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Abstract

This map includes four geologic/geographic areas, each consisting of a distinct suite of Cretaceous bedrock, local Quaternary surface deposits, and topographic features with associated geologic processes. These areas are (1) the impounded valley of the Colorado River (and adjacent lower reaches of tributaries), meandering diagonally across the map from northwest to southeast; (2) high-standing remnants of the once-continuous Edwards Plateau, underlain by resistant strata of the Edwards Limestone and with a surface locally pocked by karst features; (3) steeply dissected Hill Country terrain, underlain mainly by the Glen Rose Limestone; and (4) in the southeast part of the map, a complex landscape underlain by dislocated strata that include limestone and claystone/shale bedrock units possessing a wide range of engineering properties within the Balcones Fault Zone.

Water is the most important natural resource occurring within the map area, which features surface waters from Lake Travis and Lake Austin, and various groundwater bodies, including the prolific Edwards aquifer that feeds Barton Springs (near the southeast corner of the map). Most rock and mineral resources have been nullified by high-value real-estate development, although at least one limestone quarry continues to produce crushed aggregate from the plateau terrain in the map's northeast quadrant. The main geologic attributes of value to residential and commercial development ventures pertain to stable ground, but other highly prized areas have value for wildlife habitat, water-quality protection, and scenic and/or educational use. Finally, in a negative context, water also poses threats to human life and property; the Balcones Escarpment region has the highest recurrence of flood-producing storms in the conterminous United States. This geologic map provides a rational basis for understanding where and why these resources and threats occur.

Specific Attributes

This map comprises four 7.5-min topographic quadrangles (Mansfield Dam, Jollyville, Austin West, and Bee Cave) that are reduced to 1:50,000 scale from their original scales of 1:24,000. The map thus encompasses 15 min of latitude and longitude; it is bounded on its northwest corner by lat 30°30'N and long 98°00'W, and on its southeast corner by lat 30°15'N and long 97°45'W. Total area within the limits of this map is approximately 260 mi² (674 km²), which includes the western part of downtown Austin and extensive sprawling suburbs to the north and west. In addition, this map includes significant areas of undeveloped Hill Country and plateau uplands. Ground-surface morphology is represented by topographic contour lines with contour intervals of 50 ft. Total relief on this map is roughly 790 ft, with a maximum elevation of somewhat more than 1,220 ft above mean sea level (msl) near the map's northwest corner and a minimum elevation of about 430 ft msl near the southeast corner. Geology depicted on this map is modified from work by Rogers (1969), Rodda and others (1970), Garner and others (1976), Collins (2016), and Woodruff (2017). Compilation of this map involved field visits and aerial-photo review of selected localities, as well as a reevaluation and modification of certain map units.

This map presents a synoptic overview of a geologically diverse area under intense developmental pressure resulting from Austin's having become one of the fastest-growing large cities in the United States. Owing to unique geographic features of this area, various water-related geologic processes pose threats to life and property. Yet water is a key resource that sustains population growth in this area. The map encompasses sites of the three water-treatment plants that provide all of the municipal supply for the City of Austin. Lakeshore lands near the sites of raw-water withdrawal for treatment are highly prized for both residential and commercial development, but lakeshore development poses potential threats to quality of water in these reservoirs. The map area also includes recharge areas for significant aquifers and the site of Barton Springs, the fourth-largest spring system in Texas.

The most arresting feature of the landscape on this map is the Colorado River, with its incised and impounded meanders extending across the map from northwest to southeast. Most of the area represented by this map lies within the Colorado River watershed. However, the Brazos River basin occupies the map's northeast corner, and the Colorado–Brazos drainage divide roughly coincides with the Travis–Williamson county line. The Colorado River is dammed to create three man-made lakes—Lake Travis, Lake Austin, and Lady Bird Lake—that lie wholly or partly within the map limits. These lakes and adjacent bottomlands and major tributaries constitute one of four distinct landscapes that occur within the map area. The other three landscapes include remnant uplands of the Edwards Plateau; dissected Hill Country; and the main area of dislocated strata within the Balcones Fault Zone, with diverse terrains formed on juxtaposed bedrock units. Each of these four landscape areas comprise characteristic substrates and/or landforms, with associated resources, geologic processes, or engineering properties that bear on land use.

Bedrock depicted on this map is all of Cretaceous age. These rock units are displaced by normal faults that compose the Balcones Fault Zone, which includes a complex geometry of multiple faults concentrated in the map's southeast corner. Local, widely spaced faults also occur elsewhere within the map's limits. The main line of fault displacement has been sculpted to form the Balcones Escarpment, which marks a dramatic, albeit locally discontinuous, break in terrain that is especially well expressed at Mount Bonnell, a promontory overlooking Lake Austin at the brink of the escarpment. Erosion across the escarpment exposes Lower Cretaceous strata to the west. To the east are sequences of Lower Cretaceous units locally overlain by Upper Cretaceous strata, with the youngest units occurring in the southeast corner of the map. Quaternary alluvial deposits occur in major stream valleys, but many of these deposits are now inundated beneath the man-made lakes. East of the escarpment, high alluvial deposits occur as discontinuous terraces occupying uplands far from the courses of today's Colorado River or its main tributaries.

The impoundments of the Colorado River and adjacent tributaries are important as freshwater resources, both for potable supply and as river flow for various demands downstream. These lakes are also important aesthetic and recreational resources. Lake Travis, the most upstream of the three impounded water bodies, also encompasses the greatest areal extent, stretching well beyond the map's western boundary (Woodruff and Collins, 2016). It is the largest of the six lakes that compose the Highland Lakes chain, operated by the Lower Colorado River Authority (LCRA). Lake Travis is impounded behind Mansfield Dam with normal-pool elevation of 681 ft msl and spillway elevation of 718 ft msl. Prominent impounded tributaries shown on this map include Sandy Creek from the north and Cypress Creek from the northeast. Although lake levels fluctuate as a function of rainfall and air temperature, the map's blue color depicting the water body is delimited by normal-pool elevation. This expanse of blue masks all topographic and geologic features below that level, even though local alluvial deposits and some bedrock contacts along the lake's middle and upper reaches are visible during periodic declines in lake levels.

Almost all of the Lake Travis shoreline abuts the Glen Rose Limestone (mostly the upper member). The lower member of the Glen Rose occurs along most of the northwest shoreline reaches on this map, and Hensel Sand is mapped at lake level near the map's northwest corner. When lake level is low, the underlying Cow Creek Limestone is exposed. The lake thus provides recharging waters for the lower, high-permeability members of the Middle Trinity aquifer. Farther west, Sycamore Sand is exposed along the lake and thus receives recharge for the Lower Trinity aquifer, and equivalent underground units are confined between two low-permeability units: the Hammett Shale above, and the underlying weakly metamorphosed shale strata that compose the Ouachita structural belt in this area (Flawn and others, 1961). These geologic and hydrologic units are depicted on the cross sections below, although precise elevations of most underground contacts are inferred, owing to a lack of well control. Lake Travis is the site of raw-water withdrawal for the largest of Austin's three water-treatment plants, and sites for additional withdrawals for potable supplies are being developed by other entities.

Immediately downstream from Mansfield Dam and extending across the south-central part of the map is Lake Austin, impounded by Tom Miller Dam, with a spillway elevation of 492.8 ft msl. Even at this maximum elevation, the lake does not fill the narrow valley carved by the Colorado River. Instead, this LCRA reservoir is commonly bordered by alluvial terraces and local, near-vertical limestone bluffs consisting mostly of Glen Rose Limestone. The impounded river crosses the main line of fault displacement near Tom Miller Dam, and there the lakeshore locally abuts downfaulted Edwards Limestone. Upstream from the main line of faulting, incised meanders and straight reaches of the impounded river parallel the north-east–southwest trend of the Balcones Fault Zone. The most prominent tributary to Lake Austin is Bull Creek, whose watershed includes deeply incised streams draining much of the map's northeast quadrant. Lake Austin is the site of two water-treatment plants for the City of Austin, both of which draw raw water from the lake's lower reaches. Although alluvial terraces contain potential economic resources (sand and gravel), demands for lakeshore home sites preclude extraction of these deposits because of the greater value of those areas for real estate.

Downstream from Tom Miller Dam is the upstream reach of Lady Bird Lake, impounded behind Longhorn Dam, which lies about 2.5 straight-line mi beyond the east edge of this map. Despite being designed as a constant-level lake at an elevation of 428 ft msl, lake levels fluctuate somewhat with seasonal rainfall and runoff. Quaternary alluvium borders most of this lake, but high Edwards Limestone bluffs line parts of the lake's upstream reaches. The largest tributary to Lady Bird Lake is Barton Creek, which drains an extensive watershed to the west. The Barton Creek valley (including the Little Barton Creek tributary) is a prominent feature crossing the southern part of the map and includes incised meanders, narrow alluvial bottomlands, and a general west-to-east trend. Alluvial terraces constitute the only potential arable land in the map area and also provide local sources of sand, gravel, and clay for construction purposes, although no borrow pits are still active within the map limits. Another important tributary to Lady Bird Lake is Shoal Creek, but only a short reach of this stream near its confluence on the north side of the lake occurs within the map boundaries.

Remnants of the once-continuous Edwards Plateau compose an extensive landscape that includes much of the map area northeast of the impounded Colorado River and west of the Balcones Escarpment. This landscape stands tall, in marked contrast to the incised, impounded meanders of the Colorado River and its tributaries and the intervening dissected limestone hills. Since the time of Balcones faulting, streams have cut deeply below the ancient plateau surface, which once comprised a continuous upland that stretched across almost the entire breadth of Central and Southwest Texas. The main extent of undissected plateau in this area encompasses the Colorado–Brazos drainage divide, which provides sites of minimal surface erosion owing to the presence of poorly developed surface-drainage networks in a low-relief terrain underlain by resistant bedrock. This relict upland is characterized by local karst features as well as fault-bound contacts with older geologic units (Comanche Peak limestone and members of the Walnut Formation).

Outliers of that high surface, capped by the Edwards Limestone, occur as isolated ridges and hilltops elsewhere within the map's boundaries. In the area of contiguous plateau terrain, a fraction of rainfall infiltrates to recharge a perched outlier of the Edwards aquifer. Discharge from this perched aquifer occurs as seeps and springs along the plateau's dissected margins near the tops of strata that underlie the Edwards Limestone. In the undissected terrain of the Brazos watershed, recharge supplies the water table within the northern Edwards aquifer. Stone resources, including crushed aggregate and dimension stone, also occur within this plateau terrain, although most quarries within the limits of the map are now abandoned because of encroachments by residential subdivisions and commercial developments.

The most extensive of the map's four landscapes consists of dissected terrain that lies below the plateau caprock. This area includes classic landscapes of the Central Texas Hill Country, with its steep-gradient streams, high-drainage density, and "stair-step" topography that is typical of both the upper and lower members of the Glen Rose Limestone. The stepped terrain results from erosion of repetitious interbeds of limestone and dolomite of variable consistency such that resistant strata form floors of treads and ledges above intervening beds that are less resistant to weathering. These recessive intervals form the risers of the stair steps, which exhibit surprising properties, including unexpectedly thick soils with high water-retention properties and associated low rates of runoff and erosion (Woodruff and Wilding, 2008). High-standing parts of this dissected terrain include more-or-less friable rock units that lie directly below the Edwards Limestone: the Comanche Peak Limestone and various members of the Walnut Formation (Moore, 1964). These units are readily eroded beneath the resistant Edwards Limestone cap to form steeply sloping edges of the plateau.

Below that abrupt margin, most of this area is underlain by the upper member of the Glen Rose Limestone, which encompasses the greatest area of any geologic unit on this map. The uppermost part of the Glen Rose section consists of a friable, leached dolomitic interval, which is mapped as an informal unit (the Upper Dolomite). The lower member of the Glen Rose Limestone is mapped below the so-called Corbula Bed and is mostly inundated beneath Lake Travis in this map area. However, this lower member crops out along lakeshores in the northwest quadrant and along the margins of the Colorado River's incised valley (partly inundated by Lake Austin) for about 5 mi south of Mansfield Dam. Local rock resources derived from these weathered interbeds include "caliche" deposits, commonly used as road metal, and diverse materials such as vuggy rock and flagstone beds that are extracted locally for landscaping and other decorative purposes. The Glen Rose Limestone composes parts of two aquifers: the Upper Trinity aquifer that roughly coincides with the upper member of the Glen Rose Limestone, and the Middle Trinity aquifer, of which the Lower Glen Rose forms the top unit in a section that includes the Hensel Sand and Cow Creek Limestone. For the exposed Glen Rose sections in this map area, limited porosity and localized zones of permeability constrain recharge and storage capacities of that rock unit. Recurrent flooding poses hazards throughout this map area and beyond, owing to the proximity of the Gulf of Mexico and the orographic influence of the Balcones Escarpment. However, flood hazards are especially acute in this area of steep slopes and high-gradient streams that promote rapid runoff during times of heavy rainfall.

The southeastern corner of this map comprises the intensively faulted terrain within the Balcones Fault Zone, where dramatic landscape changes are associated with bedrock dislocations that occurred chiefly during the Neogene or late Paleogene (ca. 28–15 Ma). These faults are regarded as being largely dormant and pose little or no ongoing seismic threats. The east-facing Balcones Escarpment extends along the Mount Bonnell fault, the main fault line in this area, with almost 600 ft of displacement. This fault marks the break between the intensively faulted area to the east and the hills, incised water courses, and high-standing plateau landscapes to the west. Fault displacement has been the prime influence on long-term landscape evolution in Central Texas; surface-water courses cut deeply into the uplifted limestone strata, creating steep stream gradients and sculpting the landscapes that exist today.

The modern expression of the fault zone in this map area includes displaced rock units that encompass the entire stratigraphic section from Edwards Limestone (Lower Cretaceous) to the Austin Chalk (Upper Cretaceous). This section includes sequences of limestone, claystone, and shale strata that display dramatically different engineering properties. South of the Colorado River, the Edwards Limestone has been upgraded to the Edwards Group that comprises two formations, the Kainer and the overlying Person (Rose, 1972). The Edwards Group and Georgetown Formation make up the karstic recharge zone for the Barton Springs segment (BSS) of the Edwards aquifer; Barton Springs, the main discharge site for this segment, occurs along a fault exhumed by Barton Creek about 0.5 mi south of the Colorado River.

Overlying units in the southeast corner of the map include Del Rio Clay, Buda Limestone, Eagle Ford Shale, and the bottommost section of the Austin Chalk. In general, the limestone units provide stable sites for most construction endeavors, although karst cavities (and water-quality concerns) impose limitations where the substrate consists of the Edwards Limestone/Group. Also, terrain breaks at contacts between limestone units overlying clay or shale commonly pose problems with slope stability. In contrast, the Austin Chalk provides a dense and compact limestone with low permeability values that limit that unit's potential as an aquifer; it also exhibits excellent engineering properties such as high strength and stable slopes. Thus, the Austin Chalk provides ideal substrate for intensive development, and it is the bedrock underlying downtown Austin, the University of Texas main campus, and adjacent areas. This important bedrock unit has a thickness of more than 300 ft in the Austin area, but this map's boundaries include only the basal part of the unit, with a thickness of about 80 ft.

In contrast, the two clay units are notorious for their engineering challenges. Both the Del Rio Clay and the Eagle Ford Shale exhibit high plasticity, low bearing strength, low slope stability, low permeability, and high corrosion potential (Rodda, 1970). In addition, the Eagle Ford Formation contains flaggy limestone intervals, posing additional problems owing to disparate localized rock properties. Surficial deposits of Quaternary alluvium occur adjacent to Lady Bird Lake, as well as on disjunct surfaces high above the modern Colorado River valley. These alluvial deposits pose problems resulting from variable engineering properties and generally are not suitable for sustaining heavy structures. In addition, these deposits may locally store perched groundwater that may be either a valuable resource or a constraint for construction. Finally, surface deposits mask underlying bedrock, thereby requiring subsurface investigations (i.e., geotechnical drilling) to ascertain the properties of underlying bedrock.

Acknowledgments

This map is a modified compilation of geologic mapping of the aforementioned 7.5-min quadrangles that make up the study area; topographic information is incorporated from U.S. Geological Survey (USGS) sources via digital files of the Texas Natural Resources Information System (TNRIS). Digital files of roads, county boundaries, drainage, and lakeshores were also obtained from TNRIS.

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GEOLOGIC MAP of MANSFIELD DAM, JOLLYVILLE, AUSTIN WEST,
AND BEE CAVE QUADRANGLES, CENTRAL TEXAS
(Lower Lake Travis and Lake Austin Vicinity)
OPEN FILE MAP 0237



SCALE 1:50,000

0 5 1 2 3 4 5 MILES
0 1 2 4 6 8 10 KILOMETERS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION, ZONE 14N, NAD 83

GEOLOGIC MAP of MANSFIELD DAM, JOLLYVILLE, AUSTIN WEST, AND BEE CAVE QUADRANGLES, CENTRAL TEXAS (Lower Lake Travis and Lake Austin Vicinity)

C. M. Woodruff, Jr. and Edward W. Collins
2018

N
4°MN
Approximate 2018 Magnetic North (MN) declination



Quaternary

Qal—Alluvium: Unconsolidated gravel, sand, silt, and clay along stream courses and low floodplains of Colorado River and its tributaries; maximum thickness approximately 20–35 ft; includes local bedrock exposures.

Qat—Alluvial terrace, undifferentiated: Tributary deposits of gravel (mostly clasts of limestone and chert, derived from nearby uplands), sand, and calcareous silt and clay, generally unconsolidated but may have local caliche cement; thickness highly variable but maximum of about 20 ft.

Qt1—Alluvial terrace complex 1: Gravel, sand, silt, and minor clay deposits, less than10 ft thick; mostly unconsolidated; occupies various low topographic levels along Lady Bird Lake; corresponds to Sand Beach and Riverview terraces of Rodda and others (1970).

Qt2—Alluvial terrace complex 2: Gravel, sand, and silt (local clay), mostly unconsolidated; local weak cementation, 20–30 ft thick; forms gently sloping, undissected bench above low-lying terraces and floodplain; corresponds to First Street terrace of Rodda and others (1970).

Qt3—Alluvial terrace complex 3: Gravel, sand, and silt, unconsolidated to weakly cemented; locally dissected; thicknesses range 10–30 ft; corresponds to Sixth Street terrace of Rodda and others (1970).

Qt4—Alluvial terrace complex 4: Gravel, sand, and silt, unconsolidated to weakly cemented; broad, nearly flat topographic bench with dissected edges; thickness up to 25–30 ft; corresponds to Capitol Terrace of Rodda and others (1970).

Qht—High terrace: Mostly gravel admixed with sand and muddy sediments; local caliche cement; thickness highly variable up to about 30 ft; occupying rolling terrain; deposits 60–100 ft above nearby water courses; in downfaulted areas of West Austin; corresponds to Asylum Terrace of Rodda and others (1970).

Upper Cretaceous

Kau—Austin Group undivided: Limestone, chalk, local marly intervals, thin to medium-bedded; light-colored (buff to white), compact, dense, locally nodular, a few discrete clay interbeds (some bentonitic); total thickness in map area approximately 80 ft; exhibits excellent engineering properties: high strength, high slope stability, low permeability except in fracture zones; does not contain appreciable amounts of groundwater; no karst openings known in this area.

Kef—Eagle Ford Shale: Shale, claystone, dark-colored, approximately 35 ft thick; poses engineering problems owing to low strength, high plasticity, and low permeability coupled with occurrence of flaggy limestone in the formation's mid reaches; basal 3–5 ft consists of extremely weak, nearly black, unctuous, bentonitic clay (Pepper Shale).

Kbu—Buda Limestone: Limestone, gray to tan, glauconitic with abundant fossil fragments, 35–40 ft thick; upper part thick-bedded, well-cemented rock with local vuggy intervals; lower part nodular and somewhat friable, forming recessive slopes beneath caprock; commonly forms bluffs above the weak, erodible Del Rio Clay; vertical fractures and erosion (or excavation) of underlying clay result in slope failures along limestone/claystone contacts; may locally store and transmit groundwater as thin, perched aquifer.

Kdr—Del Rio Clay: Claystone, dark gray, weathering to yellow-brown or olive-green; contains pyrite and local lenses of shell coquina; selenite occurs in zones of surface weathering; 70–75 ft thick; notorious for high plasticity, low strength, low slope stability, and high corrosion potential; forms a confining seal above Edwards aquifer.

Lower Cretaceous

Kgt—Georgetown Formation: Limestone, gray to tan, commonly nodular, fossiliferous, locally dense, thin to medium-bedded, 40–60 ft thick; considered to be upper part of Edwards aquifer, although enhanced porosity and permeability are not generally evident in outcrops.

Ked—Edwards Formation/Group: Limestone, dolomitic limestone, dolomite; highly variable properties, generally light gray to off-white, thick-bedded rudist boundstone at base forms resistant caprock at edges of plateau uplands; local flaggy beds; ranges in overall thickness from about 350 ft on downthrown side of main fault line in southeast part of map area to roughly 150 ft beneath plateau terrain to the north; outlying hilltops capped by thin erosional remnants (locally less than 20 ft thick); stratigraphic nomenclature changes at Colorado River with Edwards Group designated by Rose (1972) south of the river in the Balcones Fault Zone (see descriptions of Person and Kainer Formations, below); formation status (Edwards Limestone) maintained throughout map area west of main fault line; dissected plateau terrain north of river contains nodular and "marly" intervals (containing multiple clay partings) similar to facies of Comanche Peak and Walnut Formations; overall lithology highly diverse, including resistant, thick-bedded intervals of limestone and dolomitic limestone to nodular or "marly" horizons; burrowed intervals commonly expressed as vuggy "honeycomb rock"; extremely friable beds of pulverulite consisting of loosely bound, silt-sized dolomite particles; chert nodules and tabular chert layers locally abundant with maximum dimensions of nodules ranging from about 1.5 inches to more than 18 inches; thin clay partings occurring locally; dissolution features common, ranging from vugs with dimensions measured in inches to extensive caverns with maximum dimension of underground mapped in tens of feet; secondary porosity is important for groundwater storage and transmission in the Edwards aquifer; Edwards terrain typically covered by thin clayey soils, but thick terra rossa soils occur locally; bedrock generally stable and secure, but karst features at shallow depths may threaten foundations or other man-made facilities.

Kp—Person Formation: Upper unit of Edwards Group south of Colorado River in Balcones Fault Zone (map's southeast corner); basal member consists of nodular, clayey carbonate strata that form recessive slopes overlain by complex assortment of hard, flaggy limestone and dolomitic strata; karst features locally abundant; roughly 120 ft thick.

Kk—Kainer Formation: Lower unit of Edwards Group south of Colorado River in fault zone; consists of diverse assortment of textures and rock fabrics in limestone, dolomitic limestone, friable dolomite intervals; locally interspersed chert nodules; some dense, durable strata, and strata leached and collapsed from dissolution; local intervals of leached dolomite that are highly friable (pulverulite of Rose, 1972); thickness approximately 220 ft.

Kcp—Comanche Peak Formation: Limestone, gray, mostly fine-grained and thin-bedded, nodular with clay partings; 20–30 ft thick mapped as fault-bound contacts with Edwards and Walnut Formations near map's northern boundary in Williamson County; not well exposed; similar to nodular and other recessive intervals of Edwards Limestone; locally forms basal seal for Edwards aquifer.

Kcp/Kwa—Comanche Peak Formation, Walnut Formation, undivided: Owing to dense suburban development and similar rock composition, includes both the Comanche Peak and Walnut Formations; combined unit occurs in faulted terrain in Williamson County, within the northeast quadrant of map; bedrock consists of nodular and/or "marly" intervals inferred to be 20–30 ft thick; outcrops are sparse, but ground stability appears to be high; local karst openings may occur.

Kwa—Walnut Formation: Limestone, gray to buff-colored, includes thin- to medium-bedded fine-grained burrowed limestone about 35 ft thick (Bull Creek Member) overlain by about 30 ft of thin-bedded "marly" (clayey) limestone with abundant fossils of diverse types and local dense accumulations of oysters (Bee Cave Member); thickens to north and contains other members (30–40 ft thick), including Cedar Park Member and Whitestone Member, consisting of compact uniformly bedded sparry limestone overlying a dense stratum bearing myriad fossil imprints; once quarried for dimension stone near northern map boundary (Moore, 1964); Bee Cave Member—with its off-white, fossiliferous, eroded outcrop—is easily recognized in fault zone despite urbanization, as well as along outlying remnants of the Edwards Plateau; in uplands along Travis/Williamson County line, intensive urbanization prevents easy recognition of these members; in general, various components consist of stable substrates, although nodular intervals may be subject to rapid erosion and (along with Comanche Peak Formation) form a low permeability interval beneath Edwards aquifer.

Kgru—Glen Rose Limestone (upper member): Limestone, dolomitic limestone, dolomite, and argillaceous limestone, tan to light gray; expressed on landscape as stepped terrain, owing to repeated intervals of resistant and nonresistant strata; ground generally stable, but local groundwater discharge coupled with oversteepened slopes may produce slope failure; composes Upper Trinity aquifer in this area (Brune and Duffin, 1983), although groundwater not extensively used because of limited storage and adverse water quality; fossils locally abundant and consist of clams, rudists, oysters, echinoids, and foraminifers; thickness roughly 300–400 ft; upper 80–100 ft consist mainly of weathered intervals of silty dolomite; composes an informal map unit, the Upper Dolomite (**Kgrud**), following conventions of Rodda and others (1970) and Stricklin and others (1971); lithologic datum for base of Upper Glen Rose is at top of a prominent marker horizon, the Corbula bed—above this marker is interval of leached evaporite deposits yielding vugs, boxwork structures, and poorly formed geodes; sequence-stratigraphic studies by Mancini and Scott (2006) present a sequence boundary at base of Corbula interval and designate this datum as base of Upper Glen Rose; previous studies by Kerans and Loucks (2002) interpreted a regional sequence boundary well below Corbula bed.

Kgrl—Glen Rose Limestone (lower member): Limestone, dolomitic limestone, dolomite, and argillaceous limestone, tan to light gray; 65–100 ft thick in map area; expressed on landscape by stepped terrain, resulting from same geomorphic processes active in upper member; upper boundary marked along top of Corbula bed, a bench-forming 3-ft-thick horizon composed of flaggy, often iron-stained rock containing myriad fossils clams the size and shape of wheat grains; beneath Corbula bed is recessive ("marly") interval containing copious fossil casts including gastropods, bivalves, and echinoids (especially the roughly spherical *Salenia texana*); this couplet of resistant, flaggy stratum overlying recessive interval is readily noted in the field (and commonly on aerial photos); base is gradational with Hensel Sand and consists of silty dolomite strata with sharply interbedded sandstone having clasts ranging from fine-grained to granule- and pebble-sized; upper component of Middle Trinity aquifer, an important source of groundwater in the Central Texas Hill Country.

Khe—Hensel Sand: Sandstone, buff-colored to reddish tan; weakly cemented beds composed of diverse clasts ranging from fine-grained quartz arenite to subarkose, to granule and pebble conglomerate with local cobbles; weakly cemented by calcite; locally well-indurated; gradational contact with Glen Rose Limestone containing interbeds of silty and sandy dolomite; 50–80 ft thick in map area; composes middle part of Middle Trinity aquifer; uniform porosity allows widespread infiltration/recharge, especially where lying at or below variable lake levels.

Kcc—Cow Creek Limestone: Limestone, light-gray to nearly white carbonate rock; only uppermost strata occur at lake level near the northwest corner of map; this sequence consists of cross-bedded shell-fragment aggregate admixed with quartz sand (beach rock); overall thickness 40–65 ft thick where exposed to west along Lake Travis, but only the top few feet are exposed in map area; lowest unit composing Middle Trinity aquifer.

Kha—Hammett Shale: Not exposed in map area; occurs in subsurface and consists of shale and claystone, with local beds of sandstone and conglomerate; typically 20–30 ft thick; forms low-permeability seal at top of Lower Trinity aquifer.

Ks/Kho—Sycamore Sand (Hosston Sand in subsurface): Not exposed in map area; basal Cretaceous unit in Central Texas; exposures mapped as Sycamore Sand; consists mostly of well-cemented conglomerate with local sand lenses and sparse lignite; outcrop thickness 30–75 ft, but formation thickens to southeast (is several hundred feet thick beneath Austin); makes up Lower Trinity aquifer; in Austin and farther east is downfaulted to sufficient depths to produce groundwater at elevated temperatures.

Paleozoic Undifferentiated

Pzo—Paleozoic Ouachita System: Basement complex underlying Cretaceous strata; composed of weakly metamorphosed shale (Flawn and others, 1961); not exposed; total thickness unknown in map area.

Contact; dashed where approximate; dotted where covered, ? indicates approximate contact queried

Normal fault; U, upthrown block; D, downthrown block; dashed where approximate; dotted where covered

Stream

Intermittent stream

Road

Railroad

1000 Elevation; contour interval 50 ft

Quarry area

Surface water bodies; norm