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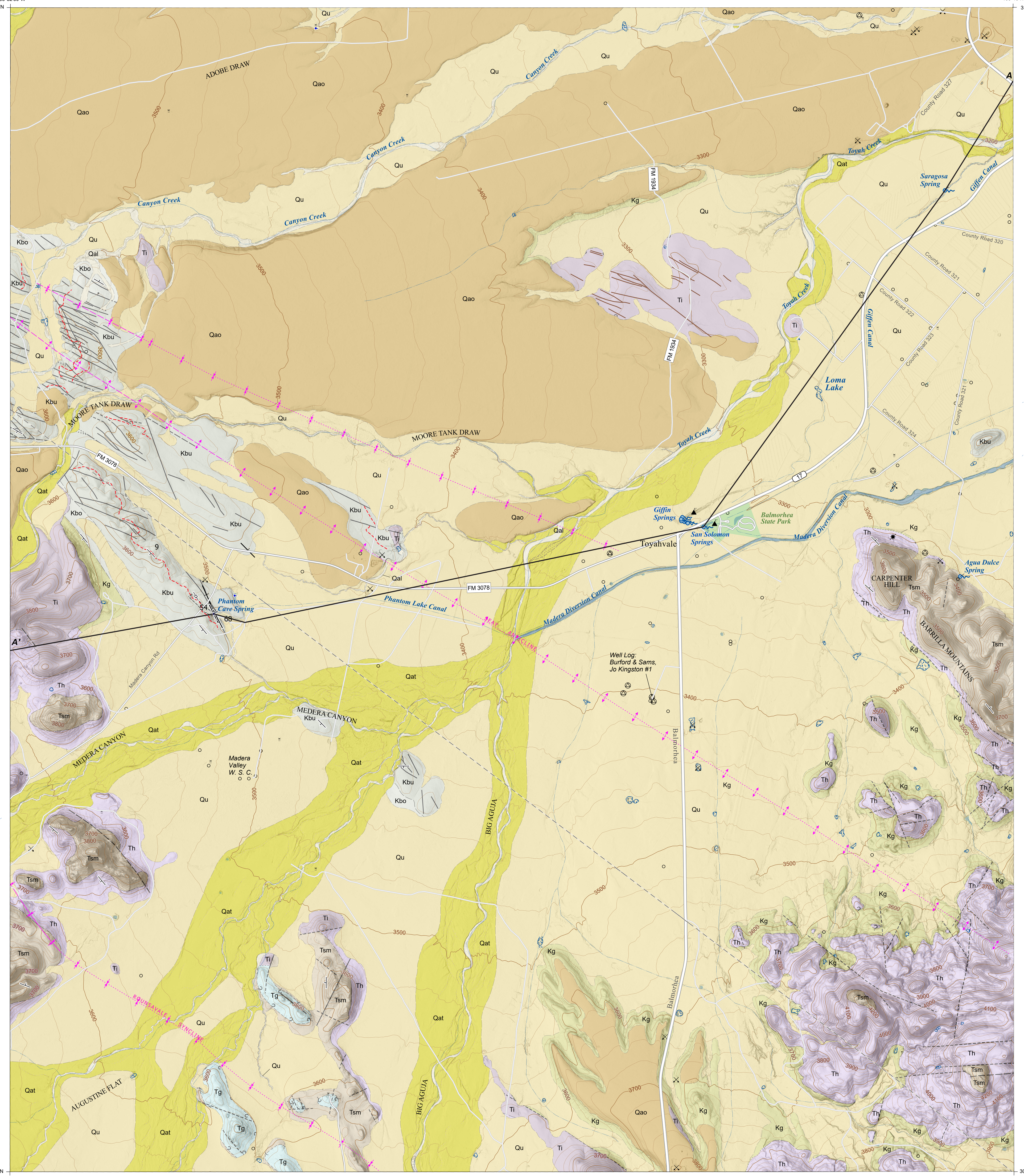
In cooperation with the State of Texas Advanced Resource Recovery (STARR) Program and the
U.S. Geological Survey National Cooperative Geologic Mapping Program under STATEMAP award No. G24AC00508, 2024



SCALE 1:24,000

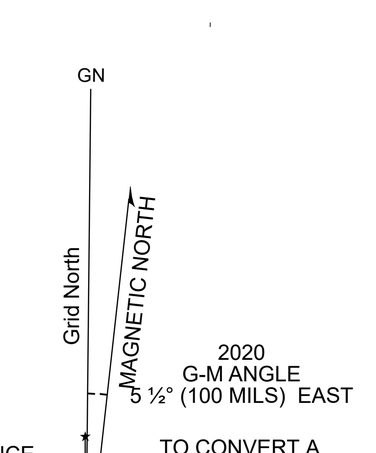
0 1 2 4 MILES

0 1 2 4 KILOMETERS

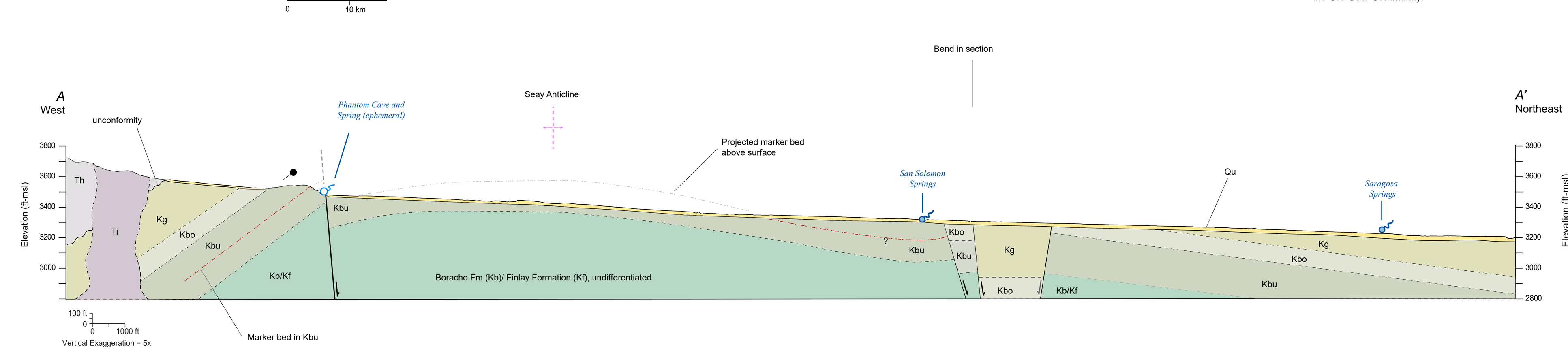
UNIVERSAL TRANSVERSE MERCATOR PROJECTION, ZONE 13N NAD 83
CONTOUR INTERVAL 20 FT
DATUM IS MEAN SEA LEVEL

GEOLOGIC MAP OF THE TOYAHVALE QUADRANGLE
JEFF DAVIS AND REEVES COUNTIES, TEXAS

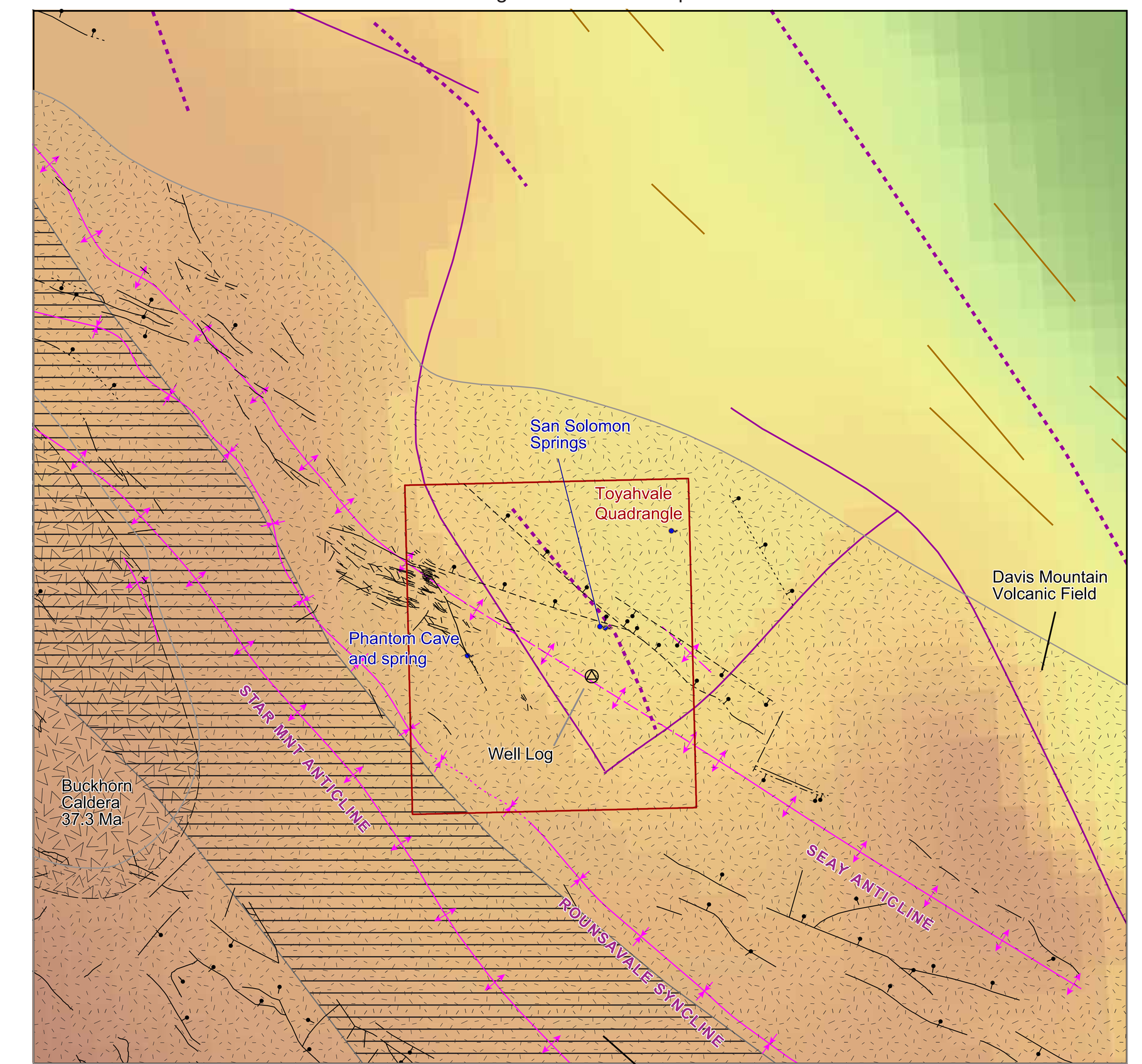
Brian B. Hunt, Mark A. Helper, Elizabeth A. Horne,
Peter H. Hennings, and Eric Rhoden
2025



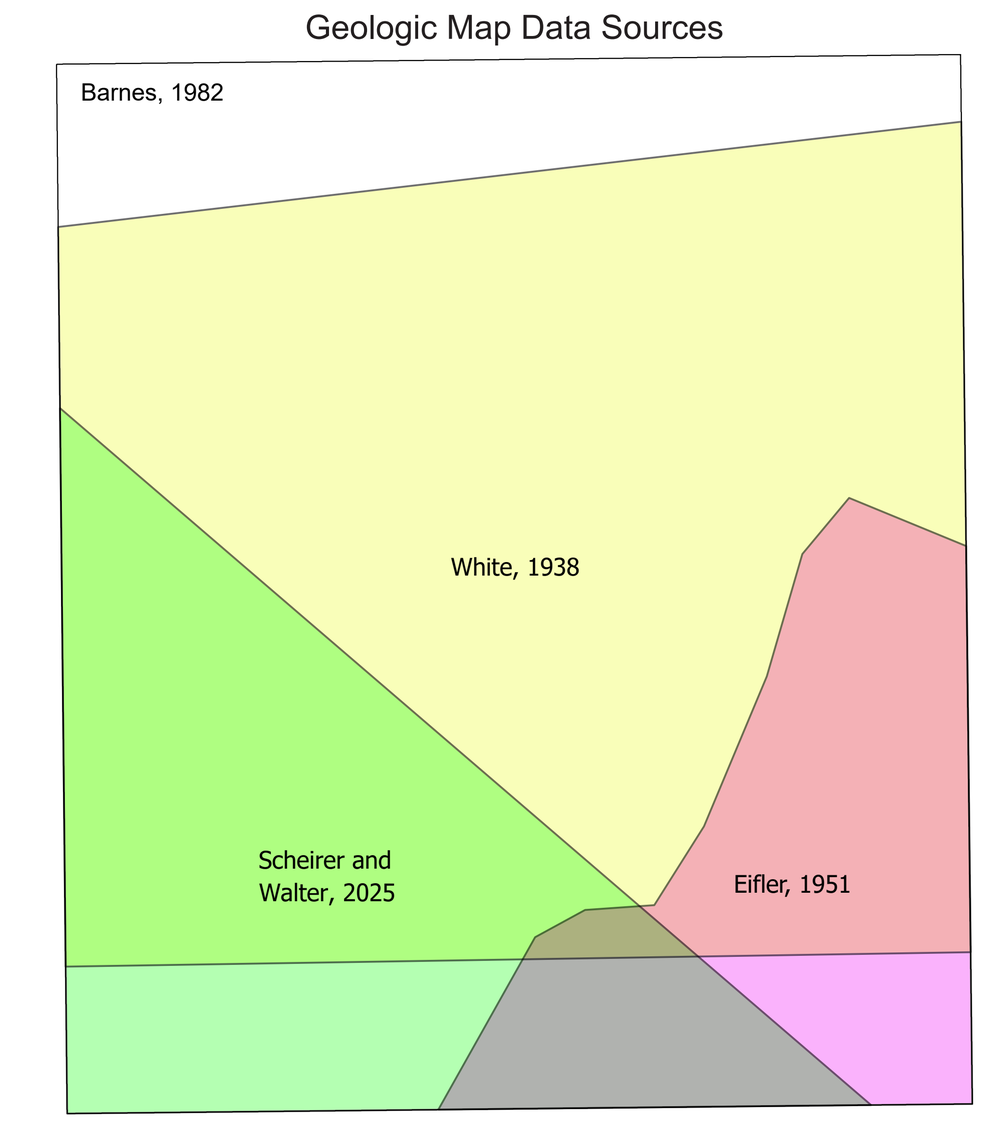
Sourcesfor basemap data: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.



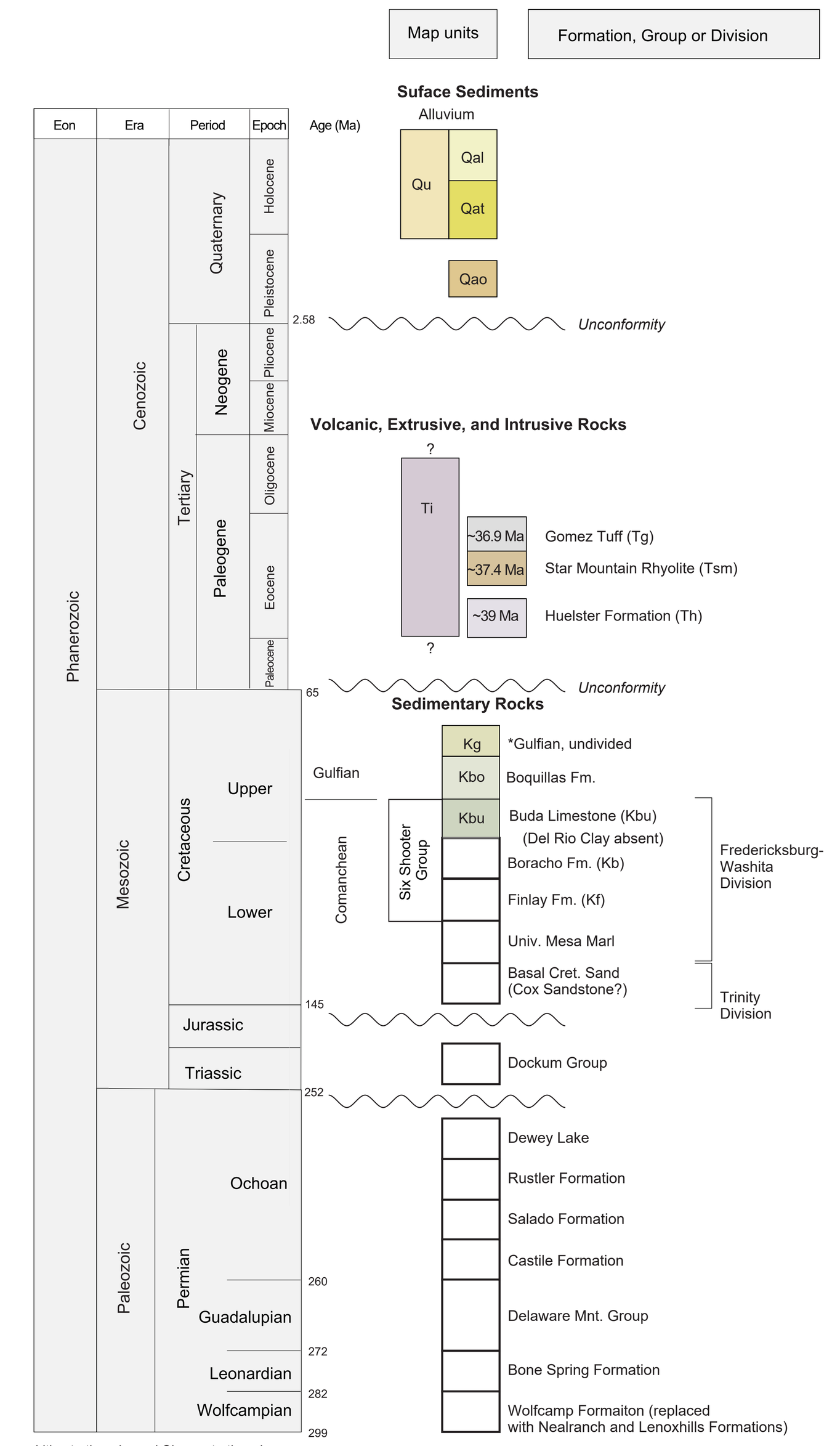
Regional Structure Map



Geologic Map Data Sources



Chronostratigraphy and Correlation of Map Units

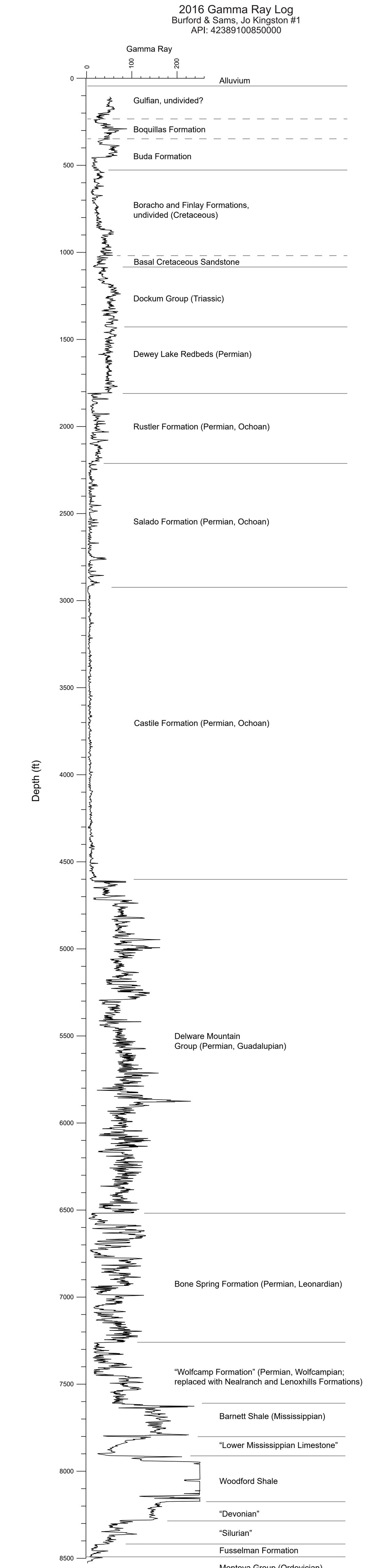


Lithostratigraphy and Chronostratigraphy modified from Eifler, 1951; Smith and others, 2000; Ewing, 2016; and Horne and others, 2021. Volcanic ages from Kunk and others, 1994 and Parker and others, 2017.

*equivalent to the Austin Chalk, Taylor Clay or Pen and Aguja Fms.

2016 Gamma Ray Log

Burford & Sams, Jo Kingston #1
API: 42389100850000



EXPLANATION

Qal—Alluvium (Holocene)—Gravel, sand, silt, and clay. Unconsolidated or weakly cemented sediments. Rounded to subrounded, sorted to poorly sorted gravels and cobbles contain varying amounts of sedimentary and igneous rock fragments. May exhibit crude to well-developed bedding, crossbedding, and fining-upward sequences characteristic of fluvial deposition. Highly variable thickness, ranging from a few feet in ephemeral stream channels to tens of feet in broader floodplains and valley fills. Fluvial in origin, deposited by modern and ancient stream systems. Found along active stream channels, floodplains, terraces, and in broader basin fills. Includes low-terrace deposits near floodplain levels; alluvial plain deposits may include fan deposits and colluvium locally near margins; coarser material toward margins (Barnes, 1982). The unit thickens to the north and east and is part of the Pecos Alluvial Aquifer system. Soil associations include a variety of profiles described by the NRCS (Soil Survey Staff, 2025) as clay, clay loam, silty to sandy loam, and gravel to cobble loam.

Qat—Alluvium and terrace (Holocene)—Gravel, sand, silt, and clay. Unconsolidated or weakly cemented sediments on irregular treads adjacent to active stream channels. Likely eroded older terrace deposits modified by modern flood sediments (Qal). Soil associations include a variety of profiles described as clay, clay loam, silty to sandy loam, and gravel to cobble loam by the NRCS (Soil Survey Staff, 2025).

Qu—Quaternary deposits undivided (Holocene to Pleistocene)—Gravel, sand, silt, clay, and caliche. Undifferentiated alluvium, alluviated terrace, colluvium, and terrace deposits.

Qao—Older Quaternary deposits (Pleistocene)—Unconsolidated to semi-consolidated, poorly to moderately sorted gravel, sand, silt, and clay. Source rocks include Tertiary igneous and Cretaceous sedimentary rocks, which vary in proportion from locality to locality depending on the bedrock and drainage areas (Barnes, 1982). Sediments were deposited as extensive alluvial fans, apron deposits, and sheetwash on broad plains and in intermontane basins during the Late Pliocene to Middle Pleistocene. Distinguishing features of older Quaternary deposits include their higher topographic position, significant dissection by modern drainages, well-developed paleosols, and often extensive caliche cementation, indicating greater age and prolonged periods of surface stability and weathering.

CENOZOIC VOLCANIC AND INTRUSIVE ROCKS

Ti—Intrusive, igneous rocks (Paleogene, Oligocene to Eocene)—Stocks, plugs, laccoliths, sills, and dikes. Undifferentiated rock types include: hawaiite, mugearite, trachyte, quartz trachyte, rhyolite, peralkaline rhyolite, phonolite, trachyandesite, dacite, basalt, and their coarser-grained equivalents (Barnes, 1982).

Tg—Gomez Tuff (Paleogene, Eocene)—Peralkaline ash-flow rhyolitic tuff, densely welded to friable, one cooling unit. Contains 1.5-mm phenocrysts of anorthoclase and some quartz, microphenocrysts of aegirine-augite and fayalite, and abundant xenoliths of mafic lava, limestone, sandstone, biotite schist, and other rock types within gray, brown, green, and reddish-brown to black devitrified glass. First major ash-flow in the Davis Mountains sourced from the Buckhorn Caldera (Parker and White, 2008). A rheomorphic tuff, extending significantly southward, from the Buckhorn Caldera to approximately 10 km north of Alpine, with concomitant decrease in lithic clast size. Characterized by its ability to surmount topographic barriers with minimal thinning and its distal thinning to approximately 2 meters, distinguishing it from silicic lava flows. Thickness up to 1,200 ft in the Adobe Canyon and Barilla Mountains, averages 300–400 ft thick, elsewhere 40–100 ft thick (Barnes, 1982). Dated with 40Ar/39Ar to 36.8 Ma (Kunk and others, 1994; Parker and others, 2017).

Tsm—Star Mountain Rhyolite (Paleogene, Eocene)—Porphyritic rhyolite and quartz trachyte with aphanitic groundmass, gray, green, greenish-gray, reddish-gray, and purplish-lavender, weathers reddish-brown to black; normally 3 flow units, in some areas 6 or more; exhibits features indicative of lava flows, such as uniform thickness, distinct flow fronts, feeder dikes, flow banding, breccias, and vitrophyres (Henry and others, 1989). Forms impressive columnar joined palisade cliffs, thickness 496 ft at Star Mountain-type locality, thins northward, thickens southward up to 810 ft (Barnes, 1982). Oldest known major eruptive rock of the Davis Mountains at 37.4 Ma (Kunk and others,1994; Parker and others, 2017). The formation overlies the Huelster Formation, is intruded by feeder dikes, and is stratigraphically equivalent to and compositionally similar to the Crossen Trachyte. Overlain by the Gomez Tuff.

Th—Huelster Formation (Paleogene, Eocene)—Tuffaceous mudstones, siltstones, sandstones, conglomerates, and local freshwater limestones, along with aphyric to sparsely porphyritic basalts or mafic trachytes; Jeff Conglomerate Member at base not separately mapped. Most of the Huelster Formation was mapped by Barnes (1982) as occurring in landslides and included under symbol Ql. Here it is instead mapped in the eastern and northern Davis and Barrilla Mountains as a distinct unit, following Eilfer (1951). Thickness at type locally is 400 ft, up to 490 ft in Madera Canyon (Barnes, 1982). Mafic lavas are likely from local sources, such as the Madera Volcano. At the same time, the origins of the tuffaceous material, particularly biotite-bearing tuffs, are debated, with potential sources in distant volcanic centers. Unconformably overlies Upper Cretaceous rocks. The formation is dated as greater than 37–38 Ma, with Ar-Ar dating indicating ages up to 39.3 Ma (Kunk and others, 1994).

CRETACOUS SEDIMENTARY ROCKS

Kg—Gulfian Rocks, undivided (Upper Cretaceous) —Marl, shale, and argillaceous limestone. Probable chronostratigraphically correlative units in Central Texas are Taylor, Austin, and possibly the upper part of the Eagle Ford (Boquillas) formation. Thickness 300 feet (Barnes, 1982).

Kbo—Boquillas Formation (Upper Cretaceous)—Thinly bedded, heterolithic unit of medium-gray, light-gray, yellowish-gray, and brownish-gray flaggy limestone, shale, platy claystone, marl, chalk, and very minor siltstone and sandstone. Contact with the underlying Buda Limestone is sharp and disconformable, marked by a distinct color change from the thick-bedded, resistant, gray-to-white tones of the Buda Limestone to the thin-bedded, more recessive, light-brown tones of the lowermost Boquillas Formation. Contains abundant marine fossils, particularly inoceramids, as well as ammonites, echinoids, cephalopods, foraminifera, and fish bones (Brand and Deford, 1958).

Six Shooter Group (Upper-Lower Cretaceous)—Group consists of three limestone formations, Buda, Boracho, and Finlay (Brand and Deford, 1958).

Kbu—Buda Limestone (Upper Cretaceous)—Limestone. Slightly argillaceous, locally cross-bedded, and extremely hard, locally fossiliferous, with "miliolid" foraminifera, gastropods (Nerinea valana Cragin), and pelecypod Pecten (Neithea roemeri). Locally, the basal part of the Buda is hard fine- to medium-grained quartzitic sandstone, and sandstone float covers the slope below. Above the basal layers, the Buda consists of aphanic, slightly argillaceous limestone similar to the underlying Boracho Formation. The upper part of the Buda consists of thin-bedded to massive, hard, light-gray limestone, which rings when struck by the hammer. Locally, it contains nodules of hard, gray chert. Minimum thickness of 122 feet (Brand and Deford, 1958). The boundary between the Buda Limestone and the underlying Boracho Limestone is disconformable. Del Rio Clay, which elsewhere underlies the Buda, is here missing and may be represented by the disconformity, or, locally, by the lower Buda sandstone. In Trans-Pecos and the western parts of the Edwards Plateau, the unit is a light gray-to-white caprock on mesas (Brand and Deford, 1958). Fractured surfaces of Buda Limestone are hackly or conchoidal; weathered surfaces are typically nodular (Barker and Ardis, 1996). The unit is part of the Texas Water Development Board's regional Edwards-Trinity Aquifer.

Kb—Boracho Formation (Upper Cretaceous)—Homogeneous limestone and marl. The upper part is mainly composed of massive, argillaceous limestone that typically forms a steep slope below a caprock of Buda Limestone (Barker and Ardis, 1996). Fossiliferous, containing: Toucasia aff., T. patagiata (C. A. White), Pecten (Neithea) duplicicosta (Roemer), and Oxytropidoceras aff., and O. belknapi (Marcou) (Brand and Deford, 1958). Adjacent to the map area, the Boracho is subdivided into the upper Levinson and lower San Martine Members. The Levinson Member is 169 ft thick, calcareous shale that contains limestone in its upper portion. The San Martine Member is 259 feet thick and consists of nodular to thick-bedded, slightly argillaceous, aphanic limestone (Brand and Deford, 1958). Total thickness is ~430 ft. The Boracho Formation unconformably overlies the Finlay Formation. The Boracho Formation is equivalent to the Fort Lancaster Formation of the Edwards Group to the east (Smith and others, 2000). The Boracho is thus broadly considered part of the regional Edwards-Trinity Aquifer of the Texas Water Development Board.

Kf—Finlay Formation (Lower Cretaceous) —Gray, thick-bedded, sandy, nodular mollusk marl and cherty wackestone, with basal interbeds of gray to brown quartz sandstone and shale. unit and thin- to thick-bedded fossiliferous limestone near the top. Fossils may correlate with the Walnut Formation, including: Gryphaea mucronata (Gabb), Ostrea crenulimargo (Roemer), and Exogyra texana (Roemer). The Finlay Formation grades laterally into the Fort Terrett Formation to the east, is part of the Fredericksburg Group, and unconformably overlies basal Cretaceous sand of Trinity age (Brand and Deford, 1958; Barker and Ardis, 1996; Smith and others, 2000). Thickness in type section (Finlay Mountains) is 300 ft.

SUBSURFACE UNITS
(Geophysical Log)

TRINITY DIVISION

Basal Cretaceous Sandstone (informal) (Lower Cretaceous) —Composed of varying mixtures of sandstone, siltstone, and conglomerate. Major constituents are well-rounded fragments of quartz, chert, and feldspar derived from Permian and Triassic red beds. Calcite is the dominant cement, but dolomite, ankerite, silica, kaolinite, and hematite are prevalent locally. This diverse, aerially extensive deposit is generally unfossiliferous and varies vertically and laterally in color, texture, composition, and degree of cementation. The lower part is generally coarse-grained; in places, fine- to medium-grained sandstone replaces a basal conglomerate . A finer-grained, variegated middle section is cross-bedded and indurated with calcareous cement in places. The upper part of the unit might include small amounts of limestone and thin, calcareous shale interbeds (Barker and Ardis, 1996). This unit is the sole Trinity-age rock in the study area. Underlying the Finlay Mountains, it includes sediments equivalent to the Maxon Sand, Yearwood Formation, and Cox Sandstone (Brand and Deford, 1958; Smith and others, 2000).

TRIASSIC SEDIMENTS

Dockum Group (Triassic) —Clastic sedimentary rocks composed of reddish-brown to grayish-green mudstone, siltstone, sandstone, and conglomerate. Includes from bottom to top the Santa Rosa, Tecovas, Trujillo, and Cooper Canyon Formations. The Dockum Group represents sediments deposited in fluvial, deltaic, and lacustrine environments within a closed continental basin (Bradley and Kalaswad, 2001).

PALEOZOIC (PERMIAN) SEDIMENTARY ROCKS

Dewey Lake Redbeds (Permian)—Reddish-brown shale and siltstone. Siliciclastic red beds that represent fluvial, eolian, and mudflats depositional environments. Youngest of the Permian formations in the Delaware Basin.

Rustler, undivided (Permian) —Carbonate and evaporite strata interlayered with sand, siltstone, and shale up to about 500 feet thick (Boghici and Van Broekhoven, 2001; Standen and others, 2001). In outcrop, they consist of dolomite, dolomitic limestone, limestone breccia, gypsum, and mudstone, with minor siltstone and sandstone near the base. Six subsurface members have been identified in the Rustler Hills area (Hentz and others, 1989).

Salado Formation (Permian)—Primarily halite, characterized by supplementary beds of anhydrite, potash salts, and interbedded red sandy clay. Its thickness varies, influenced by depositional location (basin, reef, and back-reef margins) and subsequent dissolution. On the shelf, where the salt beds overlie the Tansill Formation (on top of former reef and back-reef margins), thicknesses are generally less than 1,000 feet (Standen and others, 2009). This formation represents the second major basin-filling sequence succeeding the Castile Formation.

Castile Formation (Permian)—Gypsum, anhydrite, and intermittent, thin- to medium-bedded limestone. The formation thickness ranges from 1,500 to 2,000 feet. Subsequent dissolution and collapse of the Castile Formation have led to the development of numerous cavernous features, including sinkholes, springs, and brecciation of overlying layers as they subsided into caves and other dissolution features. Along with the Salado Formation, these are evaporite deposits that began filling the Delaware Basin during the Ochoan Epoch, in some places overlying the Capitan Reef Complex (Standen and others, 2009).

Delaware Mountain Group (Permian) —A group of limestones and clastics associated with the fringing Capitan Reef Complex, composed of massive white to gray fossiliferous limestone beds. The limestone beds grade into fore-reef deposits defined by several formations, including the Bell Canyon, Cherry Canyon, and Brush Canyon Formations. The gradation into back-reef deposits is more transitional and is defined as the Artesia Group. The Capitan Reef Complex constitutes a minor aquifer of Texas, which has been dissected by faulting and forms a series of disconnected, highly permeable aquifers (Standen and others, 2009).

Bone Spring Formation (Permian)—Interbedded dark gray, deep-marine limestones, shales, and sandstones. A complex mixed carbonate-siliciclastic succession primarily deposited in a deep-water, slope-to-basin plain setting reflecting deposition by sediment gravity flows (turbidites, debris flows) interspersed with quiet, pelagic accumulation of organic-rich mudstones. The Bone Spring Formation is commonly subdivided into the First, Second, and Third Bone Spring intervals, with the uppermost shales often referred to as the Avalon Shale. Its substantial thickness (up to 1,000 meters (~3,000 feet) or more) varies with proximity to the shelf margin and basin infill (Popova, 2019).

Wolfcamp Formation (Permian)—Heterogeneous sequence of organic-rich shales, argillaceous carbonates, and interbedded limestones and sandstones. Deposited in a deep-water basin by sediment gravity flows, it overlies Pennsylvanian strata and is capped by the Bone Spring Formation. Varying in thickness from hundreds to thousands of feet, it is a significant source of tight oil and shale gas (Popova, 2019).

Map Symbols

Geologic Points
- Strike and dip of bedding
- Strike of fracture trend
- Stike and dip of fault
- Strike of fault

Contacts and Faults
- Contact
- Contact approximate
- Contact inferred
- Contact concealed
- Contact, questionable
- Internal contact
- Fault
- Fault, inferred
- Fault, approximate
- Fault, buried
- Normal fault; ball and bar on down side
- Normal fault, approximate; ball andbar on down side

Geologic Lines
- Axial trace of anticline (dashed where concealed)
- Axial trace of syncline (dashed where concealed)
- Axial trace of anticline, approximate
- Axial trace of syncline, approximate
- Surface trace of marker bed
- Fluvial scars
- Aerial photo lineament (likely fracture zones)

Basemap Symbols
- Cross section
- Topographic contour (20 ft interval)
- Intermittent stream
- County road
- Local road
- Waterline
- Cave passage
- Phantom Cave
- Spring
- Gravel pit
- Water well
- Oil and gas well
- Windmill
- USGS gage
- Oil and gas well with geophysical log

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