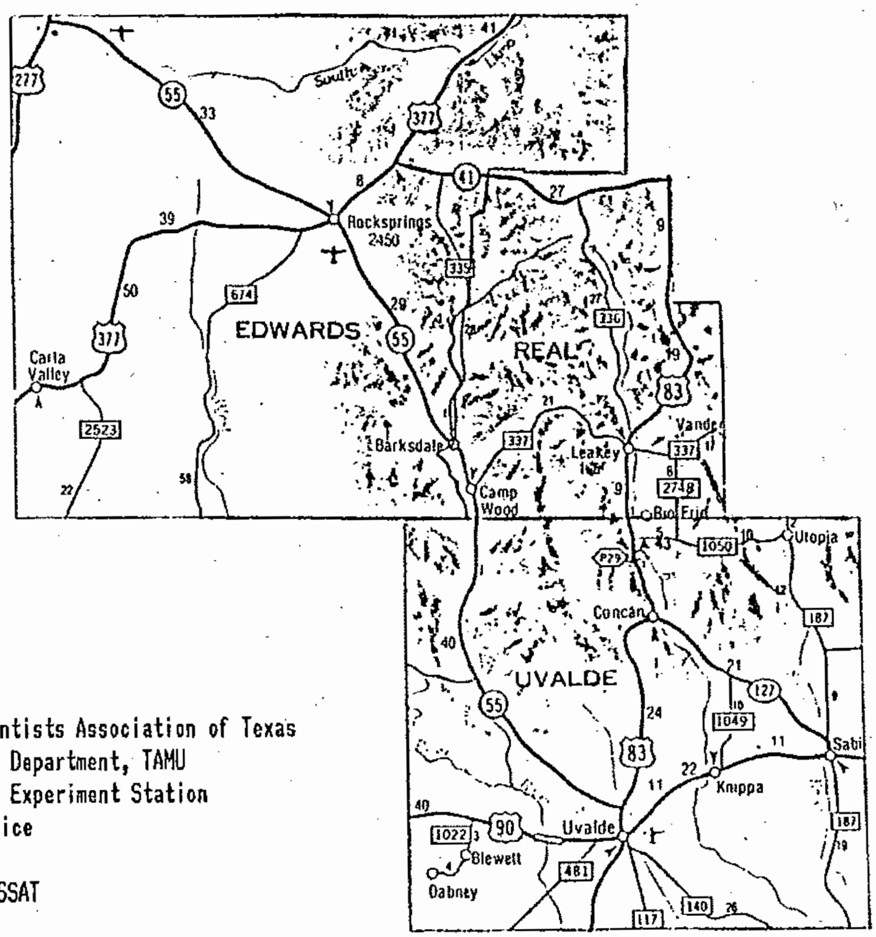
SOILS ON LATE HOLOCENE TO MID TERTIARY EROSIONAL AND DEPOSITIONAL GEOMORPHIC SURFACES IN THE CENTRAL EDWARDS PLATEAU

TOUR GUIDEBOOK



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Ninth Annual Meeting of PSSAT
Uvalde, Texas
February 14, 1991

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TOUR GUIDEBOOK

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for the

Professional Soil Scientists Association of Texas
Annual Meeting

held in

Uvalde, Texas

February 14-15, 1991

Guidebook prepared and edited by
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ACKNOWLEDGEMENTS

This field trip and guidebook are the products of several months of planning and contributions by numerous persons. Sites 1 and 2 are on the H.W. Lewis Ranch, operated and managed by Mr. Hardy Lewis. Site 4 is located on the Sidney Wells Ranch. We thank these landowners for their permission to excavate pits and examine soils on their ranches. Access to Site 3 was granted by Mr. Gary Davenport of the Texas Department of Highways and Public Transportation.

The description and data for Pedon 4 are part of the Ph.D. dissertation research of Dr. Martin Rabenhorst. Descriptions and data were published in Hallmark et al. (1986). Additional mineralogical and micromorphic data were published by Rabenhorst and Wilding (1986a,b). These data are presented courtesy of Dr. Rabenhorst, and we gratefully acknowledge his contribution. Dr. C.T. Hallmark, Texas A&M University assisted with sampling pedons 1, 2, and 3, and the Texas Agricultural Experiment Station Soil Characterization Laboratory provided quantification of physical and chemical properties. Thanks go to Dr. Hallmark and John Jacob for timely results. Discussions in the field with Michael Blum and Lee Nordt clarified concepts on alluvial stratigraphy and geomorphic surfaces. However, any errors in data interpretation are the responsibility of the editors.

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PROFESSIONAL SOIL SCIENTISTS ASSOCIATION OF TEXAS TOUR

SOILS ON LATE HOLOCENE TO MID TERTIARY AGE EROSIONAL AND DEPOSITIONAL GEOMORPHIC SURFACES IN THE CENTRAL EDWARDS PLATEAU

Thursday, February 14, 1991

9:30 am	Leave Uvalde Civic Center via chartered buses for site 1 (about 50 miles via US Highway 83 and FM 336).
10:30 am	Arrive at Site 1--Late Holocene frequently flooded low terrace (Dev taxadjunct) at H.W. Lewis Ranch.
11:45 am	Sack Lunch
12:30 pm	Board bus
12:45 pm	Arrive at Site 2--Mid Pleistocene terrace (Topia variant) at H.W. Lewis Ranch.
1:45 pm	Board bus
2:00 pm	Leave Site 2 for Site 3 (about 10 miles via FM 336, US Highway 83, and FM 337).
2:30 pm	Arrive at Site 3--Late Holocene erosional surface (Eckrant series).
3:15 pm	Board bus
3:30 pm	Drive to Site 4 (about 7 miles via FM 337).
3:45 pm	Arrive at Site 4--Mid Tertiary erosional surface (Rumple series) at Sidney Wells Ranch.
4:45 pm	Board bus
5:00 pm	Leave Site 4 enroute to Uvalde (about 54 miles via FM 337 and Texas 55).
6:00 pm	Arrive Uvalde Civic Center.

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PREFACE

Admittedly, this history of the Edwards Plateau is grossly inadequate. We are ignorant of considerable knowledge on geology, and we do not understand many geological concepts. Critical events have been omitted from this history, and the events probably did not occur in the sequence listed. Much of the discussion is pure, unadulterated speculation, without evidence for support. However, if this account stimulates discussion between soil scientists and other earth scientists, it will have served its purpose. If it prompts a search for evidence on which better soil and landscape development models may be constructed, that will be even better.

The method of multiple working hypotheses was used to test models explaining the origin of various lithologic, vegetative, geomorphic, and pedologic features observed in the Edwards Plateau (Chamberlain 1897, Platt 1964). First, observations of various phenomena are gathered. Then an attempt is made to generate all rational circumstances or mechanisms that can account for the observed phenomena (Arnold 1965, Culver and Gray 1968). The next step is to predict consequences of the hypotheses, i.e. deduce further possible 'facts' which would logically be expected to result from the reality of each hypothesis (Chorley et al. 1984). Finally, each hypothesis is tested by trying to verify the deduced 'facts' by further observation. If the deduced consequences of an hypothesis were not found to be true, the hypothesis was rejected. Tentative adoption of (=failure to reject) the hypothesis occurred after testing the consequences deduced from it and finding them to be true (Copi 1978).

GEOLOGIC HISTORY OF EDWARDS PLATEAU

CRETACEOUS EVENTS

Deposition of limestone probably occurred in warm, shallow epicontinental seas. Refer to Table 3 for the stratigraphic column and geochronologic age of various formations.

In southwestern Texas, the Edwards Group occurs in a variety of tectonic settings. Different lithostratigraphic units (formations) have been tailored to, and mapped in, each tectonic province (Lozo and Smith 1964). In the Maverick Basin Sequence, the Edwards Group has been segmented into West Nueces limestone, McKnight formation and Salmon Peak formation. The Devils River limestone is mapped over the Devils River trend along the margins of the Maverick Basin. To the east of the Maverick Basin, on the San Marcos platform, are the Person and Kainer formations. North of the Maverick Basin on the Comanche platform occur the Fort Terrett and Segovia formations. The Big Bend sequence, consisting of the Del Carmen Limestone, Sue Peaks Formation, and Santa Elena Limestone, occurs west of the Maverick Basin.

Volcanic eruptions occurred during late Cretaceous time (Welder and Reeves 1962). Ash-fall directly into Cretaceous oceans may have resulted in the silty, noncalcareous pulverulent beds observed in the Fort Terrett and Segovia formations. Bentonite (smectite?) in the Segovia, Del Rio, and Anacacho formations may have formed from subaqueous weathering of volcanic ash. Volcanic necks, formed on the resistant basalt bedrock, dominate the horizon south of the Balcones Escarpment in Uvalde and Kinney Counties. Igneous dikes occur in scattered locales along the southern margin of the Edwards Plateau.

Lowering of sea level during Cretaceous times resulted in uncomformities between lithostratigraphic units. An episode of erosion occurred after the deposition of the uppermost Segovia. The Del Rio Clay was later deposited on an eroded Segovia landscape (Rose 1972). A later erosional episode removed the Del Rio Clay from the northern Edwards Plateau prior to the deposition of the Buda Limestone. Dissolution of limestone and enlargement of primary porosity to form caverns occurred when the Segovia limestone was exposed above sea level.

TERTIARY EVENTS

Formation of Time Zero geomorphic surface of Lampasas Cut Plain in North-Central Texas (Hayward et al 1990) may have occurred during early Tertiary. Balcones faulting, the next event recorded in the rocks of the southern Edwards Plateau, occurred ~15 mya during Miocene time. Fossils derived from Edwards limestone are found in Oakville sandstone (Miocene) and younger formations on the Texas Gulf Coastal Plain (Ely 1957).

The Edwards Plateau came into existence at this time. The Carta Valley Fault Zone in Edwards and Val Verde Counties probably formed at the same time (Webster 1978). Burial of the Central and Eastern Edwards Plateau by the Ogallala Formation during Miocene and Pliocene time is considered unlikely. The Callahan Divide, a remnant of the former Edwards Plateau summit surface near Abilene, stands above the highest Ogallala sediments (Hayward et al. 1990)

The steeper gradient caused by Balcones faulting rejuvenated the existing drainage network and resulted in greater downcutting and incision of streams into the Edwards Limestone. Erosion following Balcones faulting removed the Austin Chalk from all of Edwards Plateau except for an area along the Rio Grande in Terrell and Val

Verde Counties (Waechter et al. 1977, Brown et al. 1979, McKalips et al. 1982), and subsequent dissection of plateau margin, and entrenchment of meanders at Rain Valley and Concan and on the Harding, Appfel, Brumley, and Navajo Ranches in western Edwards County.

Streams adjusted to geological structure, resulting in parallel alignment of stream segments to joints, faults, and folds (Webster 1978). Valley widening occurred after streams (Sabinal, Frio, East Nueces Rivers) cut down to Glen Rose and began lateral corrasion, undercutting of overlying "Edwards Limestones", resulting in the collapse, retreat of valley walls, and backwearing of escarpments.

The valleys of the Sabinal, Frio, Dry Frio, East Nueces, West Nueces and Devils Rivers, and Sycamore Creek probably post-date Balcones faulting (Mear 1953). At one time, the West Nueces River may have flowed southward across Kinney County into Rio Grande (Hill and Vaughan 1898a, p. 2). Later the West Nueces River flowed through the valley now containing French Creek in western Uvalde County (see Road Log). The West Nueces River was captured by a tributary of the East Nueces River that eroded northward through Salmon Peak limestone (Vaughan unpublished, as cited by Bennet and Sayre 1962). The East Nueces River at one time flowed in the channel of the present day Leona River from Uvalde south (Welder and Reeves 1962). The clayey Montell soils on alluvial plains between the present day Nueces and Leona Rivers (Stevens and Richmond 1976) may be evidence supporting this particular former stream course.

QUATERNARY EVENTS

Glacial maximum climates

During pluvial climates of the Pleistocene, more effective precipitation resulted from higher rainfall and/or cooler temperatures. Present-day analogs of Edwards Plateau Pleistocene pluvial climates may exist on limestone terranes in Alabama, Pennsylvania, Missouri, Oklahoma.

More intensive physical weathering resulted from a greater number of annual freeze-thaw cycles during colder, wetter winters. More frequent episodes of mass movement (slope failure) ensued from higher soil moisture content. More effective precipitation lead to deeper penetration of wetting fronts and deeper weathering and pedogenesis.

Chemical weathering was also more intense during pluvial climates. Greater dissolution of limestone and leaching of soluble materials resulted more acidic soil reaction. The elevation of groundwater table was higher except near springs. More effective rainfall resulted in more abundant seeps and springs, higher stream base flow, and more numerous perennial stream segments, and dense vegetation in riparian areas. Depending on the frequency of high intensity storms, the bedload in streams may have been coarser than that of present day climates. Rounded landforms resulted from the cover of residuum on bedrock.

Higher vegetative cover helped retain soil in place on steep hillslopes. Plant species characteristic of cooler climates occupied habitats in the Edwards Plateau during Pleistocene. Species such as maple (*Acer grandidentatum*), Texas madrone (*Arbutus xalapensis*), and pinion pine (*Pinus remota*) may be remnants of plant communities that were much more extensive during pluvial climates.

Interglacial stage climates

With the desiccation of climate during interglacial stages, vegetative cover on steep slopes was lost. More xeric plants and plant communities became established. High intensity storms, which may be relatively more frequent and more erosive in drier climates, may have initiated erosion of the deeper soil mantle from the watersheds. Angular landforms resulted from the expression of hard bedrock on slope geometry.

The drier climate associated with interglacial stages lead to slower physical and chemical weathering of limestone bedrock, slower soil formation, a lowering in elevation of the water table, fewer springs, lower base streamflow, fewer perennial streams, and downcutting of stream channels.

Streams debouching onto the Rio Grande Plain south of Balcones Escarpment deposited Uvalde Gravels (limestone and chert), perhaps as alluvial fans. Remnant Pliocene(?) fluvial terraces and sediments in valleys occur only at higher elevations where streams, after further entrenchment, were unable to remove them.

The deposition of younger alluvial deposits within the re-entrant valleys of the Edwards Plateau may correspond with the deposition of alluvial plains at the northern and southern margins of the plateau (Mear 1953). Therefore, relationships between soils on different alluvial terraces in the Frio and Sabinal Canyons may shed light on the formation of Calciustolls such as Angelo (in the Concho Valley), and Knippa, Uvalde, Castroville, Acuna, and Elindio soils in Val Verde, Kinney, Uvalde, Medina, Maverick, and Dimmit Counties.

GENESIS OF DEV

Genesis of the Dev soil began with the deposition of gravelly and cobbly alluvium by fast-flowing streams draining steep watersheds mantled by Lithic Haplustolls and Lithic Calciustolls. The fining upward sequence was completed by deposition of dark-colored loamy (gravelly and cobbly) sediments derived from grass covered hillslopes (Mollisols) in the watershed.

We believe the age of this surface is Late Holocene. Insufficient time has passed for significant weathering of the limestone skeleton, or pedogenesis in the fine earth of Dev soils. Minimal differentiation, limited to the formation of carbonate filaments, has occurred. The difference between Eckrant and Topia soils, and between Dev and Topia soils may simply result from the great difference in time that the parent materials have been exposed to weathering. With time on a stable geomorphic surface, the limestone in the Eckrant and Dev soils may completely weather away, leaving a residual concentration of smectitic (and kaolinitic?) clay minerals.

USDA - Soil Conservation Service
Pedon Narrative Description
Dec 19, 1990

Soils Series: Dev taxadjunct
Soil Survey # S90-TX-385-002
Survey Area ID: 607
Map Unit Symbol: 84AB
Photo Number: 109
Description Type: full pedon description
Pedon Type: Modal pedon for series
Geographically Associated Soils: Oakalla, Orif
Location: From junction of US 83 and FM 337 in Leakey, 1.05 mile N on US 83 to junction with FM 336, 4.4 miles N on FM 336 to junction with ranch road, 0.35 mile E on ranch road, 50 feet N in rangeland.
Latitude: 29-47-39-N
Longitude: 099-46-30-W
Classification: loamy-skeletal over fragmental, carbonatic, thermic Cumulic Haplustoll
Physiography: Flood Plain in River Valley
Elevation: 1670 ft MSL
Precipitation: 27 in. ustic moisture regime
MLRA: 81B
Hydraulic Conductivity: moderately high
Air Temperature: Ann 64 F Sum 80 F Win 48 F
Drainage Class: well drained
Land Use: rangeland grazed
Particle Size Control Section: 10 to 40 in.
Parent Material: alluvium from limestone-cherty material
Vegetation Code(s): QUVI, JUAS, BETR
Diagnostic Horizons: 0 to 37 in. mollic
Described By: Wayne J. Gabriel, Lynn E. Loomis
Date: 07/90
Notes: Apparent variation in color among A horizons results from differing concentrations of very pale brown (10YR 7/3) limestone rock fragments; About 10% of rock fragments are chert. Most chert fragments are pebbles. Sand at 66 inches was wet indicating proximity to an apparent water table. Vegetation includes Live oak, cedar, agarito, mountain laurel, Arizona walnut, persimmon, threeawn, fall witchgrass, purple tridens, hairy tridens, Neally grama, windmillgrass, Canada wildrye, red lovegrass, prairie coneflower, frostweed, croton, sida, evax, verbena, and senna.

Soils Series: Dev taxadjunct
Described By: Wayne J. Gabriel, Lynn E. Loomis
Date: 07/90

A--0 to 6 inches; dark grayish brown (10YR 4/2) very gravelly loam; very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure parting to weak very fine granular; slightly hard, very friable, slightly sticky, slightly plastic; many very fine and fine roots, and few medium roots; many very fine and fine tubular pores; many earthworm krotovinas filled with earthworm casts; violently effervescent (HCl, 1 normal); 40% pebbles limestone; 10% cobbles limestone; abrupt smooth boundary.

Ab1--6 to 9.5 inches; dark grayish brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure parting to weak very fine granular; slightly hard, very friable, slightly sticky, slightly plastic; common very fine and fine roots, and few medium roots; few very fine and fine tubular, and medium tubular pores; common earthworm krotovinas; few charcoal fragments; violently effervescent (HCl, 1 normal); 2% pebbles limestone; clear smooth boundary.

Ab2--9.5 to 37 inches; dark grayish brown (10YR 4/2) very gravelly sandy loam; very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure parting to weak very fine granular; slightly hard, very friable, slightly sticky, slightly plastic; common very fine and fine roots, and few medium roots; common very fine and fine tubular, and medium and coarse pores; common earthworm krotovinas and chambers; violently effervescent (HCl, 1 normal); 30% pebbles limestone; 20% cobbles limestone; clear wavy boundary.

C1--37 to 52 inches; light yellowish brown (10YR 6/4) extremely gravelly sand; yellowish brown (10YR 5/4) moist; single grain; loose, loose, non sticky, non plastic; few very fine and fine roots; common very fine and fine interstitial, and medium and coarse interstitial pores; a few vertical streaks of A material within interstitial pores in upper part of horizon; there is not enough fine earth to fill the interstices larger than 1 mm between coarse fragments; violently effervescent (HCl, 1 normal); 60% pebbles limestone; 30% cobbles limestone; 5% stones limestone; abrupt wavy boundary.

C2--52 to 62 inches; pale brown (10YR 6/3) very gravelly sandy loam; brown (10YR 5/3) moist; massive; slightly sticky, slightly plastic; few very fine and fine roots; few fine tubular pores; violently effervescent (HCl, 1 normal); 20% pebbles limestone; 13% cobbles limestone; 3% stones limestone; abrupt wavy boundary.

C3--62 to 66 inches; pale brown (10YR 6/3) extremely cobbly sand; brown (10YR 5/3) moist; single grain; loose, loose, non sticky, non plastic; few very fine and fine roots; common very fine and fine interstitial, and medium and coarse interstitial pores; there is not enough fine earth to fill the interstices larger than 1 mm between coarse fragments; violently effervescent (HCl, 1 normal); 43% pebbles limestone; 47% cobbles limestone.

CLASSIFICATION

The A, Ab1, and Ab2 horizons meet the color and organic carbon requirements for a mollic epipedon. No other diagnostic horizons are recognized. The mollic epipedon is more than 50 centimeters thick. The decrease in organic carbon from the Ab2 to the C1 horizon is irregular, because it is so abrupt. The irregular decrease in organic carbon between the C1, C2, and C3 is probably not significant. The C1 horizon has enough fine earth to determine soil texture, but most of the interstices between coarse fragments larger than 1 mm are not filled with fine earth. The upper part of the 10 to 40 inch (25 to 100 cm) control section from 10 to 37 inches (25 to 94 cm, Ab2 horizon) has a loamy skeletal particle size class, and the lower part from 37 to 40 inches (94 to 100 cm, C1 horizon) has a fragmental particle size class. The minerology is carbonatic with calcium carbonate equivalent in all parts of the control section in excess of 77 percent.

The pedon description and data support the classification of this pedon as loamy-skeletal over fragmental, carbonatic, thermic Cumulic Haplustoll. The polypedon this pedon represents is a taxadjunct to the Dev Series. The Dev series is presently classified as a loamy-skeletal, carbonatic, thermic Cumulic Haplustoll.

SOIL CHARACTERIZATION LABORATORY
SOIL AND CROP SCIENCES DEPT., THE TEXAS AGRICULTURAL EXPERIMENT STATION

SOIL SERIES: DEV TAXADJUNCT
SOIL FAMILY: LOAMY SKELETAL OVER FRAGMENTAL, CARBONATIC, THERMIC CUMULIC HAPLUSTOLL
LOCATION: REAL COUNTY, TEXAS

PEDON NUMBER: S90TX-385-002

LAB NO	DEPTH (CM)	HORIZON	PARTICLE SIZE DISTRIBUTION (MM) — SAND — VC (2.0-1.0)	C (1.0-0.5)	M (0.5-0.25)	F (0.25-0.10)	VF (0.10-0.05)	TOTAL (2.0-0.05)	SILT — FINE (0.02-0.002)	TOTAL (0.05-0.002)	CLAY — FINE (< 0.0002)	TOTAL (< 0.002)	TEXTURE CLASS	COARSE FRAG-MENTS %
			%											
4239	0- 15	A	5.9	9.0	8.8	8.5	6.7	38.9	26.8	42.2	4.9	18.9	L	6
4240	15- 24	AB1	2.6	5.5	12.0	16.0	9.6	45.7	22.8	33.6	8.0	20.7	L	5
4241	24- 94	AB2	15.1	17.6	14.8	11.3	5.2	64.0	18.2	22.6	5.5	13.4	COSL	8
4242	94-132	C1	51.3	27.0	6.0	1.8	0.8	86.9	7.5	8.3	1.8	4.8	LCOS	9
4243	132-157	C2	12.7	14.9	21.6	14.5	5.1	68.8	15.9	19.6	4.9	11.6	COSL	9
4244	157-168	C3	58.8	21.3	5.8	1.5	0.7	88.1	6.6	7.2	2.1	4.7	COS	9

LAB NO	ORGN C %	PH (H2O) 1:1	NH4OAC EXTR BASES — CA	MG	NA	K	TOTAL	KCL EXTR AL	NAOAC CEC	ECEC	BASE SAT	ESP	SAR	CAL-CITE	DOLO-MITE	CACO3 EQ	GYP SUM
			MEQ/100G								----%---			---%---			
4239	3.54	7.7	73.4	2.4	0.1	0.8	76.7		25.1		100	0		57.8	1.1	59.0	
4240	1.57	7.9	76.6	2.3	0.2	0.3	79.4		19.6		100	1		63.7	2.5	66.5	
4241	0.65	7.9	61.1	1.8	0.1	0.2	63.2		11.2		100	1		77.7	1.5	79.4	
4242	0.07	8.3	55.0	0.8	0.1	0.1	56.0		3.3		100	3		89.0	0.0	89.0	
4243	0.02	8.0	61.1	1.7	0.1	0.2	63.2		6.3		100	2		86.1	0.0	86.1	
4244	0.03	8.5	53.5	0.7	0.1	0.4	54.7		3.1		100	3		89.3	0.0	89.3	

LAB NO	SATURATED PASTE EXTRACT — ELEC COND MMHOS/CM	H2O CONT %	CA	MG	NA	K	CO3	HCO3	CL	SO4	BULK DEN 0.33 BAR	AIR DRY	COLE	WATER CONTENT 0.10 BAR	0.33 BAR	15 BAR
			MEQ/L								---G/CC--		CM/CM	------WT%------		
4239																
4240											1.40	1.41	0.002		24.3	
4241															30.2	
4242																
4243																
4244																

LAB NO	PARTICLE SIZE DISTRIBUTION (CLAY-FREE BASIS) — SAND — VCS	C	M	F	VF	TOTAL	SILT — C	F	TOTAL	RATIOS — S/SI	FSI/CSI	VFS/FS	FC/TC	CEC/CLAY
	%													
4239	7.3	11.1	10.9	10.5	8.3	48.0	19.0	33.0	52.0	0.9	1.7	0.8	0.3	1.33
4240	3.3	6.9	15.1	20.2	12.1	57.6	13.6	28.8	42.4	1.4	2.1	0.6	0.4	0.94
4241	17.4	20.3	17.1	13.0	6.0	73.9	5.1	21.0	26.1	2.8	4.1	0.5	0.4	0.83
4242	53.9	28.4	6.3	1.9	0.8	91.3	0.8	7.9	8.7	10.5	9.9	0.4	0.4	0.69
4243	14.4	16.9	24.4	16.4	5.8	77.8	4.2	18.0	22.2	3.5	4.3	0.4	0.4	0.55
4244	61.7	22.4	6.1	1.6	0.7	92.4	0.7	6.9	7.6	12.2	9.9	0.4	0.4	0.66

GENESIS OF TOPIA

Genesis of the Topia soil began with the aggradation of Frio River Canyon and Cedar Creek with at least 30 feet of cobbly and stony alluvium. The sedimentation apparently was episodic, as evidenced by at least 2 buried paleosols and 3 caliche cemented conglomerate layers observed in Cedar Creek stream cut.

The gravel may have been plugged and cemented with carbonates by one of several processes. Perhaps travertine plugged the gravels when the water table was at higher elevation (Mear 1953). When the travertine dried, it hardened to form a petrocalcic horizon.

Alternatively, the Desert Project model of petrocalcic horizon formation may have taken place (Gile et al. 1981). Calcium carbonate from illuvial horizons is dissolved by infiltrating rainfall. Calcium and bicarbonate ions in solution are transported as deep as the wetting front penetrates, and precipitate on the lower surface of rock fragments as soil moisture evaporates or is transpired.

A third mode of petrocalcic horizon formation is dissolution and reprecipitation of <2mm carbonates *in situ*. After numerous wetting and drying cycles, gravelly alluvium could by cemented by the fine earth constituents in interstitial voids (C2 horizon of Dev soil).

Solution facetting (Mear 1953) of limestone pebbles and cobbles at top of the petrocalcic horizon could have occurred at any time during the pedogenesis of the Topia soil.

Aggradation of the Rain Valley meander with skeletal sediments predated cutoff because cemented gravels (conglomerate) can be observed along the margins of Rain Valley. Based on the width of the Rain Valley meander cutoff gap, the cutoff is estimated to have occurred in Mid Pleistocene, if not earlier. Alluvial fans debouching from side valleys have partially filled Rain Valley since cutoff.

The Topia soil may have formed in the residue of a degrading petrocalcic horizon. Alternatively, the Topia soil may have developed in sediments deposited over the caliche-cemented conglomerate with the nature of the sediments depending on the source area and stream flow regime. The Topia soil may have formed in pre-weathered alluvium derived from Rumple and Comfort soils on summit surfaces. In this case, little additional weathering would have been necessary to produce the Topia soil. Alternately, the parent material may have been alluvium similar to the parent material for the Krum soils on younger terraces. Weathering in this kind of alluvium would consist of leaching carbonates and weathering (dissolution) of limestone lithoclasts contained in finer overbank sediments. In this case, the Topia soil is the residual concentration of smectitic (and kaolinitic?) clay and chert fragments.

Incision of Frio River and Cedar Creek into cemented gravelly conglomerate occurred during a period of high stream flow but low sediment supply. Gullies in the high terrace prevent runoff originating on the adjoining steep slopes from spreading across the terrace that would recharge the Topia soil with carbonates.

Continual high vegetative production, a reflection of the high available moisture holding capacity of the Topia soil, contributed high amounts of organic residues to the soil, resulting in organic darkening to depth of 21 inches.

In alluvial sediments derived from the Edwards Plateau, we believe calcic horizons form primarily by the dissolution and reprecipitation of limestone lithoclasts (fragments) *in situ*. Secondarily, calcic horizons form by the dissolution and transport of carbonates from eluvial horizons to illuvial horizons, followed by precipitation around nucleation centers (to form nodules and concretions) and root channels (to form filaments). We believe the Topia soil has been leached enough that limestone lithoclasts once present in the upper part of the solum have been completely dissolved away.

Carbonate nodules described in soils on the Edwards Plateau may represent limestone lithoclasts with a weathering rind on the exterior. Only the weathering rind consists of secondary carbonates, and only the weathered portion of the fragment can count toward the 5% visible secondary forms required for calcic horizons (Soil Survey Staff 1990). Calcic horizons in areas with ustic soil moisture regimes may be relict from a former climate that was more arid.

USDA - Soil Conservation Service
Pedon Narrative Description
Dec 22, 1990

Soils Series: Topia variant
Soil Survey # S90-TX-385-001
Survey Area ID: 607
Map Unit Symbol: 26AC
Photo Number: 100
Description Type: full pedon description
Pedon Type: Modal pedon for series
Location: From junction of US 83 and FM 337 in Leakey, 1.05 mile N on US 83 to junction with FM 336, 4.85 miles N on FM 336 to junction with Cedar Creek Road, 0.5 mile W on Cedar Creek Road to bump gate, 300 feet S along fenceline to bluff, (at top of bluff) 90 feet south, 180 feet W in rangeland.
Latitude: 29-47-30-N
Longitude: 099-47-30-W
Classification: very-fine, montmorillonitic, thermic Typic Chromustert
Physiography: Fluvial Terrace in River Valley
Elevation: 1680 ft MSL
Precipitation: 27 in. ustic moisture regime
MLRA: 81B
Hydraulic Conductivity: very low
Air Temperature: Ann 64 F Sum 80 F Win 48 F
Drainage Class: well drained
Land Use: rangeland grazed
Particle Size Control Section: 10 to 34 in.
Parent Material: alluvium from limestone material
Vegetation Code(s): QUVI, JUAS, DITE, STLE, HIBE, BOHI, ER
Diagnostic Horizons: 0 to 21 in. mollic, 21 to 34 in. cambic, 34 to 45 in. petrocalcic
Described By: Wayne J. Gabriel, Lynn E. Loomis
Date: 07/90

A1--0 to 3 inches; dark grayish brown (10YR 4/2) silty clay loam; very dark grayish brown (10YR 3/2) moist; weak medium and coarse platy structure parting to weak very fine and fine subangular blocky; slightly hard, very friable, slightly sticky, moderately plastic; many very fine and fine roots, and few medium and coarse roots; few very fine tubular pores; neutral (pH 7.0); 1% cobbles chert; abrupt smooth boundary.

A2--3 to 8 inches; very dark gray (10YR 3/1) clay; black (10YR 2/1) moist; moderate very fine and fine subangular blocky structure; hard, friable, moderately sticky, moderately plastic; common very fine and fine roots, and few medium and coarse roots; few very fine tubular pores; few medium worm casts; neutral (pH 7.0); 3% cobbles chert; 1% pebbles chert; clear wavy boundary.

Bw/A--8 to 15 inches; 75% brown to dark brown (7.5YR 4/2), and 25% very dark gray (10YR 3/1) clay; 75% dark brown (7.5YR 3/2), and 25% black (10YR 2/1) moist; moderate medium angular blocky structure; very hard, firm, moderately sticky, very plastic; common very fine and fine roots, and few medium and coarse roots; few very fine tubular pores; very dark gray (10YR 3/1) clay (A) occurs mainly as vertical streaks on faces of prisms; few distinct continuous pressure faces on vertical and horizontal faces of peds; few medium worm casts; neutral (pH 6.4); 3% cobbles chert; 1% pebbles chert; clear wavy boundary.

Bwss/A--15 to 21 inches; 65% reddish brown (5YR 4/3), 25% dark red (2.5YR 3/6), and 10% very dark gray (10YR 3/1) clay; 65% dark reddish brown (5YR 3/3), 25% dark red (2.5YR 3/6), and 10% black (10YR 2/1) moist; moderate medium angular blocky structure; very hard, very firm, moderately sticky, very plastic; common very fine and fine roots, and few medium and coarse roots; few very fine tubular pores; slickensides are concentrated in reddish brown (5YR 4/3) material; slickensides are 5 to 100 cm2 in size; very dark gray (10YR 3/1) clay (A) occurs mainly as vertical streaks; few distinct continuous pressure faces on vertical and horizontal faces of peds, and few prominent intersecting slickensides; neutral (pH 6.4); 3% cobbles chert; 2% pebbles chert; abrupt wavy boundary.

Bw--21 to 34 inches; 15% dark red (2.5YR 3/6), 10% reddish brown (5YR 4/3), and 75% reddish brown (5YR 4/4) clay; 15% dark red (2.5YR 3/6), 10% dark reddish brown (5YR 3/3), and 75% dark reddish brown (5YR 3/4) moist; moderate very fine angular blocky structure; hard, firm, moderately sticky, moderately plastic; common very fine and fine roots matted around stones, and common very fine and fine roots throughout, and few medium and coarse roots; dark red (2.5YR 3/6) clay bodies in upper 3 inches are noneffervescent; reddish brown (5YR 4/3) material occurs in 1 inch thick band at the upper boundary, and is very slightly effervescent; rock fragments appear to be remnants of a degrading petrocalcic horizon; rock fragments are strongly cemented and strongly effervescent (HCL, 1 normal) continuous; few distinct continuous pressure faces on vertical and horizontal faces of peds; mildly alkaline (pH 7.6); 25% pebbles conglomerate-calcareous; 15% cobbles conglomerate-calcareous; 15% stones conglomerate-calcareous; abrupt wavy boundary.

Bkm1--34 to 36 inches; 40% light brownish gray (10YR 6/2), 24% pinkish white (5YR 8/2), and 36% reddish yellow (5YR 7/6) very gravelly strongly cemented caliche; 40% light brownish gray (10YR 6/2), 24% pinkish white (5YR 8/2), and 36% reddish yellow (5YR 6/6) moist; strongly cemented by lime; the petrocalcic has a light brownish gray laminar cap about 2 cm thick; the limestone fragments in the petrocalcic are pinkish white; the strongly cemented caliche is reddish yellow; strongly effervescent (HCl, 1 normal) continuous; moderately alkaline (pH 8.1); 25% cobbles limestone; 15% pebbles limestone; clear wavy boundary.

Bkm2--36 to 45 inches; 55% pinkish white (5YR 8/2), and 45% reddish yellow (5YR 7/6) very gravelly weakly cemented caliche; 55% pinkish white (5YR 8/2), and 45% reddish yellow (5YR 7/6) moist; massive; very hard, firm, weakly cemented by lime; the limestone fragments in the petrocalcic horizon are pinkish white; the weakly cemented caliche is reddish yellow; strongly effervescent (HCl, 1 normal) continuous; moderately alkaline (pH 8.1); 22% pebbles limestone; 33% cobbles limestone.

CLASSIFICATION

The A1 through Bwss/A horizons meet the color and organic carbon requirements for a mollic epipedon. The Bw horizon meets the requirement for a cambic horizon. A petrocalcic horizon is recognized between 34 and 45 inches (86 and 114 cm, Bkm horizons). The mollic epipedon is more than 50 centimeters thick. The decrease in organic carbon is regular.

The upper surface of the petrocalcic horizon is more than 20 inches (50 cm) deep. The Topia soil has more then 30% clay in horizons extending down to a depth of 20 inches (50 cm). Cracks up to 1 inch at the surface are evident when the soil is dry, and we assume they are more than 1 cm wide at a depth of 20 inches. One of Wes Miller's Crackometers is needed to determine if cracks are 1 cm wide at a depth of 20 inches (50 cm). Intersecting slickensides were observed in the Bwss/A horizon.

The particle size class of the 10 to 34 inch (25 to 86 cm, Bw horizons) control section is very-fine. If the carbonate clay content of the Bw horizon is more than about 8 percent, than the particle size class is fine. Carbonate clay content is not available to answer this question. The minerology is montmorillonitic with more than 50 percent smectite.

The pedon description and data support the classification of this pedon as a very-fine, montmorillonitic, thermic Typic Chromustert. The polypedon this pedon represents is a variant of the Topia Series. The Topia series is presently classified as a very-fine, mixed, thermic Vertic Argiustoll. The proposed ICOMERT classification of this pedon is a very-fine, montmorillonitic, thermic, Petrocalcic Calciustert.

The pedon fits the concept of the Anhalt Series, very-fine, montmorillonitic, thermic Udic Chromustert, except for the presence of a petrocalcic horizon in place of limestone bedrock. Also the soil moisture regime here may be typic ustic rather than udic ustic. Most of the Anhalt and Topia correlated in the Central Edwards Plateau, appear to be mapped on high stream terraces over a petrocalcic horizon. The petrocalcic horizons appear to be degrading with solution-facetted limestone fragments embedded on the upper surface. In the Topia and Anhalt soils, the petrocalcic horizons can easily be mistaken for hard bedrock. Further study of these series is needed.

SOIL CHARACTERIZATION LABORATORY
SOIL AND CROP SCIENCES DEPT., THE TEXAS AGRICULTURAL EXPERIMENT STATION

SOIL SERIES: TOPIA VARIANT
SOIL FAMILY: VERY-FINE, MONTMORILLONITIC, THERMIC TYPIC CHROMUSTERT
LOCATION: REAL COUNTY, TEXAS

PEDON NUMBER: S90TX-385-001

PARTICLE SIZE DISTRIBUTION (MM)

LAB NO	DEPTH (CM)	HORIZON	SAND VC (2.0-1.0)	SAND C (1.0-0.5)	SAND M (0.5-0.25)	SAND F (0.25-0.10)	SAND VF (0.10-0.05)	SAND TOTAL (2.0-0.05)	SILT FINE (0.02-0.002)	SILT TOTAL (0.05-0.002)	CLAY FINE (< 0.0002)	CLAY TOTAL (< 0.002)	TEXTURE CLASS	COARSE FRAGMENTS %
			------------					-%-						
4233	0- 8	A1	0.3	0.4	0.6	1.1	3.8	6.2	40.3	63.6	8.4	30.2	SICL	10
4234	8- 20	A2	0.4	0.6	0.6	1.0	3.3	5.9	29.9	45.0	26.8	49.1	SIC	3
4235	20- 38	BW/A	0.9	0.4	0.5	0.9	3.2	5.9	23.8	34.7	38.7	59.4	C	13
4236	38- 53	BWSS/A	0.7	0.7	0.5	1.0	2.4	5.3	19.4	26.4	36.0	68.3	C	3
4237	53- 86	BW	10.9	4.8	2.2	1.8	2.1	21.8	15.7	18.1	24.7	60.1	C	7
4255	86- 91	BKM1												
4238	91-114	BKM2	8.6	14.4	16.2	13.9	7.9	61.0	19.8	25.0	5.3	14.0	SL	4

LAB NO	ORGN C %	PH (H2O) 1:1	NH4OAC EXTR BASES CA	MG	NA	K	TOTAL	KCL EXTR AL	NAOAC CEC	ECEC	BASE SAT %	ESP %	SAR	CALCITE %	DOLOMITE %	CACO3 EQ %	GYPSUM %
			MEQ/100G														
4233	3.88	6.4	38.0	3.4	0.1	1.6	43.2		37.8		100	0	0	0.5	0.0	0.5	
4234	2.44	6.7	42.2	2.5	0.1	1.3	46.1		44.5		100	0	0	0.5	0.1	0.6	
4235	1.53	6.9	42.3	2.3	0.2	1.1	46.0		46.4		99	0	0	0.4	0.0	0.4	
4236	1.22	7.3	53.1	2.3	0.2	1.2	56.8		48.6		100	0	0	0.7	0.0	0.7	
4237	1.27	7.7	92.5	2.3	0.2	1.0	96.0		47.7		100	0	0	24.9	0.2	25.1	
4255	0.04													89.3	0.1	89.4	
4238	0.44	8.0	68.9	0.4	0.1	0.2	69.6		6.7		100	2		87.8	1.6	89.5	

LAB NO	SATURATED PASTE EXTRACT ELEC COND MMHOS/CM	H2O CONT %	CA	MG	NA	K	CO3	HCO3	CL	SO4	BULK DEN 0.33 BAR G/CC	BULK DEN AIR DRY G/CC	COLE CM/CM	WATER CONTENT 0.10 BAR WT%	0.33 BAR WT%	15 BAR WT%
			MEQ/L													
4233	0.7	85	5.5	1.1	0.2	0.4					1.10	1.19	0.027		38.2	
4234	0.7	83	7.5	0.7	0.3	0.2					1.18	1.40	0.059		37.7	
4235	0.3	101	3.5	0.2	0.2	0.1					1.31	1.65	0.080		33.0	
4236	0.3	110	3.3	0.2	0.3	0.0					1.28	1.63	0.084		31.1	
4237	0.6	91	5.5	0.2	0.4	0.0										
4255																
4238																

PARTICLE SIZE DISTRIBUTION (CLAY-FREE BASIS)

LAB NO	SAND VCS	C	M	F	VF	TOTAL	SILT C	F	TOTAL	RATIOS S/SI	FSI/CSI	VFS/FS	FC/TC	CEC/CLAY
	-%													
4233	0.4	0.6	0.9	1.6	5.4	8.9	33.4	57.7	91.1	0.1	1.7	3.4	0.3	1.25
4234	0.8	1.2	1.2	2.0	6.5	11.6	29.7	58.7	88.4	0.1	2.0	3.3	0.5	0.91
4235	2.2	1.0	1.2	2.2	7.9	14.5	26.9	58.6	85.5	0.2	2.2	3.6	0.7	0.78
4236	2.2	2.2	1.6	3.2	7.6	16.7	22.1	61.2	83.3	0.2	2.8	2.4	0.5	0.71
4237	27.3	12.0	5.5	4.5	5.3	54.6	6.1	39.3	45.4	1.2	6.4	1.2	0.4	0.79
4238	10.0	16.7	18.8	16.2	9.2	70.9	6.1	23.0	29.1	2.4	3.8	0.6	0.4	0.48

LAB NO	CLAY MINERALOGY SM	VR	MI	IN	KK	GI	QZ	FD	CA	SKELETAL MINERALOGY QZ	FD	CA
4234	***		*		**		*					
4236	***		*		**		*					

SM=SMECTITE VR=VERMICULITE MI=MICA IN=INTERSTRATIFIED
KK=KAOLINITE GI=GIBBSITE QZ=QUARTZ FD=FELDSPAR CA=CALCITE
T=TRACE *=0-10% **=10-50% ***=GREATER THAN 50%

GENESIS OF RUMPLE

A gently undulating plain formed (Mid Tertiary [Time Zero geomorphic surface of Hayward et al. 1990] or Mid Pleistocene). Possibly the land surface weathered and was lowered down to an exceptionally resistant (cherty or siliceous?) limestone bed. This geomorphic surface was at one time much more extensive, perhaps covering most of the Edwards Plateau. Remnants occur on summit surface landforms from northwestern Bandera County and southwestern Kerr County across Real County into southeastern Edwards County.

Dissection of Plateau margin after Balcones faulting stripped the precursors to the Rumple and Comfort soils from most of the Edwards Plateau landscape. Rumple and Comfort soils currently occur on stable, remnant summit surfaces, and on strath terraces that have been exposed to weathering for long periods of time. A strath terrace has been defined as an erosional stream terrace surface cut on bedrock and thinly mantled with (stream deposits) alluvium (Hawley and Parsons 1980).

The parent material of Rumple soil may have formed from weathering of the Orr Ranch Bed (Rose 1972) of the Segovia Formation, or similar oxidized pulverulent limestone beds. Originally, the limestone bed may have had abundant pyrite, which upon oxidation, yielded iron oxides to impart a reddish hue to residuum, and sulfuric acid. The sulfuric acid then neutralized free carbonates and formed gypsum, which was then leached by percolating groundwater, leaving the material noncalcareous.

The stable geomorphic surfaces have undergone weathering and pedogenesis (leaching) since exposure during Mid Pleistocene or, perhaps Miocene. The Rumple soil has experienced a loss of carbonate constituents, oxidation of iron, and residual concentration of resistant mineral constituents. Development of pedological features included clay illuviation which resulted in clay coats on ped surfaces and rock fragments, periodic reduction and oxidation cycles which lead to the segregation of iron oxides. Long-term additions of organic residues resulted in relatively high organic carbon contents down to the lithic contact.

Young (in Abbott and Wermund 1986) states that the age of formation of Central Texas Terra Rossa is between 0.73 and 2 m.y. B.P. These dates are based on paleomagnetic and paleoecologic data of some cave deposits in Travis County. Lithic Argiustolls (Speck series) are mapped on the Callahan Divide in Nolan and Taylor Counties of north-central Texas. Hayward et al. (1990) inferred a late Miocene to early Pliocene age for the Callahan Divide. Is it reasonable to hypothesize a Mid Tertiary age for geomorphic surfaces in the Edwards Plateau on which Lithic Argiustolls occur?

CLASSIFICATION

A mollic epepedon is recognized at 0 to 14 inches (0 to 35 cm). Dr. Martin Rabenhort, one of the original describers of this pedon, told us that the pedon was described and sampled late in the day and the description had to be completed with headlights. In the pedon description he noted that the only feature that made this pedon a variant of the Rumple series was the absence of a mollic epipedon. A mollic epepedon in soils with the base of an argillic horizon more than 29.5 inches (75 cm) must be more than 10 inches (25 cm) thick. In January 1991 on a field review of the Edwards and Real Counties Soil Survey, we exhumed the former profile and read the color of the Bt1 horizon. Four soil scientists on the review agreed that the moist color in full sun was reddish brown (5YR 3/3).

An argillic horizon is at 8 to 31 inches (20 to 80 cm). The particle size control section is 8 to 28 inches (20 to 71 cm). The minerology is montmorillonitic (more smectite than any other clay mineral).

Assuming that the soil is dry less than 40% of the days when the soil temperature exceeds 5°C at a depth of 20 inches (50 cm) the soil moisture regime is wet ustic (udic ustic). The revised pedon description and data support the classification of this pedon as the Rumple Series, clayey-skeletal, montmorillonitic, thermic Udic Argiustoll.

From Hallmark et al. 1986

SOIL SERIES: RUMPLE VARIANT PEDON: S81TX-385-001 COUNTY: REAL

PEDON CLASSIFICATION: UDIC HAPLUSTALF; CLAYEY-SKELETAL, MONTMORILLONITIC, THERMIC

LOCATION: SIDNEY WELLS RANCH; ON RT 337, 10.25 MI W OF JUNCTION WITH RT 83 AT LEAKEY; N OF ROAD JUST INSIDE GATE AND 50 FT W UNDER SOME TREES.

LANDFORM: UPLAND ELEVATION (M): 715 SLOPE: <1% SLOPE ASPECT:

PARENT MATERIALS: HARD CHERTY LIMESTONE FORMATION: DEVILS RIVER

TOPOGRAPHY: NEARLY LEVEL DRAINAGE: WELL DRAINED LANDUSE: PASTURE

COLLECTORS: M. RABENHORST, L. WEST, AND T. MOORE DATE: 08/18/81

HORIZON	DEPTH (CM)	SOIL DESCRIPTION (COLORS FOR MOIST SOIL UNLESS STATED)
A11	0-8	VERY DARK BROWN (10YR 2/2) CHERTY SILTY CLAY LOAM; WEAK MEDIUM GRANULAR STRUCTURE; FRIABLE; MANY FINE ROOTS; NEUTRAL; CLEAR SMOOTH BOUNDARY.
A12	8-20	VERY DARK GRAYISH BROWN (10YR 3/2) CHERTY SILTY CLAY LOAM; WEAK MEDIUM SUBANGULAR BLOCKY AND WEAK MEDIUM GRANULAR STRUCTURE; FRIABLE; MANY FINE ROOTS; NEUTRAL; CLEAR SMOOTH BOUNDARY.
B21T	20-35	DARK REDDISH BROWN (5YR 3/4) CHERTY CLAY; MODERATE FINE SUBANGULAR BLOCKY STRUCTURE; FIRM; COMMON FINE ROOTS; MEDIUM CONTINUOUS CLAY FILMS ON PED FACES; 40% COARSE FRAGMENTS; NEUTRAL; GRADUAL SMOOTH BOUNDARY.
B22T	35-65	DARK REDDISH BROWN (2.5YR 3/4) CHERTY CLAY; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE; FIRM; COMMON FINE ROOTS; MEDIUM CONTINUOUS CLAY FILMS ON PED FACES; 30% COARSE FRAGMENTS; NEUTRAL; CLEAR SMOOTH BOUNDARY.
B3TCA	65-80	REDDISH BROWN (5YR 4/4) CHERTY CLAY; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE; FIRM; FEW MEDIUM ROOTS; MEDIUM PATCHY CLAY FILMS; SOME CARBONATE COATINGS ON COARSE FRAGMENTS; MATRIX MATERIAL NONCALCAREOUS AND NEUTRAL; WHITE NODULES STRONGLY EFFERVESCENT; 35% COARSE FRAGMENTS; ABRUPT IRREGULAR BOUNDARY.
R	80-84+	LIGHT GRAY (5Y 7/1) HARD LIMESTONE BEDROCK.

REMARKS: SOIL IS LIKE THE RUMPLE BUT LACKS A MOLLIC EPIPEDON. SOIL SHOULD BE CLASSIFIED IN THE IMPLIED SUBGROUP OF MOLLIC HAPLUSTALFS BUT PRESENTLY SOIL TAXONOMY HAS NO SUCH SUBGROUP. THIS PEDON CONTAINS MANY CHERT FRAGMENTS BOTH WITHIN THE SOIL AND ON THE SURFACE. THESE FRAGMENTS RANGE BETWEN 1-25 CM ALONG THE LONG AXIS.

SOIL SCI. SOC. AM. J., VOL. 50, 1986

From Rabenhorst and Wilding 1986b

Table 1. Plasmic fabrics† and major micromorphic features

Horizon	Depth	COLE	Related distribution	Plasmic fabric (125×)	Comments and features
				Pedon 11	
A1	0-8	ND	Agglomeroplasmic	Argillasepic	Occasional illuvial ferriargillans in pores of chert fragments.
A2	8-20	0.11	Porphyroskelic	Weak skelmasepic	Illuvial argillans and ferriargillans present in pores of chert fragments.
Bt1	20-35	ND	Porphyroskelic	Strong skelmasepic	Illuvial ferriargillans present in pores of chert fragments. Strong striated argillans around chert fragments.
Bt2	35-50	ND	Porphyroskelic	Strong skelmasepic	Occasional illuvial argillans in chert pores. Strong striated argillans around skeleton grains. Common Fe nodules.
Bt2	50-65	0.22	Porphyroskelic	Strong skelmasepic	Strong striated argillans around skeleton grains. Abundant Fe nodules.
BCtk	65-80	ND	Porphyroskelic	Strong skelmasepic	Strong striated with some moderate continuous illuvial argillans around skeleton grains and pores. Abundant Fe nodules and some carbonate nodules.

From Hallmark et al. 1986

SOIL CHARACTERIZATION LABORATORY
SOIL AND CROP SCIENCES DEPT., THE TEXAS AGRICULTURAL EXPERIMENT STATION

SOIL SERIES: RUMPLE VARIANT — PEDON NUMBER: S81TX-385-001
SOIL FAMILY: UDIC HAPLUSTALF; CLAYEY-SKELETAL, MONTMORILLONITIC, THERMIC
LOCATION: REAL COUNTY, TEXAS

LAB NO	DEPTH (CM)	HORIZON	PARTICLE SIZE DISTRIBUTION (MM) — SAND — VC (2.0-1.0)	C (1.0-0.5)	M (0.5-0.25)	F (0.25-0.10)	VF (0.10-0.05)	TOTAL (2.0-0.05)	SILT — FINE (0.02-0.002)	TOTAL (0.05-0.002)	CLAY — FINE (< 0.0002)	TOTAL (< 0.002)	TEXTURE CLASS	COARSE FRAG-MENTS %
			%											
1260	0- 8	A11	0.8	1.2	0.9	1.2	0.9	5.0	41.7	67.5	11.9	27.5	SICL	19
1261	8- 20	A12	1.8	1.5	0.9	1.4	0.5	6.1	37.8	57.2	21.1	36.7	SICL	14
1262	20- 35	B21T	2.4	1.2	0.5	1.1	0.6	5.8	22.3	32.3	46.6	61.9	C	56
1263	35- 50	B22T	1.9	0.8	0.6	0.8	1.0	5.1	16.0	23.2	57.5	71.7	C	36
1264	50- 65	B22T	0.8	0.4	0.3	0.6	0.8	2.9	14.5	21.7	53.8	75.4	C	36
1265	65- 80	B3TCA	6.4	3.2	1.6	1.7	1.6	14.5	16.2	22.8	21.5	62.7	C	38
1266	80- 84	R												0

LAB NO	ORGN C %	PH (H2O) 1:1	NH4OAC EXTR BASES — CA	MG	NA	K	TOTAL	KCL EXTR AL	NAOAC CEC	ECEC	BASE SAT	ESP	SAR	CAL-CITE	DOLO-MITE	CACO3 EQ	GYP SUM
			MEQ/100G								%			%			
1260	5.98	7.2	40.5	1.8	0.1	0.8	43.3		37.9		100	0	0				
1261	2.51	7.2	36.3	1.4	0.1	0.5	38.2		28.8		100	0	0				
1262	1.75	7.0	47.9	1.9	0.1	0.6	50.6		46.4		100	0	0				
1263	1.46	7.0	51.7	2.1	0.2	0.6	54.5		50.9		100	0	0				
1264	1.29	7.0	57.3	2.2	0.3	0.6	60.4		57.0		100	1	0				
1265	0.72	7.2	77.5	1.8	0.2	1.0	80.5		45.4		100	0	0	15.3	3.7	19.3	
1266	0.67															94.8	

LAB NO	SATURATED PASTE EXTRACT — ELEC COND MMHOS/CM	H2O CONT %	CA	MG	NA	K	CO3	HCO3	CL	SO4	BULK DEN 0.33 BAR	AIR DRY	COLE CM/CM	WATER CONTENT 0.10 BAR	0.33 BAR	15 BAR
			MEQ/L								G/CC			WT%		
1260	0.7	73	6.2	0.6	0.2	0.3	0.0	4.9	1.6	0.6						
1261	0.6	59	5.4	0.4	0.3	0.1	0.0	3.8	0.9	0.3	1.29	1.77	0.111		37.1	
1262	0.6	84	5.9	0.3	0.3	0.1	0.0	3.3	0.6	0.3						
1263	0.4	89	3.6	0.2	0.3	0.0	0.0	2.2	0.3	0.4						
1264	0.3	94	1.5	0.2	0.3	0.0	0.0	1.3	0.8	0.4	1.00	1.83	0.223		64.3	
1265	0.6	80	6.0	0.2	0.6	0.0	0.0	2.8	0.7	0.6						
1266																

LAB NO	CLAY MINERALOGY — SM	VR	MI	IN	KK	GI	QZ	FO	CA	SKELETAL MINERALOGY — QZ	FO	CA
1260	***		**		**		**	*				
1261	***		**		**		**	*				
1262	***		**		**		**	*				
1263	***		**		**		*	T				
1264	***		**		**		*	T				
1265	***		**		**		*	T				
1266												

SM=SMECTITE VR=VERMICULITE MI=MICA IN=INTERSTRATIFIED
KK=KAOLINITE GI=GIBBSITE QZ=QUARTZ FD=FELDSPAR CA=CALCITE
T=TRACE *=0-10% **=10-50% ***=GREATER THAN 50%

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From Rabenhorst and Wilding 1986b

Table 2. Semiquantitative interpretations of XRD analyses

Horizon	Fraction	Relative quantity† of minerals present — Qtz	Kaol	Mica	Sm	K spar	Plag	Goethite	Fluorite
				Pedon 11					
A1	<0.2 μm	–	XX	XX	XXXX	–	–	–	–
Bt2		–	XX	X	XXXX	–	–	–	–
2R		–	XX	XX	XXXX	–	–	XX	–
A1	0.2–2 μm	XXX	XX	XX	XX	X	–	–	–
Bt2		XX	XXX	X	XXX	tr	–	X	–
2R		XXX	XXX	X	X	tr	–	tr	–
A1	5–20 μm	XXXX	–	–	–	X	–	tr	–
Bt2		XXXX	–	–	–	X	–	tr	–
2R		XXXX	tr	–	–	tr	–	–	–

† tr = trace, X = low, XX = moderate, XXX = high, XXXX = dominant, Qtz = quartz, Kaol = kaolinite, Sm = smectite, Plg = plagioclase, and K spar = K feldspar.

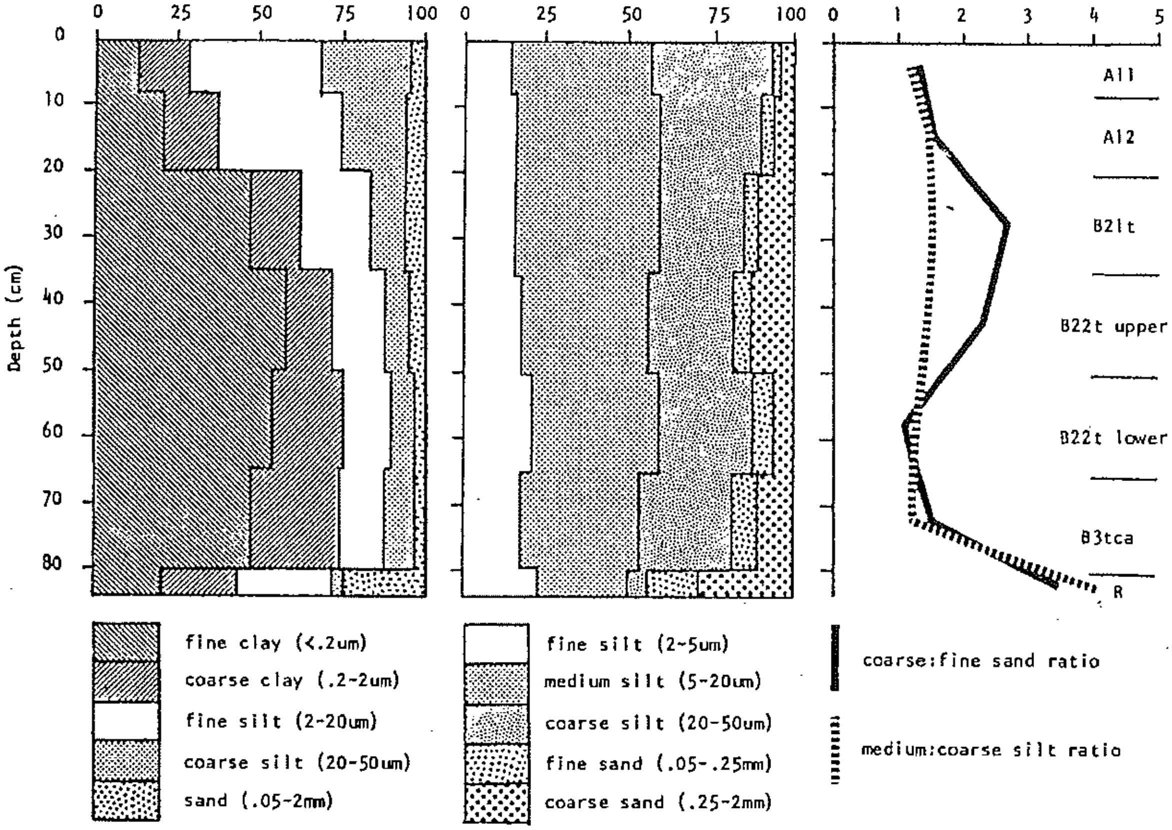

Fig. 22. Carbonate-free and carbonate-free, clay-free PSD and sand and silt ratios shown with depth for the Real Co. pedon (#11).
From Rabenhorst 1983

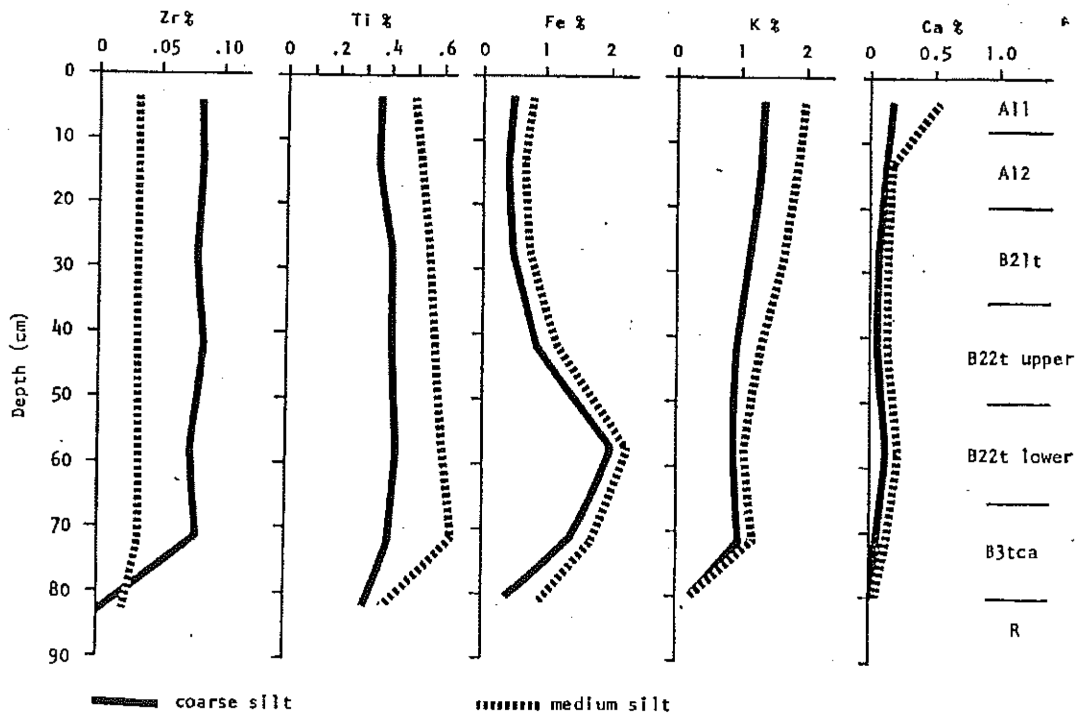

Fig. 23. Elemental analyses of carbonate-free silt fractions from soil and residue of the Real Co. pedon (#11). From Rabenhorst 1983

Fig. 24. General SEM fields showing representative silt grains from the B22t horizon (A), B3tca horizon (B), and the limestone residue (C and D). Note the abundance of quartz prisms marked by prominent striations in the limestone residue. Prismatic quartz crystals are rare in the B3tca (arrows) and absent from the B22t. Line scale is 10µm.

From Rabenhorst 1983

From Rabenhorst 1983

Appendix A -- Carbonate Free Residue of Bedrock. From Rabenhorst 1983

Lab #	Site	Horizon	% CO_3-free Residue	<.2μm	.2-2μm	2-20μm	20-50μm	50μm-2mm	%>2mm
				------	------	†%	------	------	
1266	11	R	0.49	19.5	23.5	29.0	3.2	24.8	12.1

† % by weight based on weight of <2mm fraction

GENESIS OF ECKRANT

The parent material of the Eckrant soil was probably derived from the weathering of marly interbeds within the Devils River Formation. The fine earth fraction of the Eckrant soil probably was not derived from the weathering of hard limestone beds of the Edwards Group, nor did aerosols contribute significantly (Rabenhorst 1983).

The addition of organic residues from plants (importance of cedar?) resulted in dark colors and a mollic epipedon. Plant roots grow, die, and decompose in the limited volume of fine earth, hence the high (6%) organic carbon content. The leaching hydrologic regime and dolomitic nature of limestone bedrock retards formation of secondary carbonates in Eckrant soil.

The soils on landforms currently occupied by Eckrant soils may have been moderately deep (or even deep) during Pleistocene pluvial climates with greater vegetative cover. The soil mantle may have been partially removed after loss of vegetative cover resulting from desiccation of climate in Holocene. The former soil mantle is a possible source of sediment for early and Mid Holocene age allostratigraphic units found in valley fill landscape positions.

The skeletal nature of present-day soil cover retards further loss of fine earth by water erosion. However, with loss of all vegetative cover on steep slopes (extreme drought and/or extremely heavy livestock grazing), all fine earth between rock fragments may be lost, leaving a smooth, unproductive limestone bedrock surface littered with detached pebbles, cobbles, and stones.

USDA - Soil Conservation Service
Pedon Narrative Description
Dec 19, 1990

Soils Series: Eckrant
Soil Survey # S90-TX-385-003
Survey Area ID: 607
Map Unit Symbol: 82G
Photo Number: 118
Description Type: full pedon description
Pedon Type: Modal pedon for series
Location: From junction of US 83 and FM 337 in Leakey, 4.7 miles W on FM 337 to turnout,
140 feet S in Hwy. right of way
Latitude: 29-44-23-N
Longitude: 099-49-15-W
Classification: clayey-skeletal, montmorillonitic, thermic Lithic
Haplustoll
Physiography: Hillside in Deeply Dissected Plateau
Elevation: 2010 ft MSL
Precipitation: 27 in. ustic moisture regime
MLRA: 81B
Air Temperature: Ann 64 F Sum 80 F Win 48 F
Land Use: rangeland not grazed
Particle Size Control Section: 0 to 9 in.
Parent Material: residuum from limestone material
Vegetation Code(s): JUAS, SOSE, CAPL
Diagnostic Horizons: 0 to 9 in. mollic, 9 in. to lithic contact

Soils Series: Eckrant
Described By: Lynn E. Loomis and Wayne J. Gabriel
Date: Ø7/9Ø

Oe--1.7 to Ø inches; 65% very dark grayish brown (1ØYR 3/2), and 35% white (1ØYR 8/2) cobbly partially decomposed organic matter; very dark brown (1ØYR 2/2), and white (1ØYR 8/2) moist; single grain; slightly hard, very friable, non sticky, non plastic; composed of juniper needles in varying stages of decomposition, juniper twigs and mountain laurel leaves; the upper 1 cm contains identifiable juniper needles; duff has accumulated in small dams between rock fragments; somewhat hydrophobic when dry, slightly hydrophobic when moist; worm casts are very slightly effervescent and occur in lower part; few snail shells; no roots; common fine and medium worm casts; very slightly effervescent (HCl, 1 normal) discontinuous; 11% cobbles limestone; 1Ø% pebbles limestone; 1% pebbles chert; abrupt smooth boundary.

A--Ø to 9 inches; very dark gray (1ØYR 3/1) very cobbly clay; black (1ØYR 2/1) moist; moderate fine and medium subangular blocky structure parting to moderate fine granular; hard, very friable, moderately sticky, moderately plastic; common very fine and fine roots matted around stones, and common medium and coarse roots matted around stones, and few very coarse roots throughout; common fine, and few medium interstitial pores; the lower 1-2 inches has slightly lighter color; granular structure appears to be earthworm casts of various ages; very slightly effervescent only in peds that contain limestone sand particles; common fine rounded worm casts; very slightly effervescent (HCl, 1 normal) discontinuous; 2Ø% stones limestone; 25% cobbles limestone; 15% pebbles limestone; abrupt wavy boundary.

R--9 to 15 inches; light brownish gray (1ØYR 6/2) unweathered bedrock; light brownish gray (1ØYR 6/2) moist; indurated; many distinct brownish yellow (1ØYR 6/8) continuous weakly cemented calcium carbonate coats Ø.5 to .75 inch thick with many white (1ØYR 8/1) discontinuous laminar strongly cemented calcium carbonate coats on upper surface 1 to 2mm thick; strongly effervescent (HCl, 1 normal) continuous.

CLASSIFICATION

The Oe horizon is a layer dominated by organic material that is partially decomposed and would be classified as hemic soil material. It is estimated that the upper 1Ø inches (25 cm) of the soil would not meet the 17 percent organic carbon content required for a histic epipedon with 5Ø percent clay (organic matter removed). Also, a histic epipedon is defined as a layer that is saturated with water for 3Ø consecutive days or more at some time in most year, or is artificially drained.

A mollic epepedon is recognized at Ø to 9 inches. The mollic epipedon is defined as mineral soil material. Mineral soil material has less than 2Ø percent organic carbon in soils that are not saturated for more than a few days.

A lithic contact is identified at 9 inches and corresponds with the upper surface of fractured, indurated limestone bedrock. Distance between fractures in the bedrock was coded as a minimum of 45 cm to 1 m spacing horizontally in the Pedon Description Program (PDP). PDP did not print this feature in the narrative description we generated. Eckrant more than 35% clay the control section from +1.5 inch to 9 inches (+4 cm to 23 cm) in the particle size class control section. The minerology is montmorillonitic (more smectite than any other clay mineral), but with a strong component of kaolinite (Richard Drees, personal communication).

The epipedon is noncalcareous to the surface after the upper 7 inches (18 cm) is mixed. The coarse fragments have very little secondary accumulation of calcium carbonate. This indicates a leaching moisture regime that flushes calcium carbonate from the soil. Only a thin rind of secondary carbonate coats the surface of the limestone bedrock.

The pedon description and data support the classification of this pedon as the Eckrant Series, clayey-skeletal, montmorillonitic, thermic Lithic Haplustoll.

SOIL CHARACTERIZATION LABORATORY
SOIL AND CROP SCIENCES DEPT., THE TEXAS AGRICULTURAL EXPERIMENT STATION

SOIL SERIES: ECKRANT
SOIL FAMILY: CLAYEY-SKELETAL, MONTMORILLONITIC, THERMIC LITHIC HAPLUSTOLL
LOCATION: REAL

PEDON NUMBER: S90TX-385-003

LAB NO	DEPTH (CM)	HORIZON	PARTICLE SIZE DISTRIBUTION (MM) SAND VC (2.0-1.0)	SAND C (1.0-0.5)	SAND M (0.5-0.25)	SAND F (0.25-0.10)	SAND VF (0.10-0.05)	SAND TOTAL (2.0-0.05)	SILT FINE (0.02-0.002)	SILT TOTAL (0.05-0.002)	CLAY FINE (< 0.0002)	CLAY TOTAL (< 0.002)	TEXTURE CLASS	COARSE FRAGMENTS %
			%											
4257	4- 0	OE												
4256	0- 23	A	0.6	0.5	0.6	0.5	0.4	2.6	34.8	56.3	11.0	41.1	SIC	32
4282	23- 38	R												

LAB NO	ORGN C %	PH (H2O) 1:1	NH4OAC EXTR BASES CA	MG	NA	K	TOTAL	KCL EXTR AL	NAOAC CEC	ECEC	BASE SAT	ESP	SAR	CALCITE	DOLOMITE	CACO3 EQ	GYP SUM
			MEQ/100G								%			%			
4257																	
4256	5.91	7.4	79.3	2.5	0.2	1.0	83.1		56.3		100	0	0	1.6	0.1	1.7	
4282																	

LAB NO	SATURATED PASTE EXTRACT ELEC COND MMHOS/CM	H2O CONT %	CA	MG	NA	K	CO3	HCO3	CL	SO4	BULK DEN 0.33 BAR	BULK DEN AIR DRY	COLE CM/CM	WATER CONTENT 0.10 BAR	0.33 BAR	15 BAR
			MEQ/L								G/CC			WT%		
4257																
4256	0.8	90	9.0	0.5	0.3	0.1		0.0	1.0							
4282																

LAB NO	CLAY MINERALOGY SM	VR	MI	IN	KK	GI	QZ	FD	CA	SKELETAL MINERALOGY QZ	FD	CA
4257												
4256												
4282												

SM=SMECTITE VR=VERMICULITE MI=MICA IN=INTERSTRATIFIED
KK=KAOLINITE GI=GIBBSITE QZ=QUARTZ FD=FELDSPAR CA=CALCITE
T=TRACE *=0-10% **=10-50% ***=GREATER THAN 50%

LAB NO	PARTICLE SIZE DISTRIBUTION (CLAY-FREE BASIS) SAND VCS	C	M	F	VF	TOTAL	SILT C	F	TOTAL	RATIOS S/SI	FSI/CSI	VFS/FS	FC/TC	CEC/CLAY
	%													
4256	1.0	0.8	1.0	0.8	0.7	4.4	36.5	59.1	95.6	0.0	1.6	0.9	0.3	1.37

LAB NO	CLAY MINERALOGY SM	VR	MI	IN	KK	GI	QZ	FD	CA	SKELETAL MINERALOGY QZ	FD	CA
4256	**				**		*					

SM=SMECTITE VR=VERMICULITE MI=MICA IN=INTERSTRATIFIED
KK=KAOLINITE GI=GIBBSITE QZ=QUARTZ FD=FELDSPAR CA=CALCITE
T=TRACE *=0-10% **=10-50% ***=GREATER THAN 50%

GEOLOGY OF THE EDWARDS PLATEAU

The Edwards Plateau is a generally flat lying, elevated tableland nearly entirely composed of Cretaceous limestone and dolomite. The plateau is bordered on the northeast by the Llano Uplift and on the south and east by the Balcones fault zone. The northern part of the plateau is moderately dissected, while the eastern and southern margins are deeply and thoroughly dissected by small rivers that cut headward into the Plateau from the east and south. The Concho, San Saba, Llano, Pedernales, Guadalupe, Medina, Frio, Sabinal, East Nueces, West Nueces, Dry Devils, and Devils Rivers flow radially away from a broad divide that extends southeast from near Big Lake in Reagan County, across Irion, Crockett, and Schleicher Counties to Eldorado, then southward through central Sutton and northern Edwards Counties to Rocksprings, and then eastward through northern Real County into western Kerr County (Rose 1972). Extensive alluvial plains veneer the lowlands north and south of the plateau.

STRATIGRAPHY

The Edwards Plateau is underlain by igneous and sedimentary rocks. The exposed sedimentary rocks include deposits of Cretaceous, Tertiary(?), and Quaternary age. The Cretaceous rocks were deposited under marine conditions, whereas the Tertiary(?) and Quaternary surficial deposits are subaerial in origin.

The system of stratigraphic nomenclature for Cretaceous rocks in the Edwards Plateau developed by Lozo and Smith (1964) during the late 1950's, modified by Rose (1972) and Webster (1978), and adopted by the University of Texas Bureau of Economic Geology is used in this report (Table 3).

Cretaceous rocks belong to the Lower Cretaceous (Comanche) Series and the Upper Cretaceous (Gulf) Series (Table 3). The Comanche Series is divided into three groups. In ascending order, they are: the Trinity, the Fredericksburg, and the Washita. Trinity Group rocks include the Cow Creek Limestone, Hensell Sand, and the Glen Rose Limestone. The Cow Creek Limestone is the oldest formation exposed on the Edwards Plateau. It occurs along the Guadalupe River in Comal County. The Hensell Sand outcrops along the northeastern margin of the Edwards Plateau in Kimble, Gillespie, and Mason counties, and along the Guadalupe River in Kendall and Comal Counties. The Glen Rose limestone crops out along the southern and eastern margins of the plateau, and is exposed in the deeper valleys extending into the central part. "Edwards" limestones belong to the Fredericksburg and Early Washita Groups. Fredericksburg Group rocks include the Ft. Terrett, West Nueces, and McKnight Formations. Early (Lower) Washita rocks include the Ft. Lancaster, Segovia, and Salmon Peak Formations (Table 3). "Edwards" limestones (Ft. Terrett, Ft. Lancaster, Segovia, Devils River, West Nueces, McKnight, Salmon Peak, Santa Elena, Sue Peaks, and Del Carmen Formations) crop out over most of the plateau surface. Down-thrown blocks of "Edwards" limestones crop out along the eastern and southeastern margins of the plateau and form resistant base levels for streams draining across the outcrop. Upper Washita rocks (Del Rio clay [=Grayson shale] and Buda limestone) occur on the divides between major drainage systems. Exposures of the Boquillas Flags (=Eagle Ford Group) are limited to broad surfaces above the Buda limestone. The Austin Chalk is exposed south of the Balcones Fault Zone in Kinney, Uvalde, and Medina Counties, along the Rio Grande in Val Verde and Terrell Counties, and in a small down-thrown fault block in western Edwards County (Webster 1978). The overlying Anacacho limestone crops out in the Anacacho Mountains of Kinney and Uvalde counties.

The Uvalde gravel of Pliocene(?) age overlies Cretaceous rocks in the southwestern part of the Edwards Plateau, and Quaternary surficial deposits occur in stream valleys throughout the plateau and on alluvial plains at the plateau margins. Igneous rocks, mainly basalt, occur along the Balcones Fault Zone.

The following descriptions were taken from the Bureau of Economic Geology geologic atlas sheet legends.

Cow Creek Limestone--Massive, off-white, in part honeycombed, fossiliferous. Thickness about 75 feet, lower part does not crop out.

Hensell Sand--Limestone and sandstone; upper half sandstone, sandy, glauconitic, honeycombed-nodular; lower half mostly sandstone, fine grained, argillaceous, calcareous, contains white hard, siliceous geodes up to 8 inches in diameter, yellowish brown, fossils are *Exogyra* and oysters, some hard limestone contains large oysters. Thickness about 45 feet.

Glen Rose Formation--Limestone, dolomite, and marl as alternating resistant and recessive beds forming stair step topography; limestone, aphanitic to fine grained, hard to soft and marly, light gray to yellowish-gray; dolomite, fine grained, porous, yellowish-brown; marine megafossils include molluscan steinkerns, rudistids, oysters, and echinoids. Upper part, relatively thinner bedded, more dolomitic, and less fossiliferous; thickness about 400 feet. Lower part, more massive, contains some rudistid reefs and at top Corbula Bed, C, with abundant steinkerns of *Corbula harveyi* (Hill) in an interval up to 5 feet thick; thickness about 500 feet. Thickness of Glen Rose Formation 900 feet.

Table 3. Stratigraphic sequence in the Edwards Plateau.

Chronostratigraphic unit	Erathem	System	Series	Stage		Lithostratigraphic unit	
Geochronologic unit	**Era**	**Period**	**Epoch**	**Age**	**Geochronologic Age (Ma)**	**Group**	**Formation**
	Cenozoic	Quaternary	Holocene				Alluvium
			Holocene or Pleistocene		0.01		Low terrace deposits Alluvial fan deposits and colluvium
			Pleistocene	Calabrian			Playa deposits Fluviatile terrace deposits
					1.7		Quaternary deposits undivided Leona Fm
		Tertiary	Pliocene	Piacenzian			Uvalde gravel
					4.6		
	Mesozoic	Cretaceous	Upper Cretaceous (Gulf)				Cretaceous igneous rocks
							Anacacho Austin Chalk
						Eagle Ford	Boquillas Flags
					90		
				Cenomanian		Upper Washita	Buda Ls Del Rio Clay
					100		
			Lower Cretaceous (Commanche)	Albian		Edwards	
							Glen Rose Fm (upper)
				Albian		Trinity	Glen Rose Fm (lower)
					108		Hensell S
				Aptain			Cow Creek Ls
					115		

Edwards Group	San Marcos Platform Sequence	Commanche Platform Sequence	Devils River Trend	Maverick Basin Sequence	Big Bend Sequence
Lower Washita	Person Fm	Segovia Fm (Ft Lancaster Fm)	Devils River Ls	Salmon Peak Ls McKnight Fm	Santa Elena Ls Sue Peaks Fm
Fredericksburg	Kainer Fm	Ft Terrett Fm		West Nueces Fm	Del Carmen Ls

San Marcos Platform Sequence

Person Formation
Kainer Formation

Comanche Shelf Sequence

Segovia Formation--limestone and dolomite; in upper part, cherty, light gray, miliolid, shell fragment, rudistid limestone; in middle part, dolomite, medium brownish gray, porous, massive- to thin-bedded, cherty, collapse breccia; in lower part, light-yellowish-gray miliolid limestone and marl and marly limestone with *Exogyra texana* and oxytropidocerid ammonite. Key beds mapped locally include in upper part the Black Bed, B, the Orr Ranch Bed, B, Calvert's Zone, CZ, and the edge of Upper Caprock, UC, and in lower part Curry's *Gryphaea* bed, G; thickness 250 to 360 feet, thickens southward.

Black Bed
Orr Ranch Bed
Gryphaea Bed
Allen Ranch Breccia
Burt Ranch Member

Fort Terrett Formation--limestone and dolomite; in upper part, porcelaneous aphanitic limestone, collapse breccia, chert, and recrystallized limestone; in middle part, light- to dark-gray, cherty, miliolid, shell fragment, rudistid limestone and medium-brownish-gray dolomite; in lower part, nodular limestone with thin, yellow, *Exogyra texana*-bearing clay at base; thickness 200 to 300 feet, thickens southward.

Kirschberg Evaporite
Dolomitic Member
Burrowed Member
Basal Nodular Member

Devils River Trend

Devils River Limestone--limestone and dolomite; hard, miliolid, pellet, rudistid, shell fragment biosparite and lime mudstone; locally dolomitized, brecciated, and chert-bearing; rudistid mounds more common in upper part; nodular limestone in basal part; thickness about 700 feet.

Maverick Basin Sequence The Rio Grande Embayment, a re-entrant of the Gulf Coastal Plain, is a southward thickening depositional trough which was actively subsiding through Cretaceous and Cenozoic time (Webster 1978).

Salmon Peak Limestone--upper 75 feet granular, abundant caprinid and other shell fragments, crossbedded; lower part, *Globigerina* mudstone, abundant large chert masses, white; total thickness 310 feet.

McKnight Formation--limestone and shale; upper 55 feet, lime mudstone, thin bedded, locally contains chert layers, solution zones, and collapse breccia; intermediate 25 feet, argillaceous lime mudstone, laminated, fissile, black; lower 70 feet, limestone, granular, thin chert layers, abundant shell fragments and pellets, overlain by lime mudstone with solution zone and collapse breccia; total thickness 150 feet.

West Nueces Formation--upper 80 feet, limestone, fine grained, massive, miliolid and mollusk-bearing; lower 60 feet, limestone, nodular, oysters and other mollusks common; total thickness 140 feet.

Big Bend Sequence

Santa Elena Limestone--Fine-grained to microgranular, massive, beds up to 10 feet thick, some marl interbeds in upper part, rounded chert nodules and silicified rudistids common in more massive beds, light-gray to white; weathers dark-gray and shades of brown; rudistids and miliolids abundant; forms cliffs; Thickness about 350-450+ feet.

Sue Peaks Formation--microgranular, thin-bedded, medium light-gray to medium dark-gray; occupies slope between escarpments formed by Santa Elena and Del Carmen Limestones; marine megafossils common. Thickness 45 feet.

Del Carmen Limestone--microgranular to fine-grained, massive, chert nodules and masses up to 10 inches in size and beds exceeding 10 feet in length, gray; rudistids and miliolids common; forms sheer cliffs; Thickness up to 475 feet.

Georgetown Formation--limestone and marl; mostly limestone, fine-grained, argillaceous, nodular, moderately indurated, light gray; some limestone, hard, brittle, thick bedded, white; some shale, marly, soft, light gray to yellowish gray; marine megafossils include *Kingena wacoensis* and *Gryphaea washitaensis*. Thickness 30-80 feet.

Del Rio Clay (= Grayson Shale)--Calcareous and gypsiferous becoming less calcareous and more gypsiferous upward, pyrite common, blocky, medium-gray, weathers light-gray to yellowish-gray; some thin lenticular beds of highly calcareous siltstone; marine megafossils include abundant *Exogyra arietina* and other pelecypods; Thickness up to 200 feet, feathers out northwestward.

The Del Rio Clay contains cinnabar (mercury ore) in sufficient concentrations that extensive mining was conducted in the Big Bend area from the turn of the century until World War II. Near-commercial concentrations of chromium are reported to occur in a small outcrop of the Del Rio Clay located in Bandera County (Chris Caran, correspondence).

Buda Limestone--fine-grained, bioclastic, commonly glauconitic, pyritiferous, hard, massive, poorly bedded to nodular, thinner bedded and argillaceous near upper contact, light-gray to pale-orange; weathers dark-gray to brown; burrows filled with chalky marl, abundant pelecypods; basal beds typically marly, nodular limestone, and thin yellow marl beds with scarce

Budaiceras sp. Thickness 45-100 feet, thickens eastward, forms much of plateau surface.

Boquillas Flags (= Eagle Ford Group)--consists of four units:

1. upper unit mostly shale, silty, medium-gray, interbedded with some limestone, nodular to laminar, granular, brownish-gray;

2. followed downward by shale, silty, medium-gray, interbedded with limestone, granular, yellowish-gray;

3. shale, silty, dark-gray, interbedded with siltstone, laminated, grading upward to silty limestone; and

4. a basal unit of limestone, clastic, in thin mostly cross-laminated beds that pinch and swell along strike, interbedded with siltstone, light yellowish-gray to grayish-orange. Thickness 160-220 feet.

Austin Chalk--Hard lime mudstone to soft chalk; mostly microgranular calcite with minor foraminifera tests and *Inoceramus* prisms, sparsely glauconitic, pyrite nodules in part weathered to limonite common, occasional beds with large-scale cross-stratification, ledge-forming, grayish-white to white; locally highly fossiliferous. Thickness about 580 feet in eastern part of Del Rio sheet, thickens southwestward.

Anacacho Limestone--Limestone and marl; limestone, reefy, thick-bedded, in part cross-bedded, light-yellow to yellow-brown and light-gray; in part sandy, some volcanic rock fragments and weathered rusty bentonite beds; marine megafossils abundant. Thickness up to 500 feet, ends abruptly westward, thins to a feather edge in western Bexar County.

Cretaceous igneous rocks--Alkalic basalt and pyroclastics altered to nontronite; basalt in the form of sills, laccoliths, volcanic necks, and dikes.

Uvalde Gravel--Caliche-cemented gravel; some boulders up to 1 foot in diameter; well-rounded cobbles of chert, some cobbles of quartz, limestone, and igneous rock; occupies topographically high areas not associated with present drainage. Thickness ranges from several feet of gravel lag to 30 feet.

Leona Formation--Fine calcareous silt grading down into coarse gravel; type locality first wide terrace of Nueces and Leona Rivers below level of Uvalde Gravel. May correlate with Onion Creek Marl of Austin Sheet.

Quaternary deposits undivided--includes slope wash, alluvial fan deposits, alluvium, colluvium, and locally older Quaternary deposits; mostly in size range of cobbles to silt derived from Cretaceous limestone, dolomite, and chert.

Fluviatile terrace deposits--gravel, sand, silt, and clay; adjacent to Edwards Plateau, predominantly gravel, limestone, dolomite, and chert; contiguous terraces of different ages separated by solid line.

Playa deposits--clay and silt, sandy, light gray, in shallow depressions, usually covered by thin deposit of Holocene sediment (Wisconsinan).

Alluvial fan deposits and colluvium--caliche-cemented, poorly sorted, angular to rounded rock fragments of locally derived material.

Low terrace deposits--Mostly low terraces above flood level along entrenched streams, some alluvium; gravel,sand, silt, clay, and organic matter.

Alluvium--Floodplain deposits, includes low terrace deposits near floodplain level and bedrock locally in stream channels; gravel, sand, silt, clay, and organic material; thickness up to 35 feet.

CLIMATE, GEOLOGY, AND VEGETATION RELATIONSHIPS WITH SOIL SERIES

Rainfall on the Edwards Plateau ranges from 33.46 inches at New Braunfels in Comal County to 11.21 inches at Sanderson in Terrell County (Table 4). For the purposes of soil and range site classification, this broad range in precipitation has been segmented into four soil moisture regimes (SMR). These SMR correspond well to Thornthwaite P-E Zones, and to the four land resource subareas (Eastern, Central, Western, and Southern LRS) in the Edwards Plateau. The following paragraphs describe each SMR/LRS/P-E zone, some of the dominant soils, and pertinent vegetation features.

The Eastern Edwards Plateau LRS (81C, Comal, Hays, Kendall, Travis, and Williamson Counties) has a wet tempustic SMR and Thornthwaite P-E index greater than 44. Soils in this zone are dry in some part of the moisture control section for more then 25% but less than 40% of the days (cumulative) that soil temperature at 50 cm (20 inches) is greater than 5°C. Lithic Haplustolls and Lithic Calciustolls mapped over hard, massive limestone bedrock of the Edwards Group are classified as the Eckrant series. The Aledo series (loamy-skeletal, carbonatic, thermic Lithic [Udic] Haplustolls) is mapped in the Grand Prairie in the wet tempustic SMR (P-E index 44-58). Brackett soils (fine-loamy, carbonatic, thermic Udic Ustochrepts) are mapped on steep landscape elements forming on the upper Glen Rose Formation.

The Central Edwards Plateau LRS (81B) has a typic tempustic SMR and Thornthwaite P-E index of 31 to 44. Soils in this area (Medina, Uvalde, Real, Edwards, Kerr, Gillespie, Kimble, Sutton, Schleicher, Menard, Concho, Tom Green, and western Irion Counties) are dry in some part of the moisture control section between 40 and 60% of the days (cumulative) that soil temperature at 50 cm (20 inches) is greater than 5oC. Lithic Calciustolls in this area are classified in the Purves, Tarrant, and Oplin series whereas Lithic Haplustolls are classified in the Eckrant and Eckert (skeletal), and Harper (non-skeletal) series. These soils are characterized by the presence of Plateau live oak (Quercus fusiformis Small) in the plant community overstory. Kerrville soils (loamy-skeletal, carbonatic, thermic Typic Ustochrepts) are mapped on undulating to hilly landscapes eroded into the stratigraphically lower Glen Rose Limestone.

Table 5 is a key to soil map unit identification in the Soil Survey of Edwards and Real Counties in the Central Edwards Plateau. The key relates soil map units to geologic formations and SMR's. Soil map units in the survey legend were designed to correspond with landforms, groups of landforms, or subdivisions of landforms. This is why most of the map units are multi-taxa. Table 6 is a key to soil series identification in the Central Edwards Plateau. The key relates soil series to landforms, coarse fragment content, and depth class.

Appendix B is a key to landforms developed in Australia (Speight 1984). The key is not approved for use in the National Cooperative Soil Survey but is included because it is the only systematic key to landforms the authors are aware of. Some terms and definitions are different from those in the National Soils Handbook (Soil Survey Staff 1985). Such a key would be useful in soil surveys in the United States and worldwide. We hope that presentation of this key will stimulate interest among geomorphologists.

The Western Edwards Plateau LRS (81A) has a dry tempustic SMR and Thornthwaite P-E index values between 25 and 31. Soils in this area (Val Verde, Crockett, Reagan, Glasscock, and Sterling Counties) are dry in some part of the soil moisture control section greater than 60% of the time that soil temperature at 50 cm (20 inches) is greater than 5oC, but are moist in some part of the soil moisture control section more than 90 consecutive days when soil temperature at 50 cm (20 inches) is greater than 8oC. Lithic Calciustolls are classified in the Ector and Tarrant series, though currently the Tarrant series is currently restricted to areas with P-E index values greater than about 30. Plant communities on these soils are dominated by Ashe juniper (Juniperus ashei Buchh.); plateau live oak is absent. The presence of a few plants of lecheguilla (Agave lecheguilla) in the plant community is an indicator of dry ustic SMR. The Glen Rose Formation does not significantly crop out in the Western Edwards Plateau. Zorra soils (loamy-skeletal, carbonatic, hyperthermic [Aridic] Lithic Petrocalcic Calciustolls) occur over nodular limestone of the Buda Formation, and Amistad soils (loamy-skeletal, carbonatic, thermic [Aridic] Lithic Petrocalcic Calciustolls) occur over flaggy limestones of the Boquillas Flags.

The Southern Edwards Plateau LRS (81D) has a moist temparidic SMR and Thornthwaite P-E index between 19 and 25. Soils in this region (Brewster and parts of Terrell, and Val Verde, [Kinney, Uvalde?] Counties) are dry in all parts of the soil moisture control section 50-75% of the days (cumulative) that soil temperature at 50 cm (20 inches) is greater than 5°C. Langtry (loamy-skeletal, carbonatic, hyperthermic [dry tropustic SMR?] Lithic Calciustolls) and Lozier (Lithic [Ustollic] Calciorthids) soils occur over hard limestone bedrock of the Edwards Group and the Buda Limestone in this climatic zone. Mariscal soils (loamy-skeletal, carbonatic, thermic Lithic Ustollic Calciorthids) formed over flaggy limestone of the Boquillas Formation. Vegetation in this area is characterized by chino grama (*Bouteloua breviseta*), black grama (*B. eriopoda*), creosotebush (*Larrea tridentata*), sotol (*Dasylirion leiophyllum*), and skeletonleaf golden-eye (*Viguiera stenoloba*).

Table 4. Mean annual precipitation (MAP) and temperature (MAT) for selected observation stations in the Edwards Plateau.

Station	Elevation (Feet)	MAP (Inches)	MAT (^{o}F)	Period of Record	
	Eastern Edwards Plateau LRS				
Blanco	1400	34.39	65.8	1941	1970
New Braunfels	620	33.46	68.6	1951	1978
Austin	597	32.58	68.2	1931	1960
	Central Edwards Plateau LRS				
Kerrville	1645	29.57	64.1	1951	1978
Hondo	901	28.46	68.8	----	----
San Antonio	701	27.89	68.7	1931	1960
San Saba	1210	27.55	65.1	1963	1976
Fredericksburg	1747	27.44	66.2	1939	1967
Prade Ranch	2052	26.86	64.3	1956	1969
Junction	1710	24.76	64.5	1910	1968
Eden	2050	23.87	65.9	1951	1981
Uvalde	980	23.70	69.7	1932	1962
Brady	1748	23.27	64.5	1939	1968
Menard	1960	21.68	----	1933	1962
San Angelo	1903	18.63	66.5	1931	1970
San Angelo Dam	1847	18.38	64.6	1954	1970
Sonora	2120	18.33	65.9	1949	1961
San Angelo	1847	17.85	65.6	1951	1978
	Western Edwards Plateau LRS				
Big Spring	2400	18.38	----	1900	1960
Fort Stockton	2954	12.26	64.0	1955	1975
Sanderson	2800	11.21	----	1934	1963
	Southern Edwards Plateau LRS				
Brackettville	1120	21.12	----	1935	1962
Del Rio	948	18.38	70.0	1937	1976
Panther Junction	3700	13.00	66.4	1956	1978

MAP UNITS ARRANGED BY GEOLOGIC FORMATION AND SOIL MOISTURE REGIME

Table 5 -- Soil Map Unit Identification Key

PARENT MATERIAL	P-E 25 DRY TROPUSTIC SMR		DRY TEMPUSTIC SMR		P-E 31 TYPIC TEMPUSTIC SMR (P-E 44)	
Boquillas Flags					75BD	Amistad flv-l 1-5%
Buda Ls					262AC	Noelke-Kavett-Valera cpx Ø-5%
					261BD	Noelke cbv-cl 1-8%
Del Rio Clay			183AC	Kavett-Eckrant-Valera cpx Ø-5%	183AC	Kavett-Eckrant-Valera cpx Ø-5%
					90AC	Kavett-Harper cpx Ø-3%
FA & FTD			83AC	Valera-Eckrant-Kavett cpx Ø-5%	83AC	Valera-Eckrant-Kavett cpx Ø-5%
Playa deposits			2A	Roscoe-Randall cpx Ø-2%	2A	Roscoe-Randall cpx Ø-2%
Segovia Fm	335BF	RO-Langtry cpx 1-15%	235BF	Ector-Eckrant-RO cpx 1-2Ø%	135BF	Oplin-Eckrant-RO cpx 1-2Ø%
Fort Terrett Fm	382G	RO-Langtry cpx 15-6Ø%	282G	RO-Ector-Eckrant cpx 2Ø-6Ø%	82G	Oplin-RO-Eckrant cpx 2Ø-6Ø%
Devils River Fm						
Salmon Peak Ls					28BF	Comfort-Rumple-Eckrant cpx 1-12%
					128BF	Rumple-Comfort-Eckrant cpx 1-12%
FA & FTD			99BD	Olmos-Cho cpx 1-8%	26AC	Topia c Ø-5%
					24AB	San Saba c Ø-3 %
			12AB	Tobosa c Ø-3 %	12AB	Tobosa c Ø-3 %
			13AB	Rio Diablo-RW cpx Ø-3%	2ØAC	Krum-Knippa cpx Ø-5%
			184AB	Dev & Oakalla s rf Ø-3%	15AB	Nuvalde cl Ø-3 %
			33AB	Rioconcho sicl of Ø-2%		
			34A	Rioconcho sicl ff Ø-2%		
					17ØAB	Oakalla l of Ø-2%
			84AB	Dev, RW, & Oakalla s ff Ø-3%	84AB	Dev, RW, & Oakalla s ff Ø-3%
			86	RW & Dev s ff Ø-3%		
Glen Rose Fm (upper)					16AB	Pratley c Ø-3%
					229G	Real, RO, & Kerrville s 2Ø-6Ø%
					81BF	Kerrville-Real-RO cpx 1-2Ø%
					11ØBF	Real-Cho-RO cpx 1-2Ø%
FA & FTD					1Ø7AB	Mereta cl Ø-3 %
					215AC	Real, Mereta, & Denton s 1-2Ø%
					21AB	Atco l Ø-3 %
					62AB	Boerne l of Ø-3%
					168AB	Orif & Boerne s & RW ff Ø-3%

RW	Riverwash	ff	frequently flooded
RO	Rock outcrop	of	occasionally flooded
s	soils	rf	rarely flooded
cpx	complex	f	flooded

FA & FTD Floodplain alluvium and Fluvial terrace deposits

SOIL SURVEY OF EDWARDS AND REAL COUNTIES
3 FEB 1991 LEL
SOIL SERIES ARRANGED BY LANDFORM, ROCK FRAGMENT CONTENT, AND DEPTH

Landform			Series	Particle-size	M	Subgroup	Great group	Low P-E	High P-E	Range Site
Upland	N-skeletal	V Deep	Brackett	Fine-loamy	c	Udic	Ustochrepts	40	54	Adobe/Steep Adobe
		Deep	Denton	Fine-silty	c	Udic	Calciustolls	44	56	Clay Loam
		M Deep	Spires	Fine	x	Rhodic	Paleustalfs	36	44	Redland
			Valera	Fine	m	Petrocalcic	Calciustolls	28	44	Clay Loam
			Crawford	Fine	m	Udic	Chromusterts	36	56	Deep Redland
			San Saba	Fine	m	Udic	Pellusterts	40	64	Blackland
			Bexar	Fine	x	Udic	Argiustolls	38	44	Redland
		Shallow	Tarpley	Clayey	m	Lithic	Argiustolls	42	54	Redland
			Purves	Clayey	m	Lithic	Calciustolls	40	60	Shallow
			Kavett	Clayey	m	Lithic Petrocalcic	Calciustolls	28	44	Shallow
			Doss	Loamy	c,s	Typic	Calciustolls	31	46	Shallow
			Stephen	Clayey	x,s	Udorthentic	Haplustolls	44	66	Chalky Ridge
			Harper	Clayey	m	Lithic	Haplustolls	40	44	Shallow Clay
			Hensley	Clayey	m	Lithic	Rhodustalfs	32	50	Redland
	Skeletal	M Deep	Kerrville	Loamy-skeletal	c	Typic	Ustochrepts	38	52	Adobe/Steep Adobe
			Rumple	Clayey-skeletal	x	Udic	Argiustolls	36	50	Gravelly Redland
			Dina	Clayey-skeletal	x	Pachic	Paleustolls	31	44	Redland
		Shallow	Comfort	Clayey-skeletal	x	Lithic	Argiustolls	42	50	Low Stony Hill
			Roughcreek	Clayey-skeletal	m	Lithic	Argiustolls	38	50	Redland
			Real	Loamy-skeletal	c,s	Typic	Calciustolls	32	50	Adobe/Steep Adobe
			Tarrant	Clayey-skeletal	m	Lithic	Calciustolls	30	44	Low Stony Hill/Steep Rocky
			Oplin	Loamy-skeletal	c	Lithic	Calciustolls	32	44	Low Stony Hill/Steep Rocky
			Ector	Loamy-skeletal	c	Lithic	Calciustolls	16	32	Low Stony Hill/Steep Rocky
			Langtry	Loamy-skeletal	c,h	Lithic	Calciustolls	19	31	Low Stony Hill/Steep Rocky
			Zorra	Loamy-skeletal	c,h	Lithic Petrocalcic	Calciustolls	19	31	Low Stony Hill
			Amistad	Loamy-skeletal	c	Lithic Petrocalcic	Calciustolls	16	32	Flagstone
			Noelke	Loamy-skeletal	x	Lithic Petrocalcic	Calciustolls	22	31	Limestone Hill
			Eola	Loamy-skeletal	c,s	Petrocalcic	Calciustolls	32	38	Shallow Ridge
			Eckrant	Clayey-skeletal	m	Lithic	Haplustolls	31	54	Low Stony Hill/Steep Rocky
			Eckert	Loamy-skeletal	x	Lithic	Haplustolls	38	44	Low Stony Hill/Steep Rocky
Flood-plain	Skeletal	V Deep	Orif	Sandy-skeletal	c	Typic	Ustifluvents	28	40	Loamy Bottomland
			Dev	Loamy-skeletal	c	Cumulic	Haplustolls	10	35	Loamy Bottomland
	N-skeletal	V Deep	Boerne	Coarse-loamy	c	Fluventic	Ustochrepts	42	50	Loamy Bottomland
			Frio	Fine	m	Cumulic	Haplustolls	38	56	Loamy Bottomland
			Oakalla	Fine-loamy	c	Cumulic	Haplustolls	36	46	Loamy Bottomland
			Bosque	Fine-loamy	x	Cumulic	Haplustolls	42	64	Loamy Bottomland
Terrace	N-skeletal	V Deep	Shep	Fine-loamy	x	Typic	Ustochrepts	32	50	Hardland Slopes
			Karnes	Coarse-loamy	c	Typic	Ustochrepts	30	44	Clay Loam
			Atco	Coarse-loamy	c,h	Aridic	Ustochrepts	25	44	High Lime
			Luckenbach	Fine	m	Udic	Argiustolls	36	46	Clay Loam
			Lewisville	Fine-silty	x	Typic	Calciustolls	44	66	Clay Loam
			Uvalde	Fine-silty	x	Typic	Calciustolls	26	44	Clay Loam
			Sunev	Fine-loamy	c	Typic	Calciustolls	40	56	Clay Loam
			Rowena	Fine	x	Vertic	Calciustolls	25	44	Clay Loam
			Rio Diablo	Fine	x	Aridic	Haplustolls	26	34	Clay Loam
			Krum	Fine	m	Udertic	Haplustolls	38	50	Clay Loam
			Rioconcho	Fine	x	Vertic	Haplustolls	24	38	Loamy Bottomland
			Barbarosa	Fine	m	Udertic	Paleustolls	40	50	Clay Loam
			Tobosa	Fine	m	Typic	Chromusterts	23	36	Clay Flat
			Depalt	Fine	m	Udic	Chromusterts	42	48	Deep Redland
		M Deep	Topia	Very-fine	x	Vertic	Argiustolls	32	48	Deep Redland
			Pratley	Fine	m	Petrocalcic	Paleustolls	32	44	Clay Loam
			Anhalt	Very-fine	m	Udic	Chromusterts	32	50	Redland
		Shallow	Speck	Clayey	x	Lithic	Argiustolls	31	46	Redland
			Mereta	Clayey	x,s	Petrocalcic	Calciustolls	24	42	Shallow
			Olmos	Loamy-skeletal	c,h,s	Petrocalcic	Calciustolls	25	40	Shallow Ridge
			Cho	Loamy	c,s	Petrocalcic	Calciustolls	25	50	Very Shallow
De-pression	N-Skeletal	V Deep	Roscoe	Fine	m	Typic	Pellusterts	25	38	Clay Flat
			Randall	Fine	m	Udic	Pellusterts	24	38	Lakebed

Mineralogy family: c = carbonatic, m = montmorillonitic, x = mixed
Depth family: s = shallow
Temperature family: h = hyperthermic

Appendix B -- Australian Key to Landform Elements (modified from Speight 1984)

A. Landform element that stands above all, or almost all, points in the adjacent terrain

CREST

Landform element that stands below all, or almost all, points on the adjacent terrain

DEPRESSION

B. Depression that extends at the same elevation, or lower, beyond the locality where it is observed

OPEN DEPRESSION

C. Depression that stands below all points on the adjacent terrain

CLOSED DEPRESSION

D. Landform element that is neither a crest nor a depression and that has an inclination greater than about 1%

SLOPE

E. Landform element that is neither a crest nor a depression and that is level or very gently inclined (less than about 3%)

FLAT

F. Compound landform element comprising a narrow crest and adjoining slopes, the crest length being less than the width of the landform element

HILLOCK

G. Compound landform element comprising a narrow crest and adjoining slopes, the crest length being greater than the width of the landform element

RIDGE

CREST Landform element that stands above all, or almost all, points in the adjacent terrain. It is characteristically smoothly convex upwards.

AA. Very gently inclined to steep crest, smoothly convex, eroded mainly by creep and sheet wash, standing above a hillslope

HILLCREST

AB. Extensive level to gently inclined crest with abrupt margins, commonly eroded by water-aided mass movement or sheet wash

SUMMIT SURFACE

DEPRESSION Landform element that stands below all, or almost all, points on the adjacent terrain.

B. Depression that extends at the same elevation, or lower, beyond the locality where it is observed

OPEN DEPRESSION

BA. Moderately inclined to very steep open depression with concave cross-section, eroded by collapse, landslides, creep or surface wash

ALCOVE

BC. Open depression with moderately inclined to very gently inclined floor or small stream channel and short precipitous walls, eroded by channelled stream flow and consequent gravitational fall and water-aided mass movement

GULLY

BD. Linear, generally sinuous open depression forming the bottom of a stream channel eroded and locally excavated, aggraded or built up by channelled stream flow. Parts that are built up include bars

STREAM BED

BE. Linear, generally sinuous open depression, in part eroded, excavated, built up and aggraded by channelled stream flow. This element comprises stream bed and banks

STREAM CHANNEL

C. Depression that stands below all points on the adjacent terrain

CLOSED DEPRESSION

CC. Steep-sided closed depression eroded by solution directed towards an underground drainage way, or collapse consequent on such solution

DOLINE

CE. Water-filled closed depression

LAKE

CG. Long, curved, commonly water-filled closed depression eroded by channelled stream flow but closed as a result of aggradation by channelled or over-bank stream flow, during the formation of a meander plain landform pattern. The floor of an ox-bow may be more or less aggraded by over-bank stream flow, wind, and biological (peat) accumulation

OX-BOW

CH. Shallow, level-floored closed depression, intermittently water-filled, bounded as a rule by flats aggraded by sheet flow and channelled stream flow

PLAYA

SLOPE Landform element that is neither a crest nor a depression and that has an inclination greater than about 1%.

Slope element adjacent below a crest or flat but not adjacent above a flat or depression

UPPER SLOPE

Slope element not adjacent below a crest or flat, and not adjacent above a flat or depression

MID-SLOPE

Slope element adjacent above a flat or depression but not adjacent below a crest or flat

LOWER SLOPE

Slope element adjacent below a crest or flat and adjacent above a flat or depression

SIMPLE SLOPE

Element upslope is gentler, element downslope is steeper

WAXING SLOPE

Element upslope is steeper, element downslope is gentler

WANING SLOPE

Element upslope is gentler, element downslope is gentler

MAXIMAL SLOPE

Element upslope is steeper, element downslope is steeper

MINIMAL SLOPE

DA. Gently inclined to precipitous slope, commonly simple and maximal, eroded by sheet wash or water-aided mass movement

HILLSLOPE

DB. Laterally extensive steep to precipitous maximal slope eroded by gravity, water-aided mass movement or sheet flow (cf. *Cliff*)

SCARP

DC. Laterally extensive cliffed (greater than 300%) maximal slope usually eroded by gravitational fall as a result of erosion of the base by various agencies; sometimes built up by marine organisms (cf. *Scarp*)

CLIFF

DE. Short, gently or very gently inclined minimal midslope element eroded or aggraded by any agent

BENCH

DF. Moderately to very gently inclined waning lower slope resulting from aggradation or erosion by sheet flow, earth flow, or creep (cf. *Pediment*)

FOOTSLOPE

DG. Large gently inclined to level waning lower slope, with slope lines inclined in a single direction, or somewhat convergent or divergent, eroded or sometimes slightly aggraded by sheet flow (cf. *Footslope*)

PEDIMENT

DH. Waning or minimal slope situated below a scarp, with its contours generally parallel to the line of the scarp

SCARP-FOOT SLOPE

DI. Slope situated below a cliff, with its contours generally parallel to the line of the cliff, eroded by sheet wash or water-aided mass movement and aggraded locally by collapsed material from above

CLIFF-FOOT SLOPE

DJ. Moderately inclined or steep waning lower slope, aggraded by gravity

TALUS

DK. Very short but laterally extensive slope, moderately inclined to precipitous, forming the marginal upper parts of a *stream channel* and resulting from erosion or aggradation by channelled stream flow

BANK

FLAT Landform element that is neither a crest nor a depression and that is level or very gently inclined (less than 3% tangent approximately)

EA. Large very gently inclined or level element, of unspecified geomorphological agent or mode of activity

PLAIN

EB. Large flat resulting from aggradation by over-bank stream flow at some distance from the stream channel and in some cases biological (peat) accumulation; often characterized by a high water table and the presence of swamps or lakes; part of a *covered plain* landform pattern

BACKPLAIN

EC. Flat at the margin of a *stream channel* aggraded and in part eroded by over-bank and channelled stream flow; an incipient *flood plain*. Channel benches have been referred to as 'low terraces', but the term terrace should be restricted to landform patterns above the influence of active stream flow.

CHANNEL BENCH

ED. Flat inclined radially away from a point on the margin or at the end of a stream channel, aggraded by over-bank stream flow, or by channelled stream flow associated with channels developed within the over-bank flow; part of a *covered plain* landform pattern

FLOOD-OUT

EE. Small, gently inclined to level flat, aggraded or sometimes eroded by channelled or over-bank stream flow, typically enclosed by hillslopes; a miniature *alluvial plain* landform pattern

VALLEY FLAT

EG. Flat of bare consolidated rock, usually eroded by sheet wash

ROCK FLAT

HILLOCK Compound landform element comprising a narrow crest and adjoining slopes, the crest length being less than the width of the landform element

FB. Steep to precipitous hillock, typically convex, with a surface mainly of bare rock, either coherent or comprising subangular to rounded large boulders (exhumed core-stones, also themselves called tors) separated by open fissures; eroded by sheet wash or water-aided mass movement

TOR

RIDGE Compound landform element comprising a narrow crest and adjoining slopes, the crest length being greater than the width of the landform element.

GA. Elongated, gently to moderately inclined low ridge built up by channelled stream flow; part of a *stream bed*

BAR

GE. Very long, very low, nearly level sinuous ridge immediate adjacent to a stream channel, built up by over-bank flow. Levees are built, usually in pairs bounding the two sides of a stream channel, at the level reached by frequent floods. This element is part of a *covered plain* landform pattern. For *artificial levee*, use *embankment*. See also *Prior stream*

LEVEE

GG. Long, generally sinuous low ridge built up from materials originally deposited by stream flow along the line of a former stream channel. The landform element may include relict *levees*

PRIOR STREAM

GH. Long, curved very low ridge built up by channelled stream flow and left relict by channel migration. Part of a *meander plain* landform pattern

SCROLL

GI. Large gently inclined to level element with radial slope lines inclined away from a point, resulting from aggradation, or occasionally from erosion, by channelled, often braided stream flow, or possibly by sheet flow

FAN

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SOIL TOUR ROAD LOG

Mile 0.0 Sheet 60 of Uvalde County Soil Survey The Uvalde Civic Center is built on Knippa clay, 0 to 1 percent slopes over the Leona Formation (Table 3) on the west bank of the Leona River.

Uvalde--population about 15,000. elevation 913 feet Market center for Uvalde county and surrounding area. Economy based on agriculture (corn, cotton, vegetables), ranching (cattle, sheep, goats), hunting, tourism and recreation.

Head north, leave parking lot, and turn (left) west onto Nopal Street

First State Bank, owned by former Texas governor Dolph Briscoe, is on the north side of Nopal Street.

Mile 0.3 Turn north (right) at stoplight marking the intersection Nopal Street with Getty Street (US Highway 83).

Mile 1.7 Water tower to left (west) The Edwards Underground Aquifer serves as the sole water source for the city of Uvalde, and is the principal source of irrigation water for Uvalde county.

Mile 2.1 Southern Pacific Railroad overpass. The Southern Pacific Railroad, connecting New Orleans, Louisiana, with San Diego, California, was constructed in 1881.

Mile 2.9 Briefly leave Leona Formation (and alluvial plain) and climb onto upland underlain by Buda Limestone (Table 1). Soil exposed in road cut is mapped as Olmos and Ector soils, undulating. The delineation would probably be identified as Zorra (loamy-skeletal, carbonatic, hyperthermic Lithic Petrocalcic Calciustoll) if it were recorrelated today. Vegetation is characterized by guajillo (*Acacia berlandieri*), cenizo (*Leucophyllum frutescens*), and blackbrush (*Acacia rigidula*). Live oak (*Quercus virginia*) and cedar (*Juniperus ashei*) are absent from the plant community, suggesting a hyperthermic soil temperature regime.

Mile 3.2 Cross fault. Downthrown block is to the south. Buda Limestone caps hilltop just ahead. Del Rio Clay crops out on hillside. *Exogyra arietina* fossils are abundant along the base of the hill. The Del Rio Clay acts as a cap or aquitard for the Edwards Aquifer. In Uvalde County Soil Survey, these hillsides were correlated as Badland, a miscellaneous land type. Similar soils were mapped and correlated as Felipe (clayey, mixed, thermic, shallow Ustollic Camborthids) in the soil survey of Val Verde County. Areas like that east of the road (a toeslope below an outcrop of Del Rio Clay) would have been mapped as Valverde (fine-silty, carbonatic, thermic Ustollic Calciorthids) in the Val Verde County soil survey.

Mile 4.2 Leona River Bridge Sheet 52, Uvalde County soil survey

Enter Leona Formation and alluvial plain landform once again. Prior to the construction of the watershed protection structures, the Leona River was a flood hazard to the city of Uvalde. Flood waters at one time reached as high as K-Mart and HEB stores.

Knippa and Uvalde soils dominate much of the alluvial plain in Uvalde County. Most of the cropland in Uvalde County is irrigated and is situated on Knippa and Uvalde soils. Graded furrow irrigation using gated pipe is the most common irrigation system, though center pivot and lateral move irrigation systems are used as well.

Both the Uvalde and Knippa series are classified in the Clay Loam Range Site. Woody plants that dominate this range site include mesquite (*Prosopis glandulosa*), granjeno (spiny hackberry, *Celtis pallida*), blackbrush, guajillo, and guayacan (*Porlieria angustifolia*). Live oak and cedar are absent from the Clay Loam range site in the Rio Grande Plain MLRA, perhaps indicative of the hyperthermic soil temperature regime.

Mile 5.3 Terrace scarp. Sabenyo soils (fine-loamy, carbonatic, hyperthermic Aridic Ustochrepts) are mapped on terrace scarps in Uvalde county. The Sabenyo series is similar to the Seawillow series (fine-loamy, carbonatic, thermic Udic Ustochrepts) mapped in Coryell County.

Mile 6.8 Enter a large delineation (several thousand acres) of Knippa clay. Hills on eastern horizon are volcanic necks composed of basalt. Ingram soils (fine, mixed, hyperthermic Torrertic Haplustolls) are mapped on these volcanic hills in Uvalde and Kinney Counties.

West of the road is one of the watershed structures mentioned earlier. In its basin is a recharge well that was drilled by the Edwards Underground Water District.

On the northern horizon are scarps of the eroded Balcones Fault Zone at the margin of the Edwards Plateau. The Balcones Fault Zone is the recharge zone of the Edwards Aquifer. The Edwards Artesian Aquifer is recharged primarily by stream flow into sink holes, fractures, and recharge wells located in the recharge zone.

Sheet 44, Uvalde County soil survey

Mile 9.2 Cross a small delineation of Olmos (loamy-skeletal, carbonatic, hyperthermic, shallow Petrocalcic Calciustolls). Fragments of the petrocalcic horizon were brought to the surface when the area west of the highway was root-plowed last spring.

Mile 9.5 Junction with FM 2690.

Mile 11.0 Sabenyo soil mapped on scarp between terrace and floodplain of Leona River.

Mile 11.8 Angora goats grazing small grain on Knippa clay.

Mile 12.4 Delineation of Eckrant soils (clayey-skeletal, montmorillonitic, thermic Lithic Haplustolls) on east side of highway. Eckrant soils are shallow over the Salmon Peak Limestone at this location.

The Eckrant series was established while field work for the Uvalde County soil survey was underway. The type location for the series is about 10 miles northeast of here. According to Jack Stevens, "Father of the Eckrant series", it was established to include the soils between the Tarrant series (clayey-skeletal, montmorillonitic, thermic Lithic Calciustolls) to the north and the Ector series (loamy-skeletal, carbonatic, thermic Lithic Calciustolls) to the west. The Eckrant series has been correlated as far north as Bosque County.

The Eckrant series mapped here is in the Low Stony Hill range site. Live oak, Ashe juniper, prickly pear (*Opuntia lindheimeri*), and Texas persimmon (*Diospyros texana*) are the dominant woody plants on this range site. Apparently the juniper has been removed from this particular delineation. Eckrant, Ector, and Langtry soils form a continuum along a soil moisture gradient. Eckrant soils are located where precipitation is sufficient to support live oak and cedar. Ector soils receive enough rainfall on average to support cedar, but live oak is unable to tolerate the dryness of the Ector soil. Langtry soils occur in climatic zones too arid for even cedar. Eckrant, Ector, and Langtry soils occur in Uvalde County.

Mile 14.8 Drop into Dry Frio River valley.

Mile 15.4 The Dry Frio River is east of highway. Ector soil on west side of highway. The plant community contains cedar, but live oak is absent.

Ector soils ([Aridic] Lithic Calciustolls) extend further east (into more humid climate) on steep (>20%) slopes than on hilly (<20% slope) areas. Delineations of Ector soils on steep slopes may occur adjacent to areas of Eckrant on hilly landscape. Even though the two delineations receive similar amounts of precipitation, the rainfall on the steep slope is less effective because of greater runoff, greater drainage, and higher insolation.

Mile 15.8 Eckrant soils, supporting live oak, occur on a hilly (<20% slope) delineation. Underlying bedrock has been mapped Salmon Peak Limestone. The steep slope west of highway was apparently mapped McKnight Formation on the San Antonio Geologic Atlas sheet. This area is a graben (a block that has been downthrown along faults relative to the blocks on either side).

Sheet 28, Uvalde County soil survey.

Mile 17.1 Cross Deep Creek bridge. Uvalde soils are mapped on the terraces on the west side of the Dry Frio River. Cross the boundary between the Maverick Basin sequence (West Nueces Limestone, McKnight Formation, Salmon Peak Formation) and Devils River Trend (Devils River Limestone).

Mile 18.7 Steep slopes that support live oak in plant community might be mapped as Oplin today. Those that lack liveoak would be mapped as Ector.

Mile 20.2 More Limestone Rockland (Rock outcrop-Ector [Oplin?] complex) soils on steep slopes.

Mile 20.9 Speck soils (clayey, mixed, thermic Lithic Argiustolls) mapped over caliche cemented conglomerate (a petrocalcic horizon), easily mistaken for a lithic contact.

Sheet 20, Uvalde County soil survey

Mile 21.6 Frio soils (Fine, montmorillonitic, thermic Cumulic [Udic] Haplustolls) mapped on the alluvial terrace east of US 83. Large pecan trees occupy this soil in Uvalde County. This map unit is equivalent to the Oakalla series (Fine-loamy, carbonatic, thermic Cumulic Haplustolls) we are using in the legend for Edwards and Real Counties soil survey.

Mile 21.8 Cross Dry Frio River bridge.

Mile 22.8 Silver Mine Pass. Steep Eckrant on southeast side of road.

Sheet 21, Uvalde County soil survey.

Mile 25.0 Speck and Pratley (fine, montmorillonitic, thermic Petrocalcic Paleustolls) soils mapped in cutoff meander of the Frio River.

Mile 25.4 Junction of US 83 and Texas 127. Concan community.

Volente (fine, mixed, thermic Pachic Haplustolls) soils mapped on terrace of Frio River are equivalent to the Krum soils (fine, montmorillonitic, thermic Udertic Haplustolls) in the Edwards and Real Counties soil survey legend.

Mile 26.3 On the west side of the road is the first recognizable outcrop of the Glen Rose Formation of this field trip. The contact between the Devils River Limestone and the Glen Rose Formation is frequently marked by Spanish oak (*Quercus texana*) trees. Examples of Spanish oak with 1990 season leaves still on may be seen for the next 20 miles.

Mile 27.1 Cross Shut In Hollow.

Sheet 13, Uvalde County soil survey

Mile 28.2 Volente soils on valley floor, with steep Eckrant soils on either side of the valley bottom.

Mile 29.1 Junction of US 83 and River Road. The Glen Rose Formation outcrop here supports Spanish oak. Real soils (loamy-skeletal, carbonatic, thermic, shallow Typic Calciustolls) are mapped where marly beds of the Glen Rose have a mollic epipedon. Eckrant soils occur over the massive limestone beds that characterize the upper Glen Rose Formation. The Frio River valley is east of the road.

Sheet 12, Uvalde County soil survey

Mile 31.5 Cross Elm Creek bridge.

Sheet 4, Uvalde County soil survey

Mile 32.5 Old valley fill (caliche cemented limestone conglomerate) is exposed in the road cut east of highway.

Mile 33.3 Entrance to Garner State Park, the most-visited state park in Texas. The Frio River is perennial in the reach that flows through Garner State Park. The Glen Rose Formation crops out on the slopes above the valley. Brackett soils (fine-loamy, carbonatic, thermic Udic Ustochrepts) are mapped on Glen Rose outcrops that have an ochric epipedon. Brackett soils would be mapped as Kerrville (loamy-skeletal, carbonatic, thermic Typic Ustochrepts) in Edwards and Real Counties.

Mile 34.5 Junction of FM 1050, the road to Utopia.

Pecans on the lower slope east of the highway are growing on Montell clay (fine, montmorillonitic, hyperthermic Entic Pellusterts). The upper slope is mapped as Pratley clay.

Mile 35.4 Scenic overlook on east side of highway.

Mile 36.2 Uvalde-Real County line.

Population of Real County in 1990 was 2412. Real County was organized at the turn of the century from parts of Bandera, Edwards, and Kerr counties. It was named for Louis Real, a prominent local businessman. The economy is based on ranching (Angora goats, sheep, cattle), cedar harvesting, hunting, and recreation. Several youth camps are located in this scenic county. Among these are HEB Foundation Camp north of Leakey on US 83, and Alto Frio Baptist Encampment. Real County is a popular place for retirement.

Mile 36.4 Cross Buffalo Creek Bridge.

Mile 36.7 Topia soil (very fine, mixed, thermic Vertic Argiustolls) on old (Mid Pleistocene?) stream terrace.

Mile 37.6 Live oak, cedar, and little bluestem (*Schizachyrium scoparium*) characterize the Adobe Range Site on the Real series. This area would be mapped Real-Cho-Rock outcrop complex, 1 to 20 percent slopes. Classification of the Cho series is loamy, carbonatic, thermic, shallow Petrocalcic Calciustolls.

Mile 38.8 Bald cypress (*Taxodium distichum*) trees are visible along the Frio River east of the highway. Bald cypress is a deciduous conifer characteristic of slow-flowing streams on the Gulf Coastal Plain. However, it grows abundantly beside the spring-fed Frio, Sabinal, and Medina Rivers that drain the southern Edwards Plateau. It does not occur in the East Nueces and the West Nueces Rivers to the west. Bald cypress also occurs along the South Concho River near Cristoval (south of San Angelo in Tom Green County).

Mile 40.7 Cross Flat Creek bridge.

Mile 43.0 Junction with FM 1120.

Mile 43.8 Junction with FM 337. Enter the town of Leakey. Population in 1990 was 399. Leakey was founded in 1883 on the Edwards-Bandera County line by John Leakey, who built a sawmill and operated a cypress shingle business. Leakey was county seat of Edwards County until 1891, when the county seat was moved to Rocksprings. Leakey became the county seat of Real County when it was organized.

Mile 43.9 Real County courthouse, on the east (right) side of US 83, was constructed in 1935-1937 by the Works Progress Administration.

Mile 44.6 Cedar post yard on west side of highway. Harvesting cedar is an important industry in Real County. Products from cedar include corner posts, fence posts, stays, and cedar oil. The Tex-aroma cedar oil mill, located east of Leakey, extracts oil from cedar. Cedar oil is used to make fragrances for perfumes worldwide.

Mile 44.8 Junction with FM 336. Turn left onto FM 336 (Prade Ranch road).

Mile 45.3 Pit in old valley fill. Gravel is plugged 10 feet thick with caliche cement. The non-skeletal soil over the petrocalcic horizon would be mapped as Cho. The boundary (transition?) between the Devils River Trend (Devils River Limestone) and Comanche Shelf Sequence (Fort Terrett and Segovia Formations) occurs here.

Mile 46.3 Spanish oaks growing on steep slope west of road. The upper half of the slope is cut onto the Fort Terrett Formation, while the Glen Rose Formation crops out on the lower half. This area would probably be mapped as Real, Rock outcrop, and Kerrville soils, 20 to 60% slopes.

Mile 46.7 Exposure of Glen Rose Formation on the west side of road. Live oak, cedar, Spanish oak, and little bluestem dominate the Adobe Range Site on Real soils. This area probably would be mapped as Real-Cho-Rock outcrop complex, 1 to 20 percent slopes.

Mile 47.3 Cross Ash Creek bridge.

Mile 48.2 Cross cattle guard into H.W. Lewis Ranch. Soils forming in the Glen Rose Formation on the west side of the road are mapped as Kerrville-Real-Rock outcrop complex, 1 to 20 percent slopes.

Mile 48.8 STOP 1--Dev series. Exit bus, follow flagged trail to Site 1 located on an occasionally flooded, late Holocene age low stream terrace (floodplain) (see page 3 for discussion).

Mile 49.5 Low water crossing of Cedar Creek.

Mile 49.6 Turn left (west) at intersection with Cedar Creek Road. H.W. Lewis Ranch headquarters is located on the east side of FM 336.

Mile 50.1 Bump gate on Cedar Creek road.

STOP 2--Topia series. Exit bus, walk to stream cut along Cedar Creek 120 feet south of Cedar Creek road (see page 6 for discussion).

Stream cut discussion. Three layers of caliche cemented conglomerate can be observed in this stream cut. The lowermost conglomerate appears to have been truncated after it formed by stream erosion, and later filled and buried by a second episode of aggradation. The second gravel deposit was plugged and cemented, and then later buried. The third gravel deposit was plugged and cemented with lime. The Topia soil is forming in clayey material above the third conglomerate deposit.

Enter bus, turn around, retrace road back to Leakey.

Mile 50.6 Turn south (right) on FM 336.

Mile 55.4 Continue south at junction with US 83. Several state and national champion trees occur near Leakey.

Redbud (*Cercis canadensis*) in Leakey. State Champion!

Bald cypress (*Taxodium distichum*) on Bill Burditt Ranch east of Leakey. State Champion!

Carolina basswood (*Tilia caroliniana*) on Bill Burditt Ranch east of Leakey. National Champion!

Live oak (*Quercus virginia*) on Rio Frio Road. Ought to be State Champion!

Mile 56.4 Turn west (right) at intersection with FM 337. FM 337 traverses the dissected southern margin of the Edwards Plateau from Camp Wood to Leakey to Vanderpool, to Riomedina in Bandera County. This may be the most scenic road in Texas. The Tour of Texas Bicycle race was held in March-April here.

Mile 57.4 Oplin-Rock outcrop-Eckrant complex, 20 to 60 percent slopes on either side of the valley eroded by Patterson Creek. The classification of Oplin soils is loamy-skeletal, carbonatic, thermic Lithic Calciustolls.

Mile 60.5 Cross bridge and enter Leakey road cut geological section. This cut exposes the type location of the Devils River Limestone. Descriptions of this section are contained in Long (1963) and Park (1959). Park's thesis also contains mineralogical analyses of various strata.

Mile 61.0 STOP 3 Eckrant series (see page 10 for discussion).

Examine road cut (WATCH OUT FOR THE TRAFFIC AND TRY TO MAKE YOUR OBSERVATIONS FROM THE SHOULDER ONLY) that extends from the turnout on east (right side of road) downhill to the 30 MPH sign. A pulverulent limestone bed, weathering red upon oxidation is exposed in this stretch.

The steep slopes across the valley are mapped as Oplin-Rock outcrop-Eckrant complex, 20 to 60 percent slopes. Slopes range up to 50 percent in this area. Vegetation on the Steep Rocky Range Site consists of cedar, live oak, spanish oak, and Texas mountain laurel (Sophora). Evergreen sumac (Rhus) and shrubby blue sage (Salvia ballotaeflora) occur along the west side of the road.

Walk up the hill for a view to the east of the highway from Leakey.

Mile 62.5 Lackland Gun Club road to the south (left). Enter an extensive delineation of Rumple-Comfort-Eckrant complex, 1 to 12 percent slopes, on a stable summit surface. Blackjack oak (*Quercus marilandica*) and little bluestem along the road show the inherent productivity of the Gravelly Redland Range Site.

Mile 65.4 An example of pinion pine (*Pinus remota*) occurs on south (left) side of the road.

Mile 65.6 Texas madrone (*Arbutus texana*) trees may be observed along the roadside for the next one-half mile.

Mile 67.9 High Pine Ranch on north (right) side of road.

Mile 67.9 STOP 4 Rumple soil (see page 13 for discussion).

Mile 68.4 Road to the north (right) leads to a subdivision.

Mile 69.1 Start descent into Nueces Canyon. Leave delineation of Rumple-Comfort-Eckrant complex, 1 to 12 slopes on summit surface, and enter a delineation of Oplin-Rock outcrop-Eckrant complex, 20 to 60 percent slopes..

Mile 71.3 Entrance to Roaring Springs Ranch.

Mile 73.0 Entrance to Chulagua Ranch.

Mile 73.4 Cross Camp Wood Creek. Spring flow in Camp Wood Creek is the source of municipal water in the town of Camp Wood. The steep valley walls are mapped as Oplin-Rock outcrop-Eckrant complex, 20 to 60 percent slopes. Live oak and cedar are the dominant woody plants.

Mile 75.5 Entrance to Wayne Roath Ranch. The petrocalcic horizon of Olmos (Newmos [coined name for new series])-Cho complex, 1 to 8 percent slopes is exposed in the ditch cut.

Mile 76.3 Cross Camp Wood Creek.

Mile 77.2 Red-stained chert fragments on the surface here suggest that the soil should be mapped as Topia clay, 0 to 5 percent slopes.

Mile 78.1 Cross 100th meridian and enter Del Rio sheet, Geologic atlas of Texas.

Mile 79.0 Enter the town of Camp Wood. Population in 1990 was 595. The economy is based on ranching, hunting, and recreation. Camp Fawcett, Jo Jan Van Camp, Camp Eagle, and Camp Eagle Nest are located in the Nueces Canyon. A new convalescent center has been built in Camp Wood.

Mile 79.6 Intersection of FM 337 and TX 55. Turn south (right) on TX 55 to return to Uvalde.

Mile 82.2 Cross Ranch Creek bridge. The valley of the East Nueces River is about 8 miles wide.

Mile 83.1 Real-Uvalde County line. Nueces Park, a Uvalde County park, is situated between TX 55 and the East Nueces River.

Sheet 2, Uvalde County soil survey

Mile 83.6 This low water crossing on the East Nueces River is known as Arnold Crossing. During periods of wet weather, floodwaters of the river can close the road for several hours. The initial flood surge is a wall of cedar and water. The Texas Department of Highways is in the process of placing bridges beside the three low water crossings on TX 55 between Uvalde and Rocksprings.

In the soil survey of Uvalde County, the "East Nueces River" bed was mapped as such. The Riverwash and Dev soils, frequently flooded, 0 to 3 percent slopes map unit in the Edwards and Real counties legend will join with the East Nueces River "map unit" in Uvalde County.

Mile 85.7 The pecan grove east of TX 55 is situated on a delineation of Frio soils. The highway traverses a higher (late Pleistocene?) alluvial terrace, which was mapped as Castroville silty clay loam. The classification of the Castroville series is fine-silty, mixed, hyperthermic Typic Calciustolls.

Sheet 10, Uvalde County soil survey

Mile 87.4 The highway passed through a wind gap. Since the wind gap is relatively small and no alluvium remains in the saddle, the East Nueces River probably did not flow through here during the past. Mesquite, live oak, and cedar grow on the steep south-facing slope east of the highway.

Mile 89.8 Montell community. See the historical markers on the east side of the road, but you have to be quick.

Sheet 9, Uvalde County soil survey

Mile 90.9 Cross Montell Creek. The East Nueces River is just east of the highway.

Sheet 17, Uvalde County soil survey

Mile 93.8 Chilton Stoner Ranch headquarters on east (left) side of road.

Sheet 25, Uvalde County soil survey

Mile 96.1 Round Mountain The East Nueces River may have flowed on the west side of TX Hwy. 55 as evidenced by the presence of Dev, Uvalde, and Pratley soils in the valley.

Mile 96.9 Royal Stoner gate

Mile 98.2 Old meander loop of East Nueces River

Cross 100th meridian, enter San Antonio sheet, Geologic atlas of Texas

Mile 99.7 Junction of TX 55 with FM 334 (Brackettville-Laguna Road). Site of old Laguna community. Uvalde soils are mapped on terrace.

Sheet 34, Uvalde County soil survey

Mile 101.4 Cross the East Nueces River bridge. The old low water crossing, known as Nineteen Mile Crossing, is on the south (right) side of the bridge. French Creek flows into the East Nueces River about 0.75 mile downstream. According to Vaughn (undated), the West Nueces River flowed through the valley of French Creek at one time in the past. Though French Creek is a short stream, the alluvial valley is about 05 to 1 mile wide.

Mile 103.2 Road intersection

Mile 104.4 Entrance to Park Chalk Bluff. Chalk Bluff is the type location for part of the McKnight and West Nueces Formations. This could be the reason Randy Quaid filmed his latest Lite beer commercial here in a Blimp.

Mile 104.8 Small grains on west (right) side of road are growing on Knippa clay.

Mile 106.1 Entrance to Open \ / Ranch.

Sheet 42, Uvalde County soil survey.

Mile 108.8 Turnoff to Haby Crossing.

Mile 108.8 Petrocalcic horizon of Olmos soil exposed in road cut.

Sheet 43, Uvalde County soil survey

Mile 109.4 Elm Slough. To the east of TX 55 is the railroad grade of the Uvalde Cedar Company railroad spur from Uvalde to Camp Wood.

Mile 109.5 Railroad grade is visible behind Klavermann home.

Sheet 51, Uvalde County soil survey.

Mile 110.0 Cross Little Indian Creek.

Mile 111.4 Railroad grade with galvanized culvert is visible on the east (left) side of the highway.

Mile 111.5 Leave Edwards Underground Aquifer Recharge Zone. Railroad grade on the east side of the highway is littered with railroad spikes. There are a few beer cans too.

Mile 111.8 Intersection with Indian Creek road.

Mile 112.2 Cross Indian Creek. Railroad grade is evident on east side of highway.

Mile 113.8 Fragments of the underlying petrocalcic horizon in a cultivated area of Valco soils (loamy, mixed, hyperthermic, shallow Petrocalcic Calciustolls).

Mile 114.3 Sevenmile Hill is on the west (right) side of the road. Buda Limestone caps the hill, and Del Rio Clay crops out on the hillsides.

Mile 115.8 Rhome disk plow used for brush control is in the parking lot of the old facilities of Southwest Livestock Exchange Company.

Mile 115.9 Facilities of Uvalde Corn Processors, Asgrow Seeds, and Frio Foods are visible on the horizon south of the highway.

Mile 116.8 Intersection of TX 55 and FM 1403.

Mile 117.9 Cross Cooks Slough. The Soil Conservation Service plans to channelize the stretch of Cooks Slough within the Uvalde city limits for flood protection.

Mile 118.6 Vegetable packing facility.

Mile 119.1 Cross Boon Slough.

Mile 119.5 On the north (left) side of TX 55 are carrots growing on Knippa clay.

Mile 120.3 Intersection of TX 55 and US 83. Turn south (right) on US 83 (Getty Street).

Mile 122.1 Intersection of US 83 and US 90. Turn east (left) on US 90 (Main Street). US Highway 83 extends from Perryton in the Panhandle to Brownsville in the Rio Grande Valley. US Highway crosses Texas from Anthony (northwest of El Paso) on the New Mexico border, to Orange along the Sabine River and Louisiana state line. The old building opposite the northeast corner of the town square is the Uvalde Grand Opera House.

Mile 122.8 Turn north (left) into the parking lot of the Uvalde Civic Center. End of Road Log.