The Geologic History of the Laredo Formation

Texas A&M International University
Center for Earth and Environmental Studies
Field Trip #1

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Overview

Welcome to the first CEES field trip. Today we will be exploring the Eocene Laredo Formation at a total of six localities between Laredo and Zapata, Texas. In this field trip the goal will be to determine the lithology, identify any sedimentary structures and fossils, and make a depositional environment interpretation at each outcrop that we visit.

The Laredo Formation has a rich history. The original comprehensive study of the rocks that comprise the Laredo Formation were described by Longsdale and Day (1937) and these rocks were defined as the Cook Mountain Formation whose type section is located in eastern Texas. A pioneer female geologist Julia Gardner in 1938 proposed the name Laredo Formation for the unique rocks present in the Rio Grande Valley region (Gardner, 1938). The nomenclature of the Laredo Formation did not originally catch on until Eargle (1968) supported the usage resulting in its adoption in the most recent geologic map of the region developed by the Texas Bureau of Economic Geology in 1976.

The paleogeography of the Laredo region during the Eocene (42 m.y.) was markedly different with Laredo located approximately at the paleo-shoreline with an embayment located in the location of the Rio Grande valley. As we journey to Zapata today imagine the boat trip we would be taking if we were around 42 million years ago. The presence of volcanic ash beds allows us to estimate an absolute age for these rocks.

Today the geology in the Rio Grande valley is not well exposed. Outcrops are confined to river bluffs associated with the Rio Grande River, canyon cuts within some streams, and isolated outcrops located at elevated sites. Because of the discontinuous exposures precise correlation between exposures is difficult. However, rocks have been minimally deformed. The Laredo Formation has a strike and dip of N15^{o}E, 1^{o}S. Consequently, use of basic trigonometry allows one to project outcrops over significant distance facilitating reconstruction of stratigraphic relationships.

The depositional model that we will use to guide us in our environmental interpretations is a model of siliciclastic shelf deposition presented on the SEPM Sequence Stratigraphy website. Table 1 with information regarding the specific depositional environments we will examine. Figure 1 provides with pictures illustrating the features found in a siliciclastic shelf setting allowing us to relate sedimentary structures to specific depositional environments.

Presented in Figure 2 is the paleogeographic model proposed for the Lake Casa Blanca sediments modified from Westgate (1999). This reconstruction is similar in many respects to modern day South Padre Island. To the east there are shallow marine beach and foreshore deposits associated with an ancient barrier island that protected the mainland. Behind the barrier island is a brackish lagoon. Inland from the lagoon is a drowned estuarine river valley with lowlands off to the west reflecting the ancient coastal plain. Note that this marginal marine setting is complex in terms of lateral facies distribution similar to deltas. Therefore, because facies may laterally pinch out the

degree of lateral continuity is limited in this setting potentially impeding the ability to precisely correlate the Lake Casa Blanca strata with rocks found elsewhere in Laredo.
Stops 1-3 in this field-trip will focus on the complex transition between terresterial and marine facies in the immediate Lake Casa Blanca area. Stops 4-6 are to the south along US Highway 83 between Laredo and Zapata. These stops represent a continental shelf depositional setting.

Table 1. The relationship between the sediments of a siliciclastic shelf depositional setting to tide & waves, and sedimentary structures. From SEPM Sequence Stratigraphy website (http://strata.geol.sc.edu/BoocliffsIlustExercise/BC-Exercises.html)

Setting	**Relationship to Waves & Tide**	**Sedimentary Structures**
Coastal Plain	Tidal zone, subject to storm wash-over	Trough-cross bedded fill of tidal inlet, estuarine & fluvial channels Rooted seat earths & coals
Foreshore & upper shoreface	Zone of breaking waves & the wave swash zone	Trough-cross stratified sandstone sometimes overlain by planar-cross bedded sandstone
Lower shoreface sandstones	Just above fair-weather wave base	Current ripple beds Wave ripple beds, Hummocky cross-beds Contorted beds
Transition between offshore shelf & lower shore-face	Between storm wave-base & fair-weather wave-base	Alternations of hummocky cross-stratified sandstone Highly burrowed silty mudstones
Offshore shelf	Below storm wave-base	Highly burrowed mudstones

A

B

C

D

Figure 1. Four common sedimentary structures in the Laredo Formation. (A) Planar Cross-Strafication, (B) Hummocky Cross-Stratification, (C) Burrows, (D) Trough Cross-Stratification

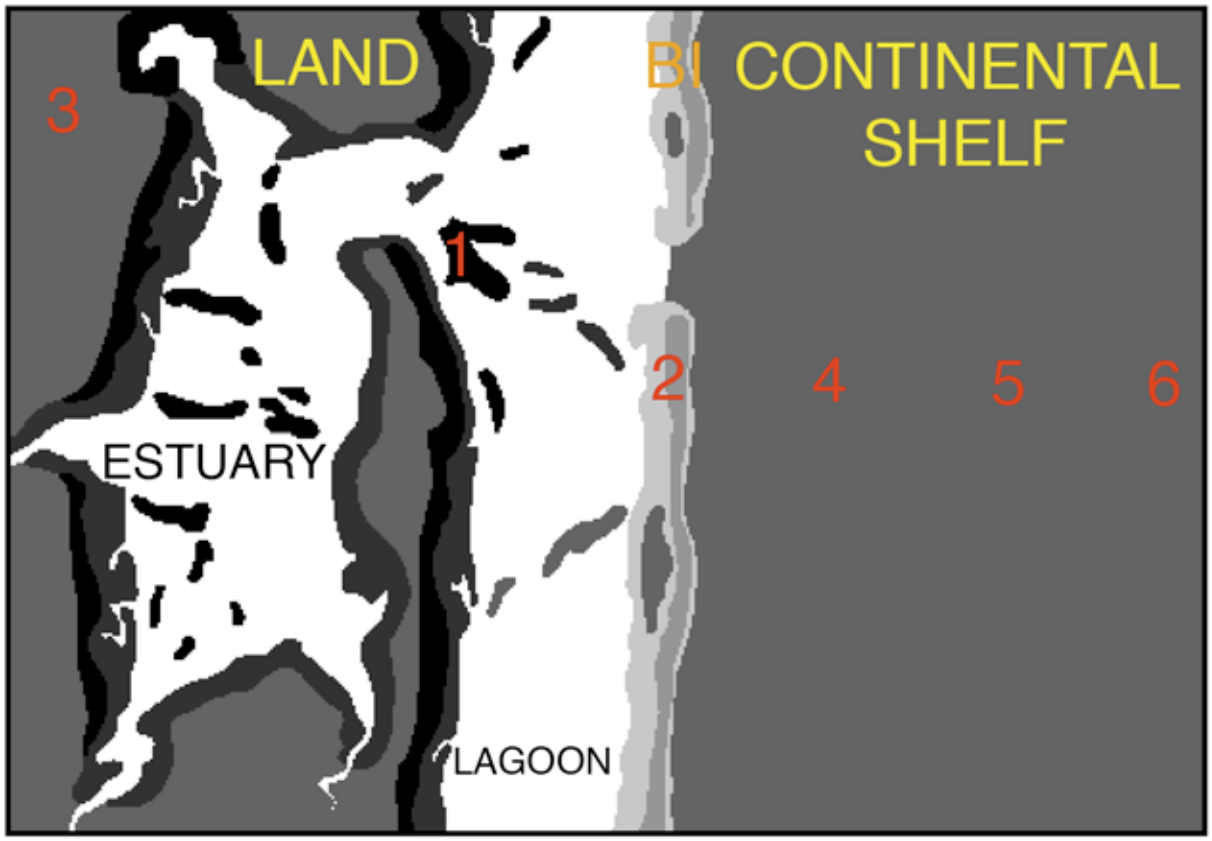

Figure 2. General paleogeographic reconstruction modified from Westgate (1988). Map shows location of stops on this field trip in red letters. General depositional settings are indicated. BI stands for barrier island.

Localities

Overview of Stops #1 to #3 - Lake Casa Blanca area

The general lithostratigraphy of the Laredo Formation in the Lake Casa Blanca area was described by Westgate (1988) and is illustrated in Figure 3. As you will note lithostratigraphic correlation is difficult in this region due to the lack of continuous exposure. In this situation geologists commonly find marker beds that have wide lateral continuity and can be used as a basis for determining location within a stratigraphic sequence. Below the lake in Chacon Creek there is such a locality (42587; unit 1; Figure 3), which consists of the index fossil Turritella Cortrzi (gastropod). Vegetation has obscured the exposure of this unit. It is stratigraphically located 72 m above the base of the Laredo Formation, which has a total thickness of 189 m. Therefore, strata in the Lake Casa Blanca vincity is near the middle of the Laredo Formation. The three localities we will be examining today are stratigraphically higher (units 2A - 5 from Figure 3). The spillway (Stops 2 and 3) outcrops are located at a stratigraphic level of 104 m above the base of the Laredo Formation.

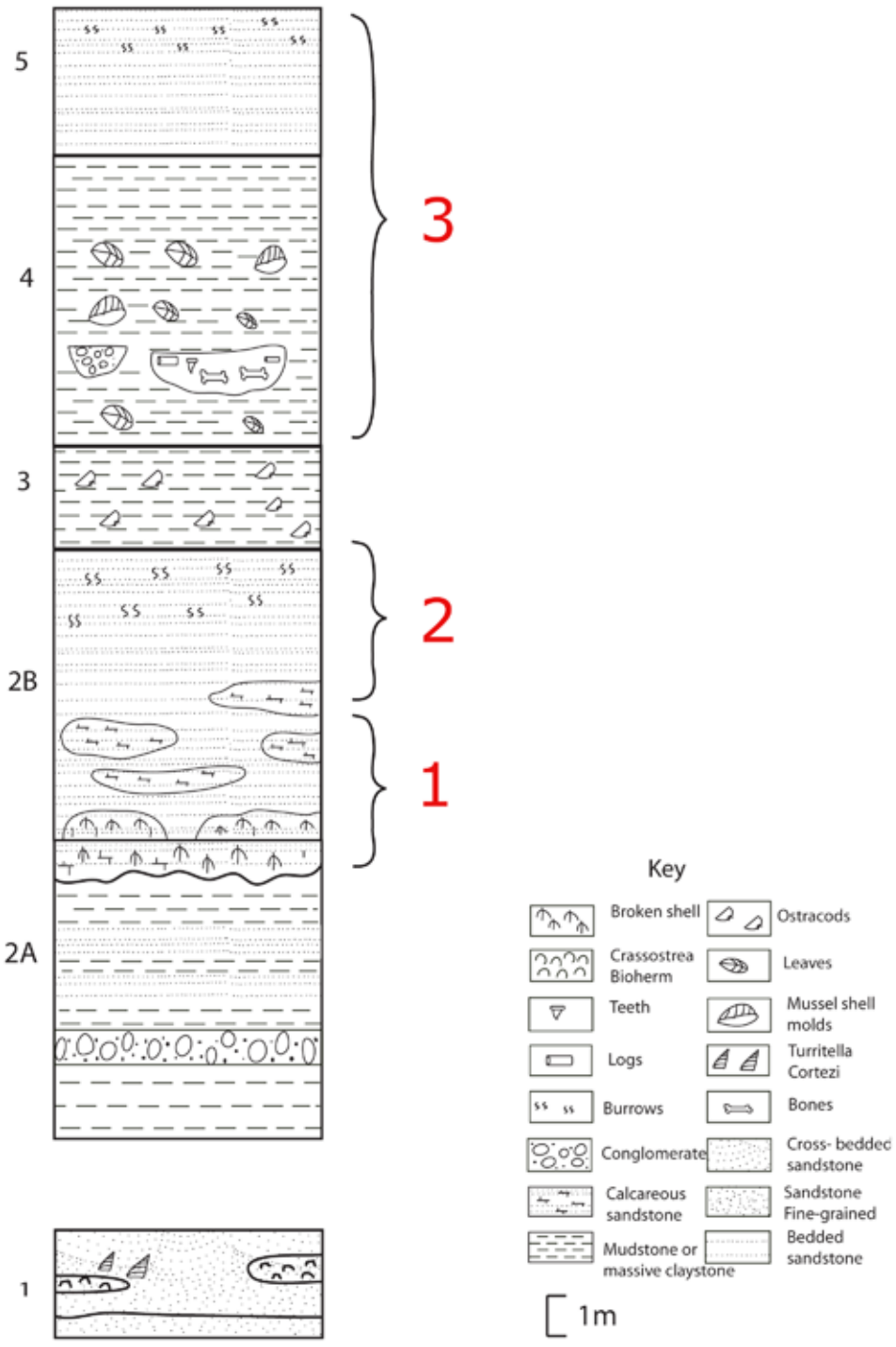

Figure 3. Stratigraphic relations in the Lake Casa Blanca vinicity. Modified from Westgate (1988). Stops 1, 2, and 3 for this field trip are indicated in red to the right of the column. Lithostratigraphic units defined by Westgate (1988) are illustrated to the left of the column.

Stop #1: Lake Casa Blanca (27^{o} 32' 57" N, 99^{o} 26' 40" W)
Vehicles should park in the large parking lot adjacent to the boat ramp.

The first outcrop we will visit is on the south shore Lake Casa Blanca where continuous exposure exists along the lakeshore. This outcrop is accessible at normal lake levels of 440 ft above sea level. Away from the shoreline, discontinuous exposure is present along trails that lead up to the picnic areas. These rocks are equivalent to units 2A-B from Westgate (1988; Figure 1).

The rock at the bottom (Unit 2A) of the outcrop is a complex mixture of both siliciclastic (quartz sand) and carbonate (oyster and gastropod) fossils, which is illustrated in Figure 4. Westgate (1988) defines these rocks as a calcareous sandstone.

In terms of the fossils, oysters (Crassostrea amichel) dominate; especially in unit 2A. Fossils are piled up into a body of shells referred to commonly as an oyster "reef" or more technically referred to as a bioherm. Finally, these organisms tend to live in brackish water with salinities of only 20 per mil (average salinity of sea water is 35 per mil).

On the side of the outcrop, you can see that there is trough-cross stratification sandstone and planar-cross bedded sandstone, impling a significant energy level associated with a tidal channel setting (Figure 2).

Figure 4. Oyster bioherm deposits exposed along a trail leading away from the shoreline of Lake Casa Blanca.

Stop #2 - Spillway (West) (27° 32' 1" N, 99° 25' 49" W) Procced 3.4 miles leaving the State Park and traveling south on Loop 20. Exit at US Highway 59. Travel approximately 1 mile east and take a left on to Representative Henry Cuellar Road. Park next to gates that block access to road that crosses the spillway. Walk 150 m west to sandstone outcrops exposed on the west side of the spillway.

This small outcrop is roughly equivalent to the top of Unit 2B from Figure 1. The rock type is mostly sandstone. There were many burrows found along with planar cross stratification. (Figures 5, 6). Also found are concretions, which consists of red sandstone cemented by hematite. Burrowed sandstone is found near the top of the outcrop and the well indurated nature of this strata is responsible for the pronounced exposure that forms an overhang. The planar stratification represents a high energy upper foreshore setting likely associated with a barrier island (Figure 2). Burrowed sandstone reflects more of an upper shoreface setting. Likely energy regimes for sediments deposited at stops 1 and 2 are depicted in Figure 7.

Figure 5 (above). Overview of exposure at stop 2. Roughly six feet of material is present at this stop.

Figure 6 (right). Close up of burrowed sandstone layer at the top of the outcrop at stop 2.

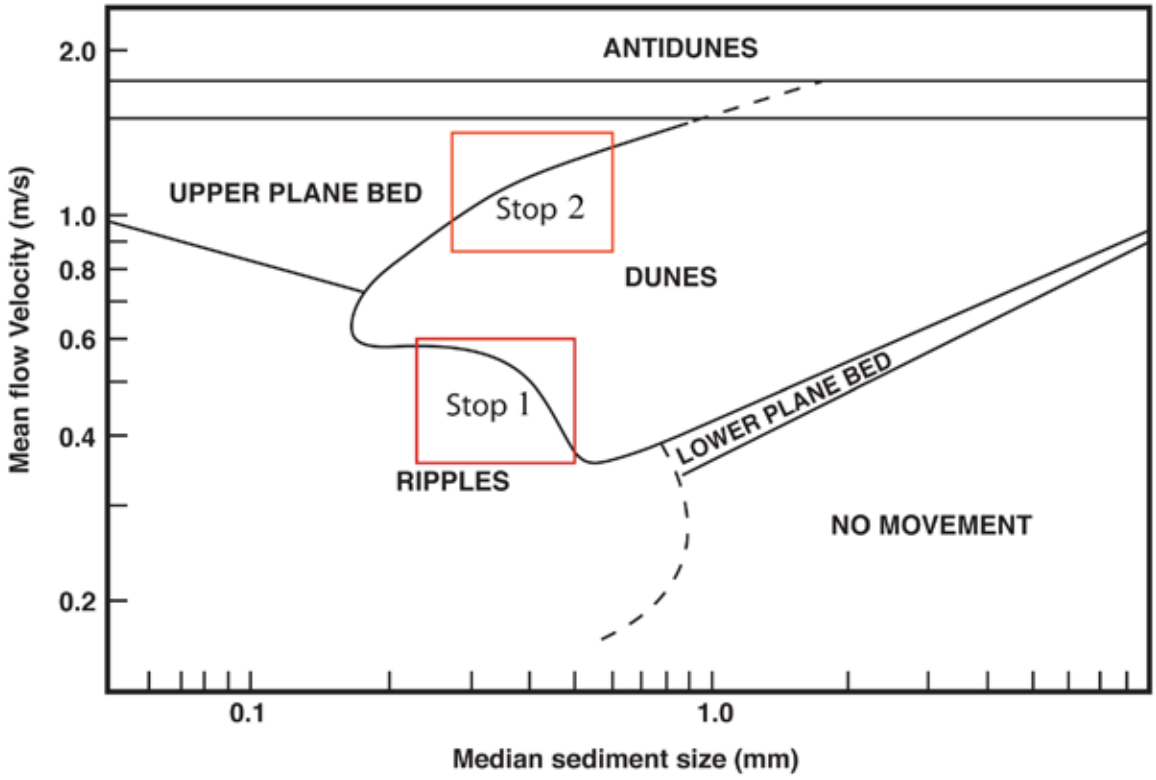

Figure 7. Relationship between bedform and current velocity modified from (from Boggs, 2006).

Stop #3 - Spillway (East) (27^{o} 32' 54" N, 99^{o} 26' 36" W)
Walk back towards the vehicles and proceed north examining the outcrop on the eastern side of the spillway.

You should note that these rocks are different from the exposures on the western spillway consisting of red siliciclastics (Figures 8, 9). Dr. Jim Westgate from Lamer University examined this outcrop in detail back in the 1980's and found a rich assemblage of fossils both plant and animal (Westgate, 1999). This outcrop hosts one of the richest deposits of early mammals in Texas and consist of 29 different species including micro-opossums, insectivores, early primates, primitive horses, rhinoceros, rodents, and early mouses.

The red color of the rock indicates oxidizing conditions associated with its deposition. The type of rock found in this locality is mostly siltstone and some sandstone. The sandstone in stop #2 is at a stratigraphically lower position than the siltstone located at stop #3. This sequence reflects a regression or drop in relative sea level. The sediments represent a coastal plain setting.

Figure 8. Overview of exposure at stop 3. Notice the highly dissected nature of this outcrop.

Figure 9. Close up of red siltstone that represents coastal plain deposits.

Overview of Stops #4 to #6 - Zapata County
The exact stratigraphic level of the localities in Zapata County is difficult to determine precisely because of the lack of exposure. However, based on examination of Laredo Formation strata on both the United States and Mexican sides of the Rio Grande, Kane and Gierhart (1935) determined that in the area of San Ygnacio the Laredo Formation is over 400 m thick. This increase in strata thickness is explained by the rapid deposition rates associated with the filling of the Rio Grande Embayment. Based on examination of the geologic map focusing on the location and elevation of outcrops it was determined that the three localities (stops #4-6) are located in the middle of the Laredo Formation roughly correlative to the rocks from the Lake Casa Blanca area.

Stop #4 - Highway US 83 - Arroyo Dolores (27^{o} 32' 1" N, 99^{o} 25' 49" W)
THIS IS A POTENTIALLY DANGEROUS LOCALITY LOCATED UNDER THE BRIDGE THAT CROSS US HIGHWAY 83. EXERCISE EXTREME CAUTION.

Outcrop is located approximately 4.4 miles south of the Zapata County line.

This stop is located under a Highway US 83 bridge (northside). There is a parking area adjacent to the arroyo. A several hundred foot downward climb on unmaintained trails is required to position oneself under the highway bridge. This is a wonderful example of how human built structures can preserve outcrops in this region. If this outcrop was out in the open it would have been long been weathered into an unrecognizable face of sand. Compare degree of weathering of rocks under the bridge versus in the open.

The type of rock present is medium grain sandstone. The sedimentary structures that are present in this location include horizontal burrows (Figure 2c), trough cross-stratified sandstone (Figure 2d), and ripples. The trough cross-stratified sandstone and ripple marks indicate that this structure was formed in a middle shoreface setting with significant current energy.

Stop #5 - Hills north of the town of San Ygnacio (27 5' 35" N, 99 25' 39" W)
THIS IS A POTENTIALLY DANGEROUS LOCALITY - EXERCISE CAUTION AROUND TRAFFIC

Multiple exposures are located in the hills north of the town of San Ygnacio. This stop is approximately 9 miles south of stop #4. Park in the road rest area at the top of the hill. Note that this rest area provides a scenic vista overlooking the Rio Grande River (refer to picture on front page of guide).

There are two areas where there are good continuous outcrops at this locality (1) below the picnic area and (2) road cut to the north of the picnic area extending over to a road cut. With the recent road construction visiting the highway exposure is not advisable. This locality is rare in South Texas in that it consists of a nearly continuous section. Figure 10 illustrates a measured section present at this locality. The base of the section (unit 1) is 50 feet below the picnic area, in the Rio Grande River floodplain. The top of the section occurs in the roadcut to the north of the pincic area.

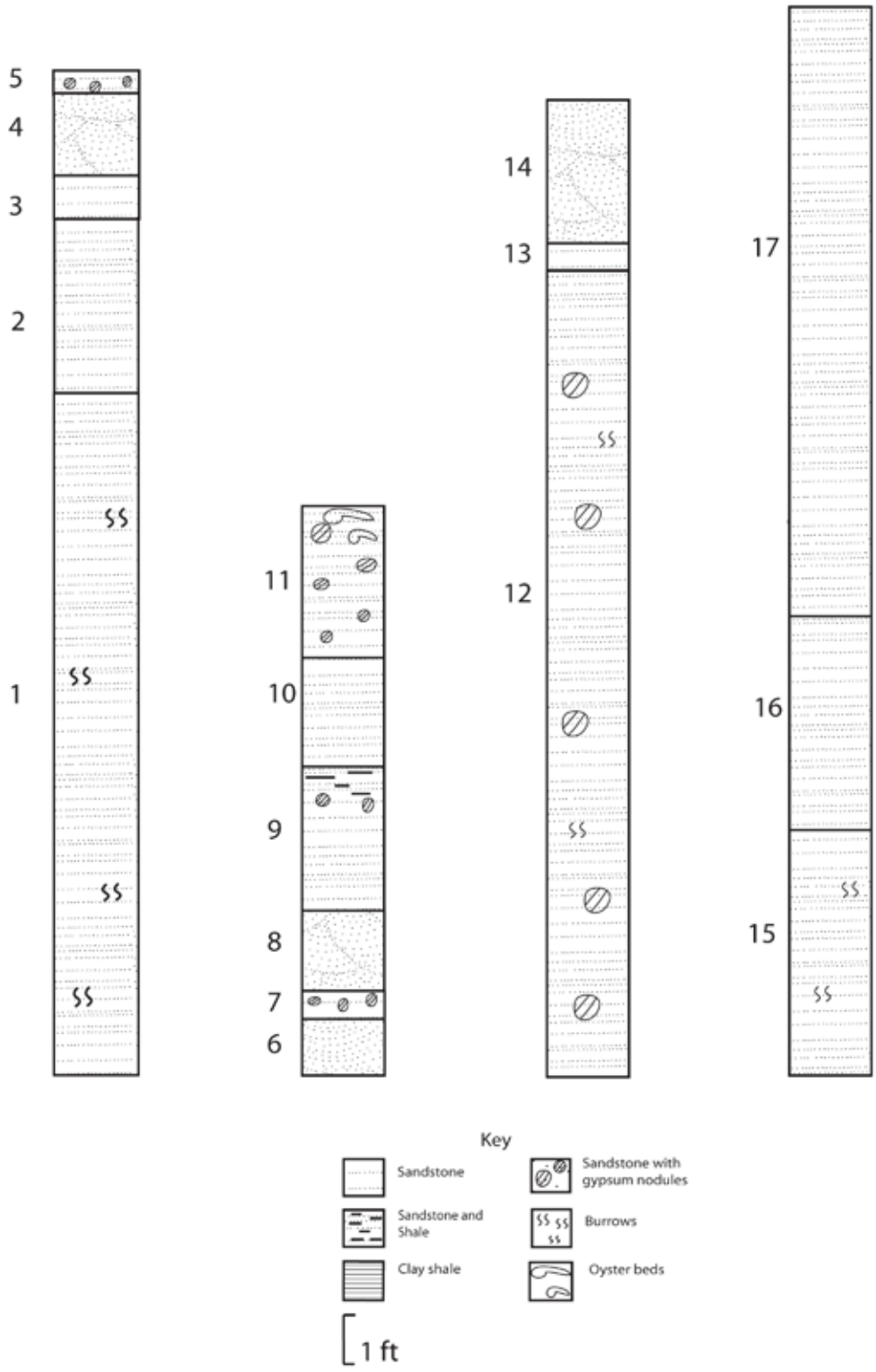

Figure 10. Composite stratigraphic section of rocks at stop #5, San Ygnacio rest area adjacent to US Highway 83.

Noteworthy features include broken shell fragments (unit 11) and a thick layer comprised of trough and hummocky cross-stratified sandstone (unit 12; Figure 11). The presencce of hummocky cross-stratification is particularly significant indicating extremely high energy conditions (storm deposits) representing lower shoreface setting (Woolfe, 1993; Table 1). Hummocky cross-stratification is believed to be associated with catastrophic storm events that happened infrequently. Oysters are likely mobilized and deposited into beds during these storm events. Note that the sandstone is finer than observed in the rocks around Lake Casa Blanca. A typical trend of fining grain-size is noted in more off-shore deposits on shelves dominated by siliciclastic sediments.

Additional geologic features of note at this locality include a reverse fault in the roadside outcrop. This fault has several feet of offset and likely was associated with the localized uplift that generated the hill at this locality.

At the top of the hill, Pleistocene river gravel lies below the Eocene deposits forming a profound disconfomity.

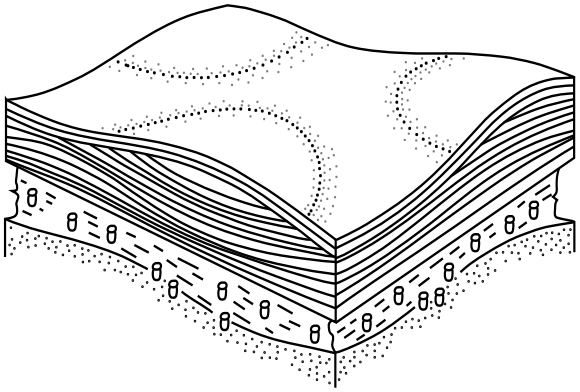

Figure 11. Hummocky cross-stratification. (Above) In the field with a hammer provided for scale. (Bottom left) Sample this shows the undulatory upper surface of this feature. (Bottom right) line drawing.

Stop #6 - Roadside outcrops near the town of Ramireno (27^{o} 1' 11" N, 99^{o} 24' 14" W)

Road cut next to southbound lane of US highway 83 in the town of Ramireno. **EXERCISE CAUTION AROUND TRAFFIC**

The stop consists of interbedded sandstone and mudstones (Figure 12). Deposits are more thinly bedded than stop #5. Cross-stratified sandstone represents deposition during higher energy storm events, whereas, mudstones are indicative of normal, low-energy conditions. Sandstone is fine-grained than at prior stops indicating a more off-shore environment. In this setting, wave action affects sediment only during storms. So this locality represents the transition between offshore shelf & lower shore-face. This is a location whose water depth is below fairweather wave base but is still above storm wave base. This site represents the most off-shore setting we will visited on the field trip (Figure 2).

Figure 12. Field photo of interbedded sandstone and mudstone deposits. Note hammer is used for scale.

References

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Mileage Log

1. Leave TAMIU, Parking Lot Adjacent to Science Building	
- Turn Left on to Loop 20 (Southbound)	0.7 miles
2. Arrive Lake Case Blanca Front Enhance	3.3 miles
3. Proceed to Stop #1 - Lake Case Blanca Boat Ramp	4.4 miles
4. Leave Stop #1	
5. Proceed to Stops #2 and 3 Lake Case Blanca Spillway	
- Back Track Through State Park	
- Leave State Park - Turn Left onto Loop 20	5.5 miles
- Turn Left onto US Highway 59	6.3 miles
- Turn Left on Representative Henry Cuellar Road	7.4 miles
- Park Next to Entrance to Spillway	7.7 miles
6. Leave Stops #2 & 3	
7. Proceed to Stop #4 - Arroyo Dolores under Zapata Highway	
- Back Track and Turn Right onto US Highway 59	8.1 miles
- Turn Left onto Loop 20 (Southbound)	9.2 miles
- Turn Right onto Magma Hein Road	18.4 miles
- Turn Left onto US Highway 83 (Southbound)	19.7 miles
- Zapata County Line	28.4 miles
- Stop #4 - Under US 83 at Sliding next to Bridge	32.8 miles
8. Leave Stop #4	
9. Proceed to Stop #5 - Hill North of San Ygnacio	
- Return to US Highway 83 Proceeding South	41.6 miles
10. Leave Stop #5	
11. Proceed to Stop #6 - Roadcut in Town of Ramireno	
- US Highway 83 Proceeding South	47.9 miles
ROADCUT IS ADJACENT TO THE SOUTHBOUND LANE	
12. Leave Stop #6	
- US Highway 83 Proceeding South	
- Turn Around and Proceed North on US 83 Returning to Laredo	48.7 miles
13. Return to TAMIU, Parking Lot Adjacent to the TAMIU Science Building	92.8 miles