycnodonte kellumi* are locally abundant in upper part. Ranges from 22 to 28 ft thick.

Kmw Whitewater Arroyo Tongue of Mancos Shale (Upper Cretaceous; upper Cenomanian). Shale and silty shale, medium gray to medium dark gray. Approximately 30 ft below the top of unit is a white to orange-weathering bentonite bed, 12–14 inches thick. Shell fragments of *Exogyra trigeri* are common in unit, particularly in upper part above the bentonite bed. Present in the slope wash as float from the overlying unit are fragments of *Pycnodonte kellumi*. Approximately 50 to 60 ft thick.

Kdtm Twowells Tongue of Dakota Sandstone and Whitewater Arroyo Tongue of Mancos Shale, undivided (Upper Cretaceous; Cenomanian).

Kd Main body of Dakota Sandstone, Paguate Tongue of Dakota Sandstone, and intervening thin sandy unit of Mancos Shale (Upper Cretaceous; Cenomanian). Main body of Dakota consists of a lower sandstone and shale unit; a middle, carbonaceous shale unit (10–50 ft thick) with very minor coal, and an upper fine- to medium-grained, flat to crossbedded sandstone unit, commonly up to 40 ft thick. Base is a profound unconformity very commonly marked by siliceous pebble conglomerate. Main body is as much as 120 ft thick locally. Locally includes overlying Paguate Tongue of Dakota Sandstone and an intervening thin (<25 ft) sandy unit of the Mancos Shale. Paguate Tongue consists of very fine- to fine-grained (coarsening upward) yellowish gray to pale olive quartzose sandstone. Large oblate concretions in lower part commonly contain fragments of bivalves including *Exogyra levis* and *Pycnodonte kellumi*. Paguate Tongue is less than 20 ft thick.

₮c Chinle Group–Painted Desert Member of Petrified Forest Formation (Upper Triassic; Carnian and Norian). Very fine-grained to fine-grained sandstone, silty mudstone and siltstone. Pale red, pale purple, yellowish gray and grayish pink, mainly lithic arenites. Base not exposed in map area.

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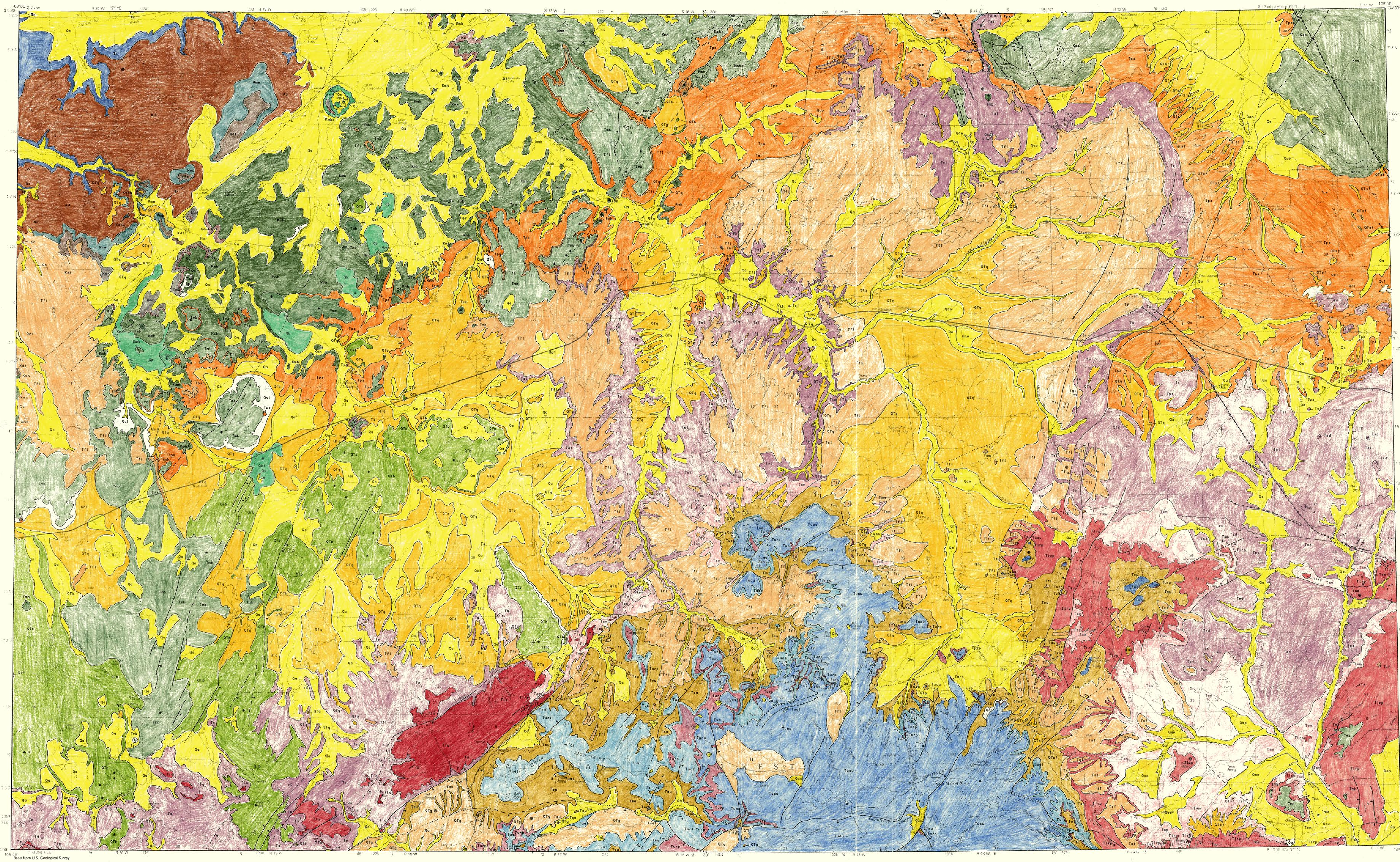


Base from U.S. Geological Survey

Map Units

Qa	Alluvium in stream valleys and closed basins (late Quaternary)
Qe	Eolian deposits (late Quaternary)
Qs	Salt deposits in Zuni Salt Lake maar (late Quaternary)
Qbt	Basaltic tephra deposits (0.07–0.21 Ma, late Quaternary)
Qb	Basaltic lava flows (0.07–0.21 Ma, late Quaternary)
Qao	Older alluvium (middle to late Quaternary)
Qcl	Colluvium and landslide deposits (Quaternary)
QTb	Basaltic lavas and near-vent tephra deposits (2.46–0.86 Ma; Pliocene to early Pleistocene)
QTq	Quemado Formation (Pliocene to early Pleistocene)
QTsf	Upper Santa Fe Group (Pliocene to early Pleistocene)
QTg	Gila Group (Miocene to early Pleistocene)
Tmb	Basaltic lava flows and near-vent tephra deposits (5.2–13.6 Ma, late Miocene)
Tmr	Rhyodacite lava flows (~12.6 Ma, late Miocene)
Tsf	Lower Santa Fe Group (Miocene)
Tfl	Fence Lake Formation (Miocene)
Tuau	Bearwallow Mountain Andesite (~26.1 Ma, late Oligocene)
Turp	Rhyolitic pyroclastic rocks—Bloodgood Canyon Tuff (28.1 Ma) and Vicks Peak Tuff (28.6 Ma)
Tual	Squirrel Springs Canyon Andesite (ca. 28.4 Ma) and andesite of San Antone Canyon (ca. 29.2 Ma)
Tuim	Mafic dikes and intrusions (~9 Ma, late Miocene and 27–29 Ma, late Oligocene)
Tsu	Upper Spears Group—sandstone of Escondido Mountain (~28–32 Ma, Oligocene)
Tsm	Middle Spears Group—volcaniclastic unit of Cañon del Leon (ca. 33–35 Ma, late Eocene) and lower Chavez Canyon Formation (ca. 36–35 Ma, SE of Mangas)
Tla	Andesite of Dry Leggett Canyon (>33.4 Ma, <34.8 Ma, late Eocene)
Tlrp	Rhyolitic pyroclastic rocks—distal ignimbrites of the Datil Group and intercalated volcaniclastic sedimentary rocks of the Rincon Windmill Formation and Chavez Canyon Formation (32.1–35.0 Ma, early Oligocene to late Eocene)
Tsl	Lower Spears Group—volcaniclastic unit of Largo Creek (ca. 37–40 Ma, middle to late Eocene)
Ts	Lower and lower middle Spears Group in area northwest of Fox Mountain
Tsd	Dog Springs Formation—lower Spears Group (ca. 37–40 Ma, middle to late Eocene)
Tps	Paleogene sedimentary rocks—Baca Formation and Eagar Formation (middle Eocene to late Eocene)
Kcco	Late Cretaceous to early Tertiary weathering profile (oxidation zone) developed on Crevasse Canyon Formation
Kmho	Late Cretaceous to early Tertiary weathering profile (oxidation zone) developed on Moreno Hill Formation
Kcc	Crevasse Canyon Formation (Coniacian and Santonian?)
Kmh	Moreno Hill Formation (upper Turonian)
Ka	Atarque Formation (Turonian)
Kmha	Moreno Hill Formation and Atarque Formation, undivided (Turonian)
Kmr	Rio Salado Tongue of Mancos Shale (Upper Cenomanian and Turonian)
Kdt	Twowells Tongue of Dakota Sandstone (Upper Cenomanian)
Kmw	Whitewater Arroyo Tongue of Mancos Shale (Upper Cenomanian)
Kdtm	Twowells Tongue of Dakota Sandstone and Whitewater Arroyo Tongue of Mancos Shale (Cenomanian)
Kd	Dakota Sandstone (Formation); Cenomanian
℞c	Chinle Group; Carnian and Norian (Upper Triassic)

Explanation

- Depositional contact
- Regional alteration boundary
- Mafic dike
- Normal fault, ball on downthrown side
- 3 Strike and dip of strata
- Horizontal strata
- Volcanic vent
- Paleovalley margins (or singular margin)
- Anomalously steep dip (or dip direction) in strata of the lower Spears group (Tsd, Tsl); associated with soft sediment deformation in Tsd
- Synclinal axis
- Anticlinal axis
- S Slump fault, ball on down side
- Ancient weathering profile (oxidation zone; Kcco, Kmho)

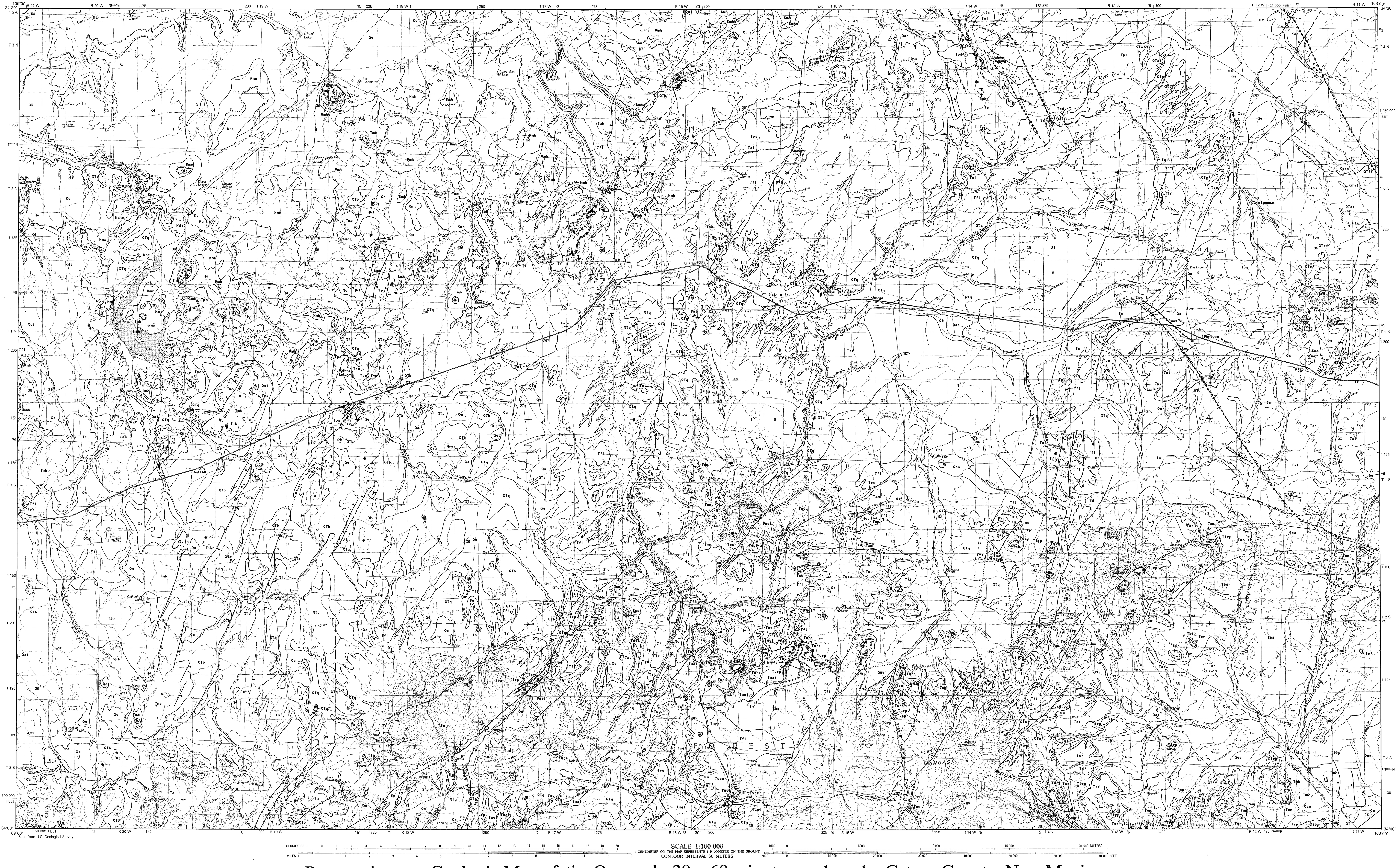
SCALE 1:100 000

1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

CONTOUR INTERVAL 50 METERS

Reconnaissance Geologic Map of the Quemado 30 x 60 minute quadrangle, Catron County, New Mexico

by Richard M. Chamberlin, Steven M. Cather, Orin J. Anderson and Glen E. Jones, 1994



SCALE 1:100 000

1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

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Map Units*

Qa	Alluvium in stream valleys and closed basins (upper Quaternary)
Qe	Eolian deposits (upper Quaternary)
Qs	Salt deposits in Zuni Salt Lake maar (upper Quaternary)
Qbt	Basaltic tephra deposits (0.07–0.21 Ma, upper Quaternary)
Qb	Basaltic lava flows (0.07–0.21 Ma, upper Quaternary)
Qao	Older alluvium (middle to upper Quaternary)
Qcl	Colluvium and landslide deposits (Quaternary)
QTb	Basaltic lavas and near-vent tephra deposits (2.46–0.86 Ma; Pliocene to lower Pleistocene)
QTq	Quemado Formation (Pliocene to lower Pleistocene)
QTsf	Upper Santa Fe Group (Pliocene to lower Pleistocene)
QTg	Gila Group (Miocene to lower Pleistocene)
Tmb	Basaltic lava flows and near-vent tephra deposits (5.2–13.6 Ma, upper Miocene)
Tmr	Rhyodacite lava flows (~12.6 Ma, upper Miocene)
Tsf	Lower Santa Fe Group (Miocene)
Tfl	Fence Lake Formation (Miocene)
Tuau	Bearwallow Mountain Andesite (~26.1 Ma, upper Oligocene)
Turp	Rhyolitic pyroclastic rocks—Bloodgood Canyon Tuff (28.1 Ma) and Vicks Peak Tuff (28.6 Ma)
Tual	Squirrel Springs Canyon Andesite (ca. 28.4 Ma) and andesite of San Antone Canyon (ca. 29.2 Ma)
Tuim	Mafic dikes and intrusions (~9 Ma, upper Miocene and 27–29 Ma, upper Oligocene)
Tsu	Upper Spears Group—sandstone of Escondido Mountain (~28–32 Ma, Oligocene)
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* See Table 1 for description of map units.

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