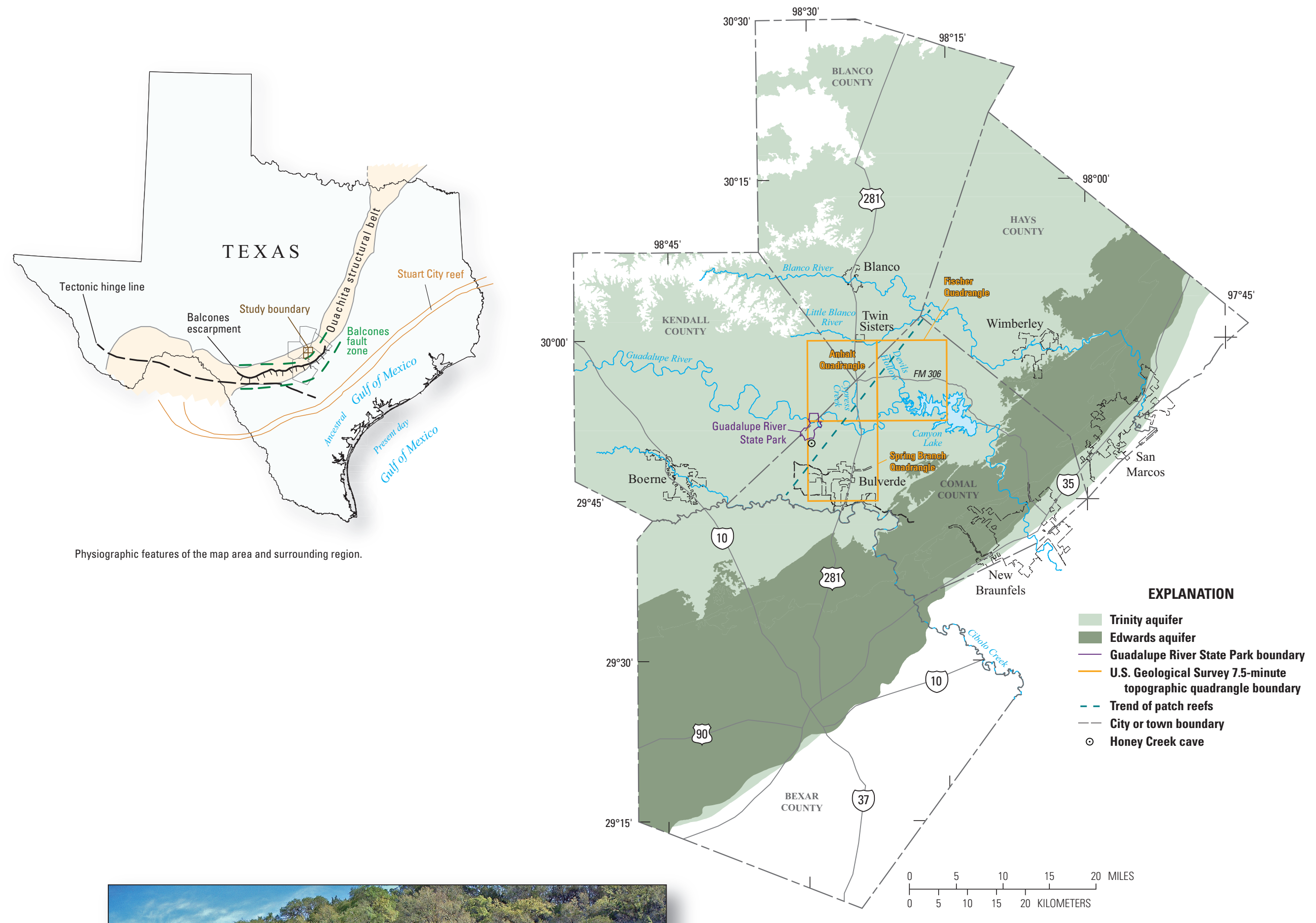
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3333
Pamphlet accompanies map



Physiographic features of the map area and surrounding region.

Figure 1. Location of the study area.

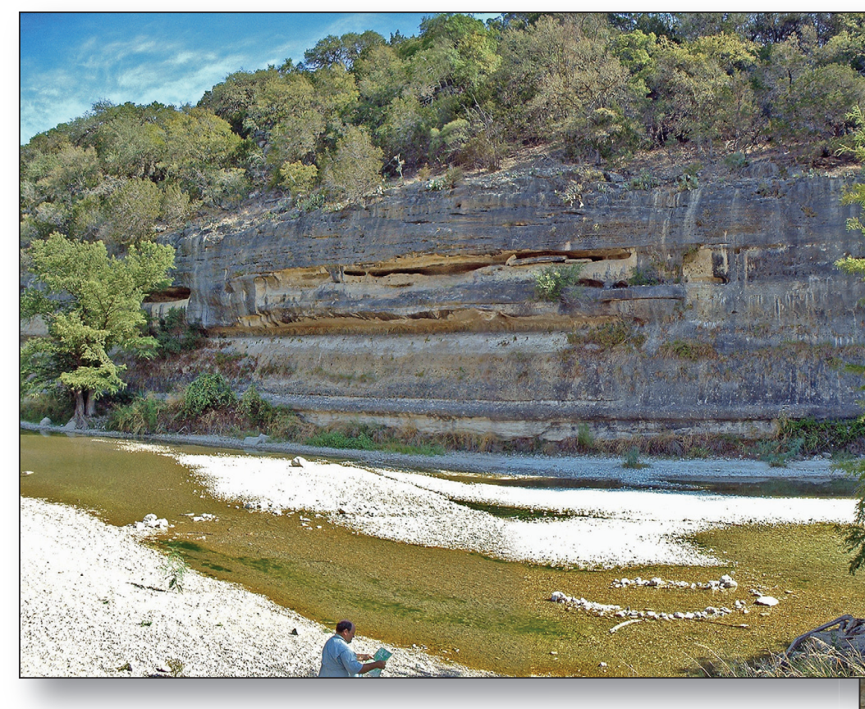


Figure 2. Outcrop of the Cow Creek Limestone Member along the left bank of the Guadalupe River in Guadalupe River State Park, Comal County, Texas. Photograph taken September 3, 2011, by Robert Morris.

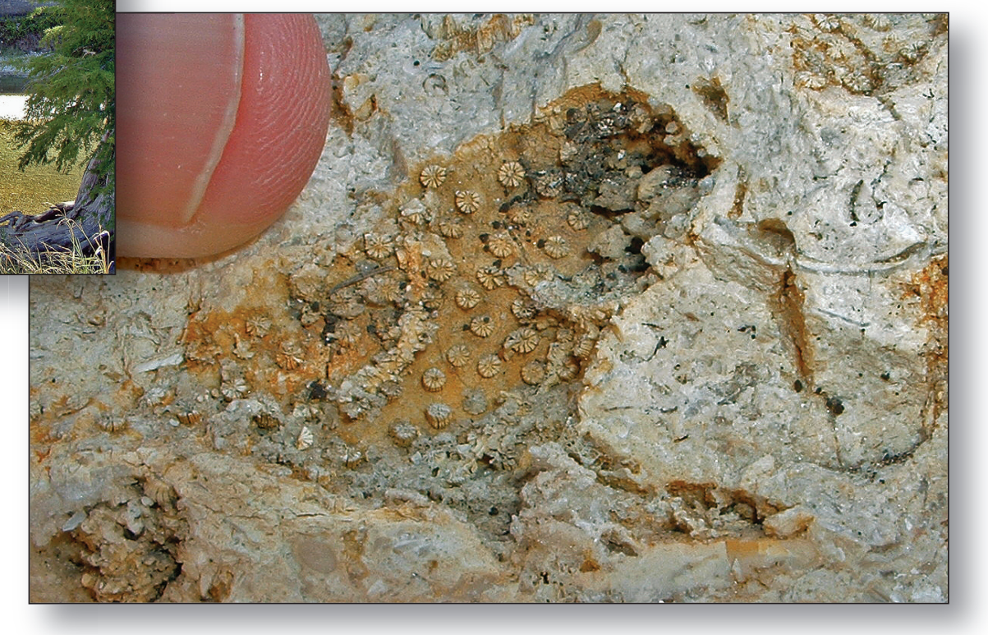


Figure 3. Unidentified coral mold from an outcrop of the lower Glen Rose Limestone (lower 50 ft). The outcrop is located in a road cut several hundred feet west of the junction of Farm to Market Road 306 and Devils Hollow, Comal County, Texas. Index finger used for scale. Photograph taken Sept. 9, 2014, by Allan Clark.

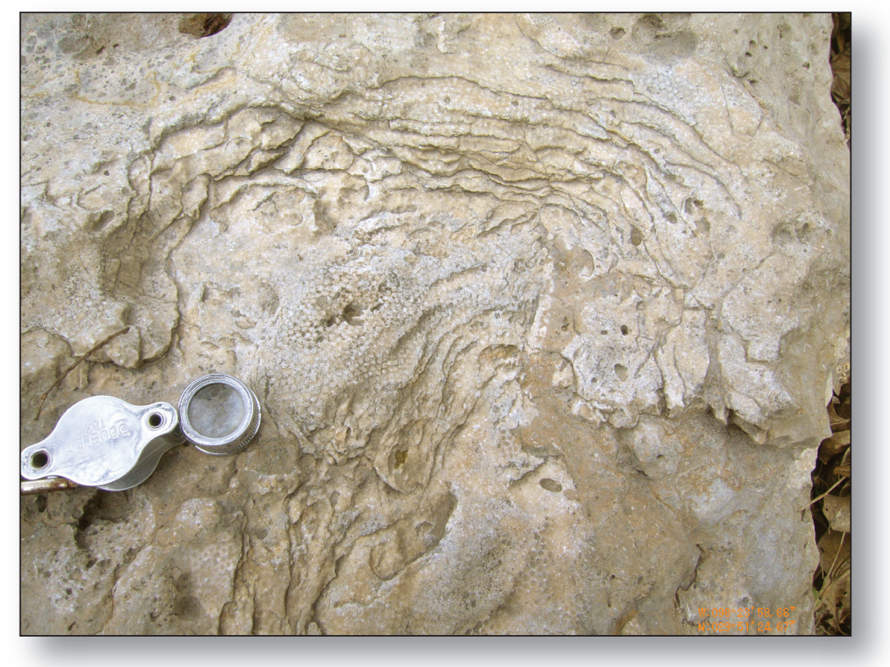


Figure 4. Unidentified species of fossil coral from an outcrop of the lower Glen Rose Limestone (lower 50 ft). The outcrop is located at the confluence of Cypress Creek and Guadalupe River, Comal County, Texas. Photograph taken January 27, 2014, by Allan Clark.

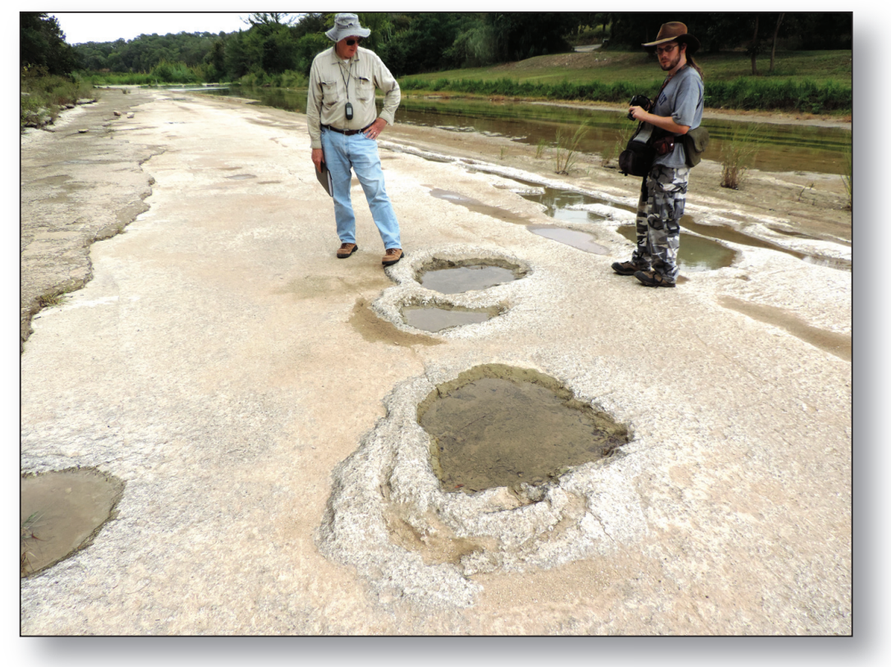


Figure 6. Sauropod tracks in the Blanco River channel approximately 2.9 miles west of the town of Blanco near the stratotype location for the *Corbula* marker bed. Photograph taken August 19, 2014, by Allan Clark.

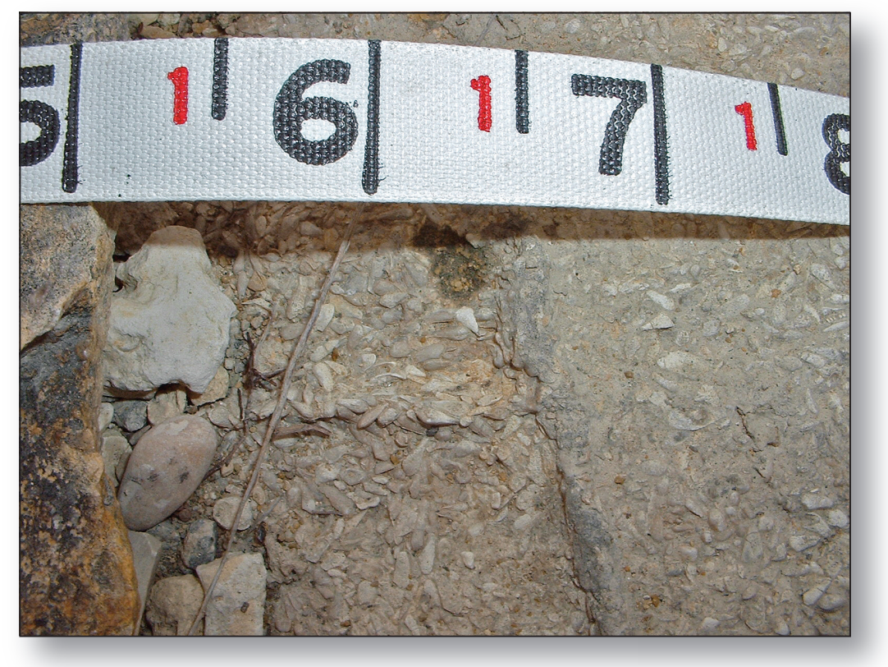


Figure 5. The marker bed of *Corbula* sp. in an outcrop 2.06 miles west of the Blanco River and 0.35 mile east of the Comal-Hays County line. Tape increments in tenths of a foot. Photograph taken April 17, 2013, by Robert Morris.

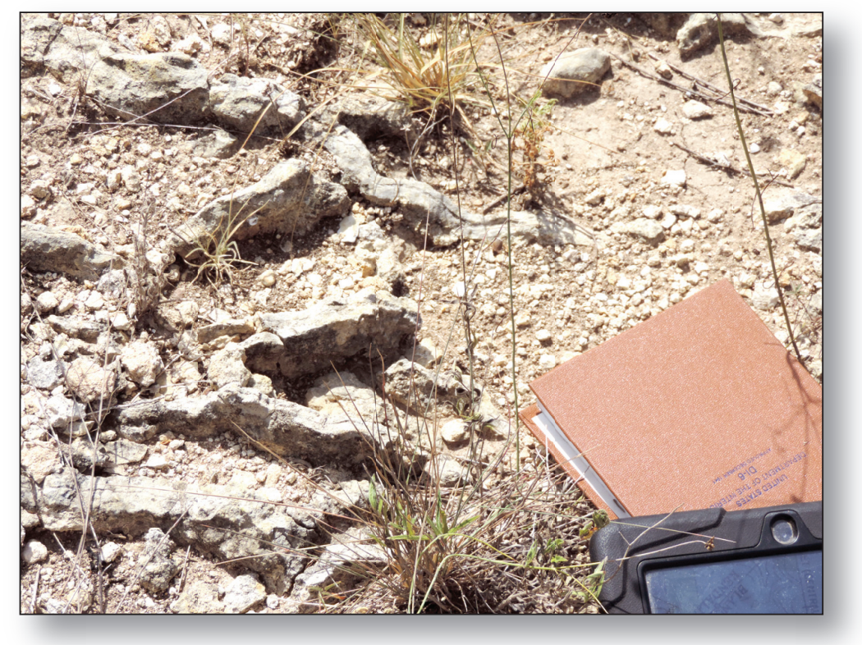
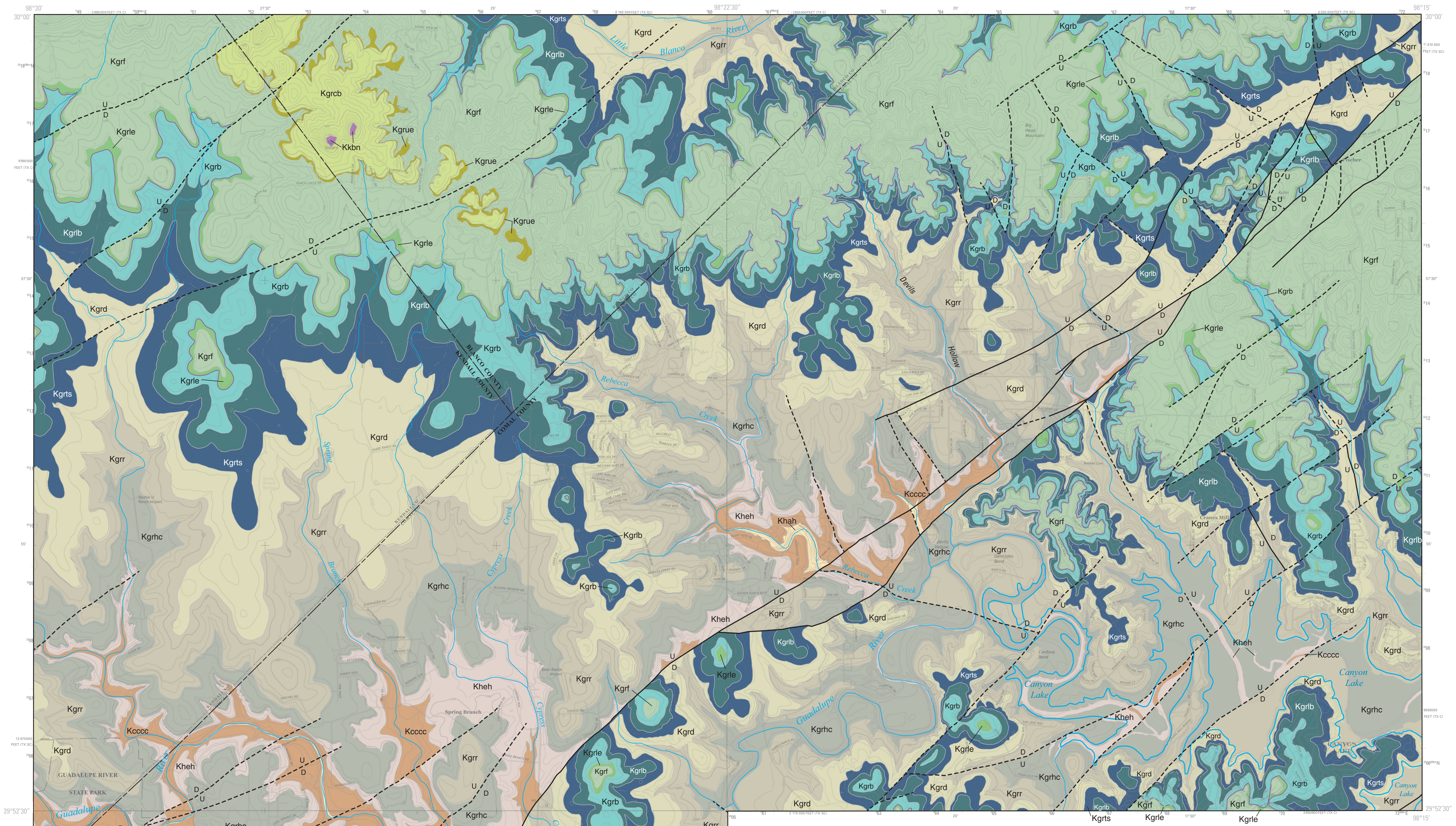
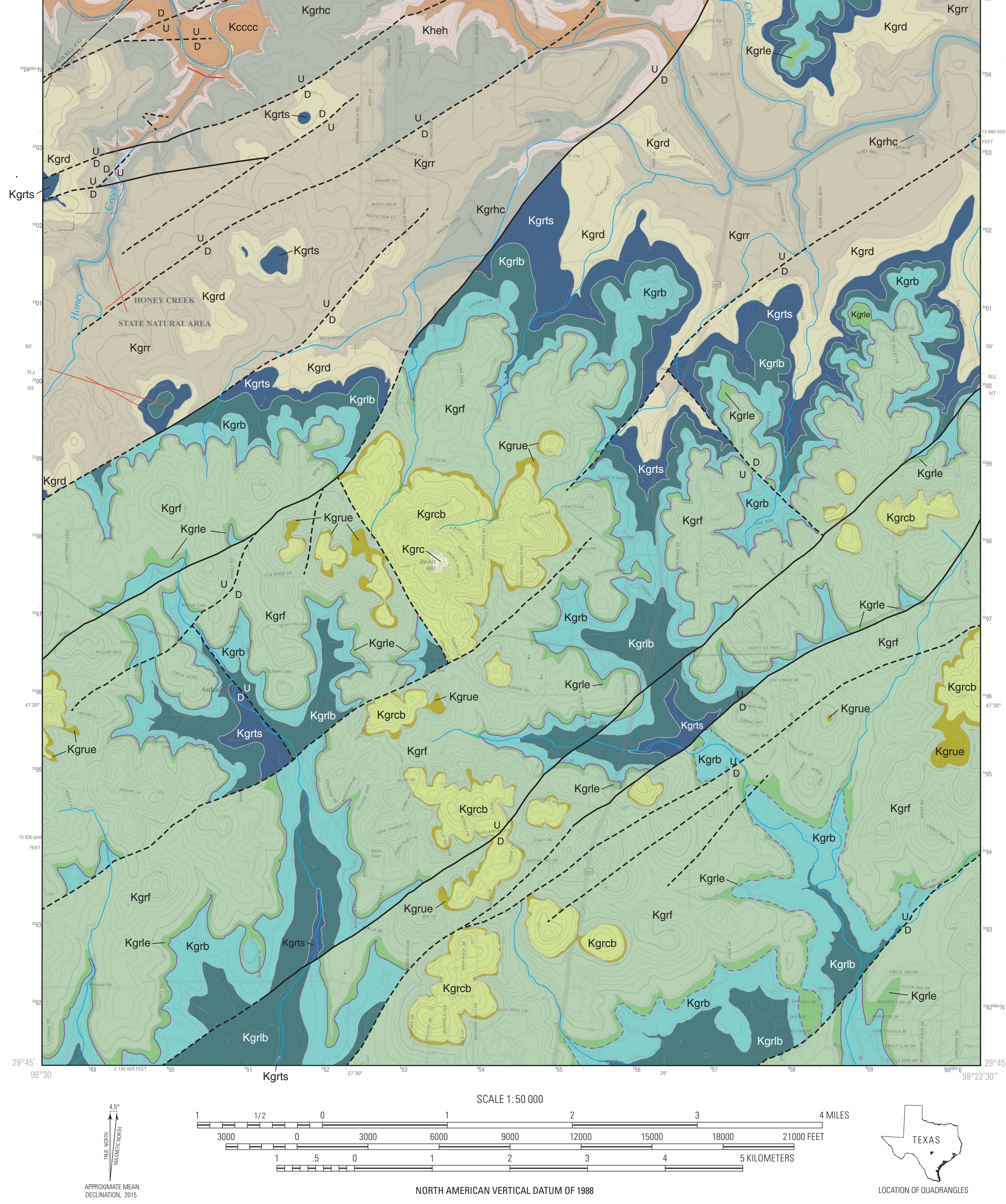


Figure 7. Boxwork porosity in the upper evaporite unit, approximately 120 ft above the *Corbula* bed and 0.8 mile south of the Blanco River and 3.22 miles west of Highway 281. Photograph taken August 15, 2014, by Robert Morris.

CONVERSION FACTORS

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi²)	2.590	square kilometer (km²)

Hydrostratigraphic map of the Anhalt, Fischer, and Spring Branch 7.5-Minute Quadrangles, Blanco, Comal, and Kendall Counties, Texas

Base modified from U.S. Geological Survey 24,000-scale US TOPO: Anhalt, Texas, 2013; Fischer, Texas, 2013; and Spring Branch, Texas, 2013

North American Datum of 1983 (NAD 83)
World Geodetic System of 1984 (WG S84)

Projection and 1,000-meter grid: Universal Transverse Mercator, zone 14N
10,000-foot ticks: Texas coordinate system of 1983 (south central zone)

Guadalupe River State Park boundary modified from Texas Parks and Wildlife Department accessed on May 11, 2015 at http://tpwd.texas.gov/state-parks/guadalupe-river/map

Field mapping of the hydrostratigraphic units was accomplished on an Apple iPad2 containing geospatially-registered 7.5-minute USGS topographic maps and utilizing their integrated global positioning system (GPS). The field data were transferred to esri ArcMap (esri, 2014), quality checked and then used to produce the study area's hydrostratigraphic map.

Lithologic and hydrostratigraphic descriptions are from field observations and previous investigations.

Digital cartography and GIS database by Diana E. Pedraza

Edit and cartographic layout by L.J. Binder
Denver Publishing Service Center

EXPLANATION OF HYDROSTRATIGRAPHIC UNITS

Group	Formation	Member	Informal hydrostratigraphic unit	
Edwards	Kainer Formation	Basal nodular	Kkbn	VIII
Trinity	Glen Rose Limestone	Upper	Kgrc	Cavernous
			Kgrcb	Camp Bullis
			Kgrue	Upper evaporite
			Kgrf	Fossiliferous
			Kgrle	Lower evaporite
		Lower	Kgrb	Bulverde
			Kgrlb	Little Blanco
			Kgrts	Twin Sisters
			Kgrd	Doeppenschmidt
			Kgrr	Rust
			Kgrhc	Honey Creek
	Pearsall Formation	Hensell Sand	Kheh	Hensell
		Cow Creek Limestone	Kcccc	Cow Creek
		Hammett Shale	Khah	Hammett

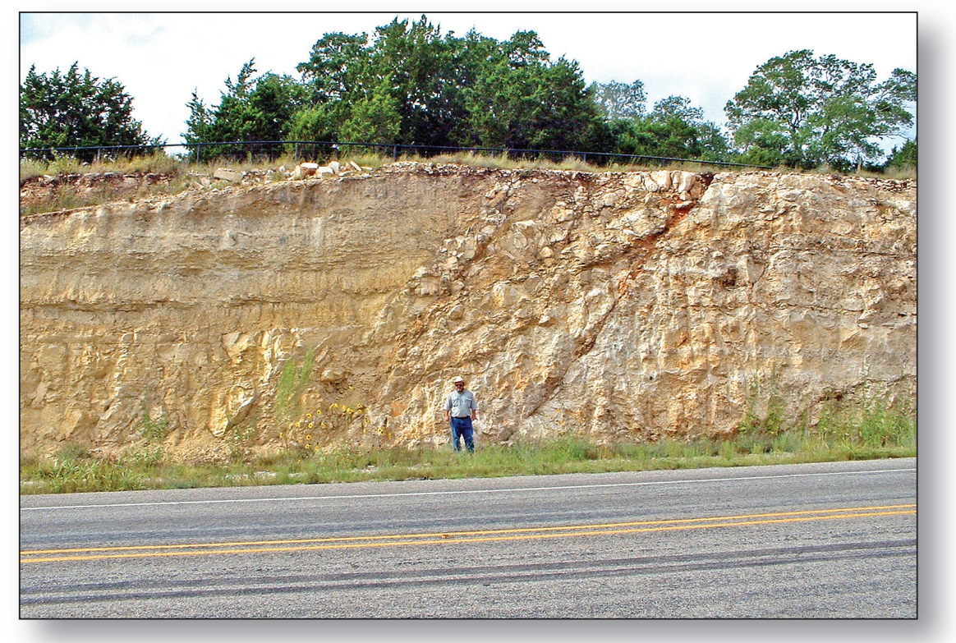
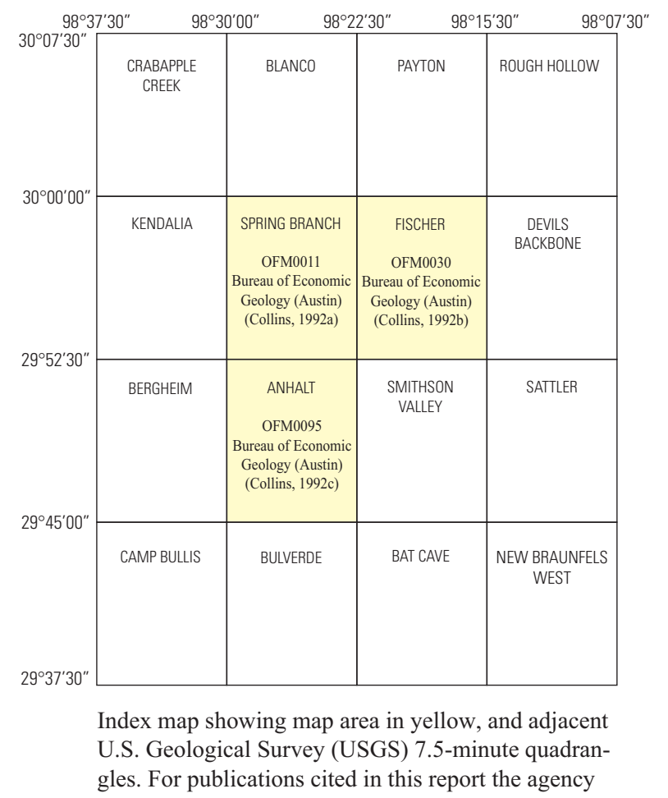


Figure 8. Fault juxtaposing the lower 50 ft of the lower Glen Rose Limestone against the middle part of the lower Glen Rose Limestone off Farm to Market Road 306 west of Devils Hollow. Fault displacement is estimated to be 140 ft, down to the south. Photograph taken September 11, 2014, by Robert Morris.



CRABAPPLE CREEK	BLANCO	PAYTON	ROUGH HOLLOW
KENDALIA	SPRING BRANCH OFM0011 Bureau of Economic Geology (Austin) (Collins, 1992a)	FISCHER OFM0030 Bureau of Economic Geology (Austin) (Collins, 1992b)	DEVILS BACKBONE
BERGHEIM	ANHALT OFM0095 Bureau of Economic Geology (Austin) (Collins, 1992c)	SMITHSON VALLEY	SATTLER
CAMP BULLIS	BULVERDE	BAT CAVE	NEW BRAUNFELS WEST

Index map showing map area in yellow, and adjacent U.S. Geological Survey (USGS) 7.5-minute quadrangles. For publications cited in this report the agency or institution, author, and publication year are shown.

DESCRIPTION OF MAP UNITS

[Stratigraphic nomenclature of the Cretaceous rocks exposed in and around the study area are from Whitney, 1952; Lozo and Stricklin, 1956; Striklin and others, 1971; Rose, 1972; Striklin and Smith, 1973; Amsbury, 1974; Barnes, 1974, 1976; Mancini and Scott, 2006; and the U.S. Geological Survey National Geologic Map Database, Geolex (http://ngmdb.usgs.gov/lex-bin/search.pl). The rocks exposed in the study area compose a section of the Edwards aquifer and the upper and middle of the Trinity aquifer. In the study area, the Edwards aquifer is composed of the basal nodular member of the Kainer Formation. The upper Trinity aquifer is contained in the upper member of the Glen Rose Limestone. The middle Trinity aquifer is composed of the lower member of the Glen Rose Limestone, and the Hensell Sand Member and Cow Creek Limestone Member of the Pearsall Formation. The Hammett Shale Member of the Pearsall Formation acts as a confining unit between the middle Trinity aquifer and the lower Trinity aquifer.

In the study area, the Edwards aquifer is up to 80 ft thick on the tops of several hills, the upper Trinity aquifer is 300–390 ft thick, and the middle Trinity aquifer is from 225 to 240 ft. thick. The lithostratigraphy of the study area was mapped and combined with the porosity characteristics using the porosity-based classification system developed by Choquette and Pray (1970) to determine the hydrostratigraphic units. The descriptions below include general information about the geologic formation or member, lithology, thickness, primary fossils present, porosity, and type locality. Averages and ranges of unit thickness shown below are derived from within the study area.]

EDWARDS GROUP

Edwards Group (upper Lower Cretaceous, Albian)—Overlies the Trinity Group; mudstone, wackestone, packstone, grainstone, boundstone, dolomitic limestone, argillaceous limestone, evaporites, shale, chert. Most removed by erosion. Thickness of remaining Edwards Group 60 ft. Only basal nodular member of Kainer Formation is present in study area

Kainer Formation (late Early Cretaceous, Albian)—Overlies the Trinity Group; mudstones, wackestone, packstone, grainstone, dolomitic limestone, shale, chert (except in the basal nodular unit). Most removed by erosion. Thickness of remaining Edwards Group 60 ft. Only basal nodular member of Kainer Formation is present in study area

Kkbn **VIII hydrostratigraphic unit**—Confining, locally water bearing; fabric selective bedding plane and not-fabric selective fracture and minor cave porosity. Thickness 60 ft

Trinity Group

Trinity Group (Lower Cretaceous)—Overlies, in the subsurface, Pennsylvanian shale (Imlay, 1940) in the study area. Contains shale, mudstone to grainstone, boundstone, sandstone, and argillaceous limestone. Thickness of Trinity Group approximately 525–540 ft.

Glen Rose Limestone (Lower Cretaceous, lower Aptian to middle Albian)—Alternating beds of yellowish-tan, medium-bedded limestone and argillaceous limestone with minor evaporite layers. Composed of the lower and upper members (informal classification), separated by a regionally extensive marker bed, composed of the small fossil identified as *Corbula* sp. (Whitney, 1952).

Upper member (Lower Cretaceous, lower to middle Albian)—Massive shale, claystone,evaporites, siltstone, mudstone, wackestone, packstone, grainstone, boundstone andargillaceous limestone. Locally 300–390 ft. thick. Composed of the following hydrostratigraphic units in descending stratigraphic order: Cavernous (Kgrc), Camp Bullis (Kgrcb), upper evaporite (Kgrue), fossiliferous (Kgrf), lower evaporite (Kgrle).

Kgrc **Cavernous hydrostratigraphic unit**—Aquifer; fabric selective interparticle, moldic, moldic (boxwork), burrow, and bedding plane. Not-fabric selective porosity in vug, fracture, channel, breccia, and cave porosity. Thickness 0–90 ft.

Kgrcb **Camp Bullis hydrostratigraphic unit**—Confining; fabric selective bedding plane, and burrow porosity. Not-fabric selective fracture porosity. Thickness 160 ft.

Kgrue **Upper evaporite hydrostratigraphic unit**—Aquifer; fabric selective interparticle, moldic (boxwork) and breccia porosity. Thickness 10 ft.

Kgrf **Fossiliferous hydrostratigraphic unit**—Aquifer; not-fabric selective fracture and cave porosity. Some fabric selective interparticle, moldic, and breccia porosity. Thickness 120 ft.

Kgrle **Lower evaporite hydrostratigraphic unit**—Aquifer; fabric selective interparticle, moldic (boxwork), and breccia porosity. Thickness 10 ft.

Lower member (Lower Cretaceous, upper Aptian)—Massive, shale, evaporites, mudstone, wackestone, packstone, grainstone, boundstone and argillaceous limestone. Locally 225–240 ft. thick. Composed of the following hydrostratigraphic units in descending stratigraphic order: Bulverde (Kgrb), Little Blanco (Kgrlb), Twin Sisters (Kgrts), Doeppenschmidt (Kgrd), Rust (Kgrr) and Honey Creek (Kgrhc).

Kgrb **Bulverde hydrostratigraphic unit**—Confining; fabric selective moldic and breccia (where evaporites have been removed), and bedding plane porosity; not-fabric selective fracture porosity. Thickness 30 ft. Named for the town of Bulverde, Tex.

Kgrlb **Little Blanco hydrostratigraphic unit**—Aquifer; fabric selective moldic and bedding plane porosity; not-fabric selective fracture porosity. Thickness 30 ft. Named for the Little Blanco River within study area.

Kgrts **Twin Sisters hydrostratigraphic unit**—Confining in shale beds, aquifer in patch reef areas; fabric selective interparticle porosity, and moldic porosity in patch reef areas. Thickness 30 ft. Named for the town of Twin Sisters within study area.

Kgrd **Doeppenschmidt hydrostratigraphic unit**—Aquifer; fabric selective interparticle, moldic, burrowed, bedding plane porosity; not-fabric selective fracture and cave porosity. Thickness 40 ft. Named for the Doeppenschmidt homestead within study area.

Kgrr **Rust hydrostratigraphic unit**—Confining; fabric selective interparticle porosity; not-fabric selective fracture, and cave porosity. Thickness 40 ft. Named for Rust homestead within study area.

Kgrhc **Honey Creek hydrostratigraphic unit**—Aquifer; contains fabric selective interparticle, moldic, burrow, bedding plane porosity; not-fabric selective fracture, channel, and cave porosity. Thickness 45–60 ft. Named for Honey Creek Cave.

Pearsall Formation (Lower Cretaceous, upper Aptian)—Defined by Imlay (1945), contains five members, three of which are in the mapped area (from top to bottom): Hensell Sand, Cow Creek Limestone and Hensell Shale Members.

Hensell Sand Member (Lower Cretaceous, upper Aptian)—Limestone and sandstone. Weakly cemented, claystone, siltstone, terrigenous sand. Quartz geodes and oysters common. Thickness 40 ft. Contains Hensell hydrostratigraphic unit.

Kheh **Hensell hydrostratigraphic unit**—Aquifer; upper part: fabric selective interparticle, moldic, porosity. Lower part: fabric selective moldic and shelter porosity and not-fabric selective cave porosity. Thickness 40 ft. Named for Hensell Sand Member lithostratigraphic unit.

Cow Creek Limestone Member (Lower Cretaceous, upper Aptian)—Lower 14 ft. dolomitic oyster mudstone to wackestone grades to dolomitic oyster wackestone to packestone. Upper 58 ft brown to white, very fine-grained to fine-grained carbonate sand grainstone, locally cross-bedded. Thickness about 72–80 ft. Contains Cow Creek hydrostratigraphic unit

Kcccc **Cow Creek hydrostratigraphic unit**—Aquifer; fabric selective interparticle, moldic, burrow, and bedding plane porosity; not-fabric selective fracture, vug, channel and cave porosity. Thickness about 72–80 ft.

Hammett Shale Member (Lower Cretaceous, upper Aptian)—Contains siltstone, thin dolomite, claystone, and sandstone. Lower 15 ft. contains siltstone and dolomite. Upper part is claystone with fine-grained sandstone lenses, contains fossiliferous dolomitic limestone (Lozo and Stricklin, 1956; Weirman and others, 2010). Total thickness 50 ft. (Lozo and Stricklin, 1956). Contains Hammett hydrostratigraphic unit.

Khah **Hammett hydrostratigraphic unit**—Confining unit, little porosity. Not exposed in study area. Inferred to underlie areas along the Guadalupe River and beneath Canyon Lake. Thickness 50 ft. Named for the Hammett Shale lithostratigraphic unit.

MAP EXPLANATION

Fault—Type unspecified, dashed where inferred. U, upthrown block; D, downthrown block

Fracture

Igneous dike

Contact—Between hydrostratigraphic units; dashed where inferred

Corbula bed contact—The *Corbula* sp. bed marks the boundary between the lower and upper members of the Glen Rose Limestone. This report considers the *Corbula* marker bed to be at the base of the upper member of the Glen Rose Limestone because three *Corbula* beds have been found in the study area. The marker bed is the lowest of three *Corbula* beds. The *Corbula* marker bed, which is a grainstone, averages 6 inches thick and often contains ripple marks. The overlying *Corbula* beds are thin, often less than an inch thick, and usually contain more muds. Dashed where inferred

Study boundary

Table 1. *Summary of the geologic framework and hydrostratigraphy of the Edwards and Trinity aquifers outcropping in the Anhalt, Fischer, and Spring Branch 7.5-minute quadrangles, Blanco, Comal and Kendall Counties, Texas.*

[Period, epoch, group, formation, members, and lithology modified from Hill (1901), Stricklin and others (1971), Stricklin and Smith (1973), Amsbury (1974), Inden (1974), Perkins (1974), Clark and others (2009), Wierman and others (2010), Blome and Clark (2014), Clark and others (2014); aquifers from Maclay and Small (1976), and Ashworth (1983); thicknesses from outcrop, geophysical logs, Clark and others (2009), Wierman and others (2010), and Clark and others (2014); hydrogeologic function modified from outcrop, Clark and others (2014) and Wierman and others (2010); porosity types modified from Choquette and Pray (1970) and Lucia (1995). I, interparticle porosity; SH, shelter porosity; MO, moldic porosity; BU, burrow porosity; BP, bedding plane porosity; FR, fracture porosity; CH, channel porosity; BR, breccia; VUG, vug porosity; CV, cave porosity]

Geologic framework							Hydrostratigraphy					
Period	Epoch	Group	Formation	Member	Approx. thickness (feet)	Lithology	Aquifer	Hydrostratigraphic unit (name abbreviation)	Thickness (outcrop of the study area)	Hydrogeologic function	Porosity type	Field identification
Cretaceous	Early Cretaceous	Edwards	Kainer	Basal nodular	20[1]	Shaly, nodular limestone; burrowed mudstone to *miliolid* grainstone	Edwards	VIII	60	Confining, locally water bearing	BP, FR	Massive, nodular and mottled limestone, BRBs[2] and orange wispys[3] in freshly broken rock, *Exogyra texana*
		Trinity	Glen Rose Limestone	Upper	300–390	Alternating and interfingering beds of limestone and argillaceous limestone, evaporites, mudstone to grainstone, primarily wackestone, highly burrowed, argillaceous limestones not well cemented with varying grain sizes	Upper Trinity	Cavernous (Kgrc)	0–90	Aquifer	I, M, BU, BP, VUG, FR, CH, BR, CV	Evaporites at the contact with the overlying basal nodular member of the Edwards Group; highly burrowed in the upper part, caves more numerous than underlying Trinity
						Alternating beds of limestone and argillaceous limestone; limestone primarily wackestone, some limestone packstone to grainstone; argillaceous limestone not well cemented with varying grain sizes		Camp Bullis (Kgrcb)	160–230	Confining	BR, FR	Alternating beds of limestone and argillaceous limestone, fossils rare; stair-step topography
						Dissolved evaporites, highly altered crystalline limestone and chalky mudstone, breccia; commonly contains boxwork voids where the evaporites have been dissolved		Upper evaporite Kgrue)	10	Aquifer	I, M, BR	Weathers to an orangish-red pebbly texture, often has less cedar growth and taller and more abundant grasses; boxwork structure, springs and seeps
						Alternating wackestone, packstone, clay, and mudstone; thin, silty "platy" mudstone at base, *Orbitolina minutia*, *Porocystis golobularis*, *Tapes decepta*, *Protocardia texana*, *Turritella* sp., *Hemiaster* sp., *Neithea* sp., gastropods and mollusks		Fossiliferous (Kgrf)	120	Confining	I, M, BR	Alternating beds of Limestone and marls with *Orbitolina minutia* common
						Dissolved evaporites, highly altered crystalline limestone and chalky mudstone, breccia; up to three *Corbula* sp., beds; lower *Corbula* bed up to 1 foot thick with ripples common, commonly contains boxwork voids where evaporites have been dissolved		Lower evaporite (Kgrle)	10	Aquifer	MO, VUG, BR	Weathers to an orangish-red pebbly texture, often has less cedar growth and larger grasses; boxwork structure, *Corbula* sp., springs and seeps
				Lower	225–240	Wackestone to grainstone with occasional *Monopleurids* sp. and *Toucasia* sp. Contains argillaceous wackestone, shales, and evaporite beds. Wackestone to grainstone grades upward into a bioturbated, nodular, fossiliferous wackestone named the Salenia bed. Common fossils in the Salenia bed are *Salenia texana*, *Hemiaster* sp., *Orbitolina texana* sp., *Nerinia* sp, pecten, gastropods, and pelecypods. The regionally extensive *Corbula* bed overlies the shale bed	Middle Trinity	Bulverde (Kgrb, formerly unit A)	30	Confining	BP, FR; moldic and breccia where evaporites have been removed	*Salinia texana* bed immediately below *Corbula* bed, abundant fossils including *Protocardia* sp., *Pectin* sp., *Orbitolina Texana*, *Porocystis* sp., gastropods, echinoids; grades into marls, bioturbated limestone beds, and evaporite beds.
						Mudstone to wackestone with beds of argillaceous wackestone, *Caprinid* patch reefs. Contains *Orbitolina texana*, *Monopleurids* sp., *Caprinid* sp., pecten, pelecypods, and gastropods		Little Blanco (Kgrlb; formerly unit B)	30	Aquifer	BP, FR, M (patch reef areas)	Limestone beds thicker more resistive to erosion than overlying and underlying units, *Orbiolina texana*
						Thick argillaceous wackestone, interspersed shale, thin shale beds and occasional thin wackestone beds. Often contains abundant *Orbitolina texana* with occasional pelecypods and gastropods		Twin Sisters (Kgts; formerly unit C)	30	Confining	I	Thick argillaceous wackestone beds, interspersed shale beds, *Orbitolina texana*; often contains ponds and seeps, often little vegetation, Steeper slopes often have "badlands" type weathering
						Mudstones to grainstones, some boundstone, contain *miliolid* grainstone, grainstone, nodular bioturbated wackestone, pectens, oysters, pelecypods, *Nerinia sp*., *Orbitolina texana*, *Tylostoma* sp., and *monoplurids* sp.		Doeppenschmidt (Kgrd; formerly unit D)	40	Aquifer	I, MO, BU, BP, FR, CV	*Orbitolina Texana*, limestone beds thicker and more resistive than overlying and underlying units; occasional spring/seeps at base,
						Alternating beds of argillaceous wackestone to packstone, mudstone to grainstone, miliolid grainstone, nodular bioturbated wackestone, and *monoplurids* sp.		Rust (Kgrr; formerly unit E)	50	Confining	I, FR, CV	Tends to form flat, topography with soils, *Orbitolina Texana*
						Wackestone to grainstone and boundstone, corals, pectens, *Miliolid* sp., *Caprinid* sp., *Trigonia* sp., shell fragments, pecten, *Turritella*, and oyster species		Honey Creek (Kgrhc; formerly unit F)	45–60	Aquifer	I, MO, BU, BP, FR, CH, CV	Thick beds of wackestone to grainstone; corals, *Caprinid* sp., *Trigonia* sp., cliff forming; outcrop often contains large limestone float with large channel and moldic porosity, caves and springs
			Pearsall	Hensell Sand	40–70	Upper part: nodular, fine-grained sandstone, fossil fragments, pelecypods and quartz geodes. Lower part: reddish claystone and siltstone which that contains terrigenous sand, oysters, pelecypods, and fossil fragments		Hensell (Kheh)	40	Aquifer	I, MO, SH, CV	Quartz geodes, large oyster shells; reddish sandy soil with good grass growth
				Cow Creek Limestone	58	Upper part is a brown to white very fine-grained to fine-grained carbonate sand grainstone with localized cross-bedding locally with areas of recrystallization		Cow Creek (Kcccc)	72	Aquifer	I, MO, VUG, BU, BP, FR, CH, CV	Carbonate sands, cross-bedding near top
					14	Dolomitic oyster mudstone to packstone						
				Hammett Shale	50	Upper: claystone, with sandstone lenses Lower: siltstone and dolomite	Confining unit	Hammett (Khah)	50	Confining	**	Holds water, springs

[1] caps tops of hills.
[2] black rotund bodies probably from oxidation of *foraminifera* (Small and Maclay, 1982).
[3] iron staining/oxidation
*previously published identification for the hydrostratigraphic unit.
**not aerially exposed in the study area.

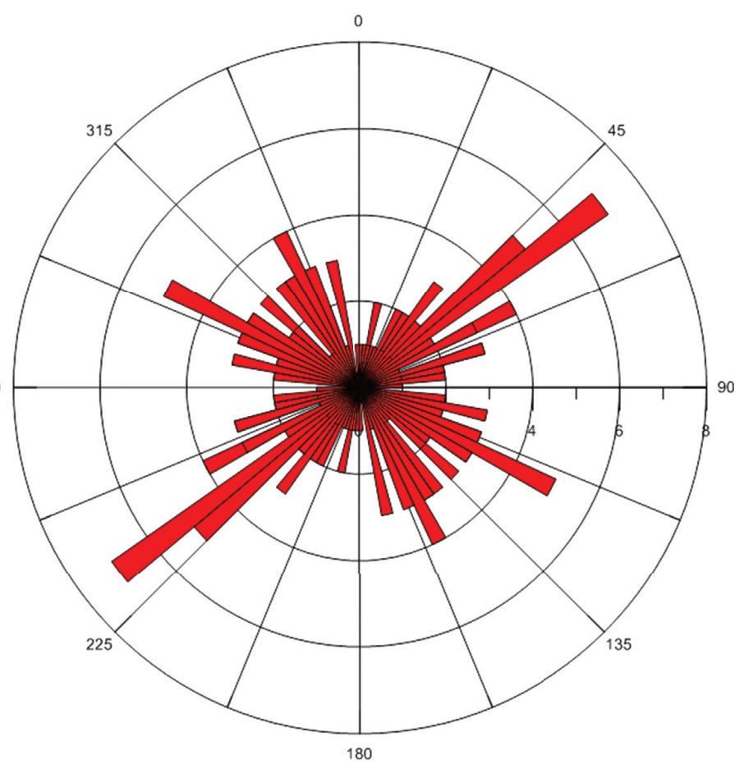


Figure 9. Rose diagram of plot of fault and fracture trends.

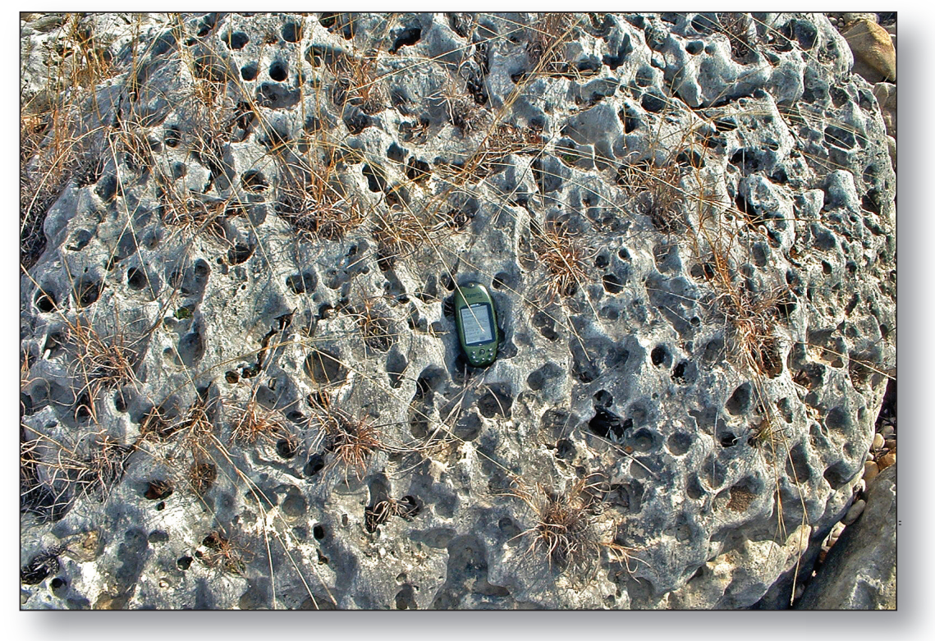


Figure 10. Moldic to channel porosity in the Honey Creek hydrostratigraphic unit, Comal County, Texas. Note handheld GPS for scale. Photograph taken September 12, 2014, by Robert Morris.

Geologic and Hydrostratigraphic Map of the Anhalt, Fischer, and Spring Branch 7.5-Minute Quadrangles, Blanco, Comal, and Kendall Counties, Texas

By

Allan K. Clark and Robert R. Morris

2015

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