

## CHAPTER 1

### **Regional geologic setting of South Texas and the Santo Thomas coal deposits**

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#### **INTRODUCTION**

This paper supplements the work that the U.S. Geological Survey has recently conducted in South Texas on the coal geology of the Eocene Claiborne Group of the Laredo area (Warwick and Hook, 1995) and the Jackson Group of the San Miguel lignite mine area (Warwick and others, 1996). I will first present a general overview of the trip route in relationship to the major structural and stratigraphic features of South Texas. Then I will present subsurface well log data to show the correlation of the coal zones into the subsurface, and place them in a regional context.

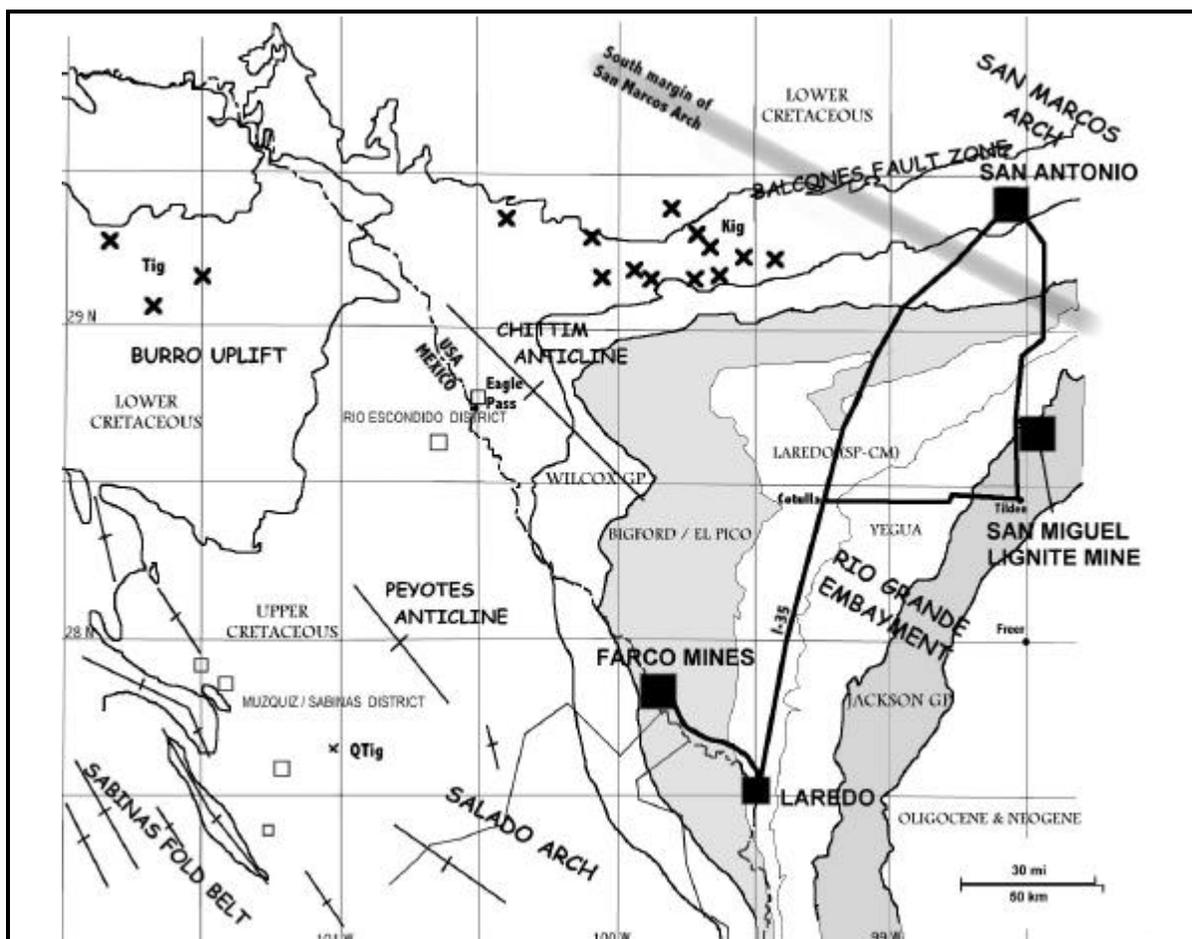
#### **GENERAL OVERVIEW OF THE FIELD TRIP ROUTE**

When we leave San Antonio, we will proceed southwest along Interstate 35 towards the city of Laredo. San Antonio is an oasis city, built around springs and deep wells drawing water from the Lower Cretaceous Edwards Aquifer along the (Miocene-age) Balcones fault zone. The city is built on rocks ranging in age from Albian (Edwards Limestone) to Paleocene (lower Wilcox Group), with younger rocks generally to the southeast.

Tectonically, the San Antonio area lies on the southwest flank of the San Marcos Arch (fig. 1), a broad southeast-trending area

of lesser subsidence than surrounding areas during Mesozoic and Cenozoic time. During the Early Cretaceous, the area was repeatedly occupied by extensive carbonate platforms (the Sligo Limestone of Aptian age and the Edwards Group carbonates of Albian age; fig. 2). As regional sedimentation shifted from carbonates to siliciclastic material in the Late Cretaceous (Campanian - Maastrichtian), the San Antonio area lay east of the major San Miguel and Olmos wave-dominated deltas of South Texas, and mainly marine shales and thin sandstones were deposited. In the Paleogene, Wilcox, Carrizo and younger sandstones were deposited in the San Antonio area, which lay in the transition between the largely strike-oriented strandplain, wave-dominated delta and bar - lagoon systems of South Texas and the fluvial-deltaic deposits of East Texas.

As we drive southwest toward Laredo, we cross the Rio Grande Embayment, a broad synclinal area between the San Marcos Arch of Central Texas and the Laramide fold systems of Mexico (fig. 1). The present Rio Grande flows along the southwest side of this embayment. The road slowly climbs the stratigraphic section, reaching the late middle Eocene ("Laredo Formation," Sparta and Cook Mountain equivalent; fig. 2) at Laredo. South of Cotulla (fig. 1), the road crosses the buried Stuart City Reef margin of the Edwards Group carbonate platform. The reef margin is gas-productive, and also controls faulting and



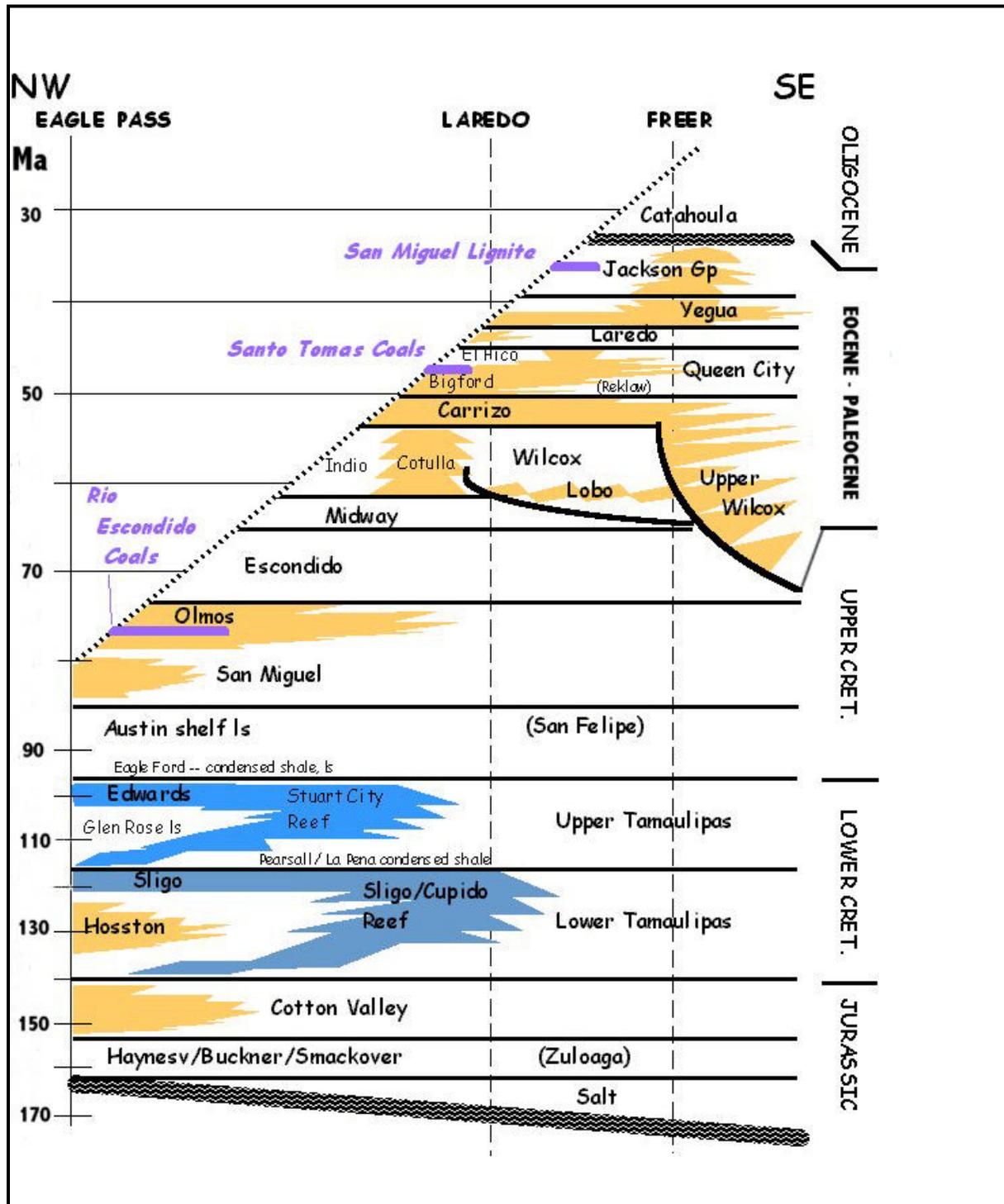
**Figure 1.** Route of the 1999 EMD field trip, with major tectonic features and outcrop belts shown. Open boxes represent locations of Upper Cretaceous coal deposits; “X” represents igneous rocks; Kig, Tig, QTig = Cretaceous, Tertiary, and Quaternary igneous rocks.

shallower marine sandstone development in the Olmos Formation. At Laredo, the position of the buried Sligo reefal shelf margin is reached. This reef contains a major gas field just across the river in the western part of Nuevo Laredo (Totonaca field) at depths of some 13,000 ft.

Jose de Escandon founded Laredo, the chief port of entry from Mexico into Texas, in the 1750s as the northernmost city of the new province of Nuevo Santander (the lower Rio Grande valley). The early trade routes from

Monclova to San Antonio passed north of the Laredo area, but the location of Laredo on the shortest route from Monterrey to San Antonio, coupled with the main rail links to both cities and to the port of Corpus Christi, ensured Laredo's economic growth.

Laredo, and the Santo Tomas district to its northwest, lie on the southwest flank of the Rio Grande Embayment. Dips are generally one degree or higher to the east in outcrops near the river. Southwest into Mexico, the dips continue until the base of the



**Figure 2.** General northwest-southeast stratigraphic section of Mesozoic and Paleogene strata along the Rio Grande, from Eagle Pass to Freer (fig. 1). The stratigraphic location of significant coal and lignite deposits are shown.

Tertiary outcrops about 12.5 mi into the interior. Several anticlinal axes, collectively referred to as the "Salado arch" or the "Burro-Peyotes arch", trend southeastward, with intermittent exposures of Austin limestone on anticlines. The east to northeast dip off the flanks of the arch towards the Rio Grande is easily visible on satellite photography. Secondary folds are seen in some areas.

After visiting the Santo Tomas area, we will travel back to the north to Cotulla, turning east to Tilden, then north to the San Miguel lignite mine (fig. 1). The trip east from Cotulla to Tilden proceeds over younger rocks than any other part of the trip. Sandy Yegua Formation deposits are overlain by the lignite-bearing Jackson Group. The hills east of Tilden are underlain by the largely volcanoclastic Catahoula (or Gueydan) Formation of Oligocene age. Zeolites have been mined from the basal Jackson strata just west of Tilden, and used as kitty litter. North of Tilden, we cross San Miguel Creek (with natural lignite exposures in its banks) and proceed to the San Miguel mine. After this classic Gulf Coast lignite deposit is viewed, we will travel back to San Antonio across Eocene and Upper Cretaceous rocks.

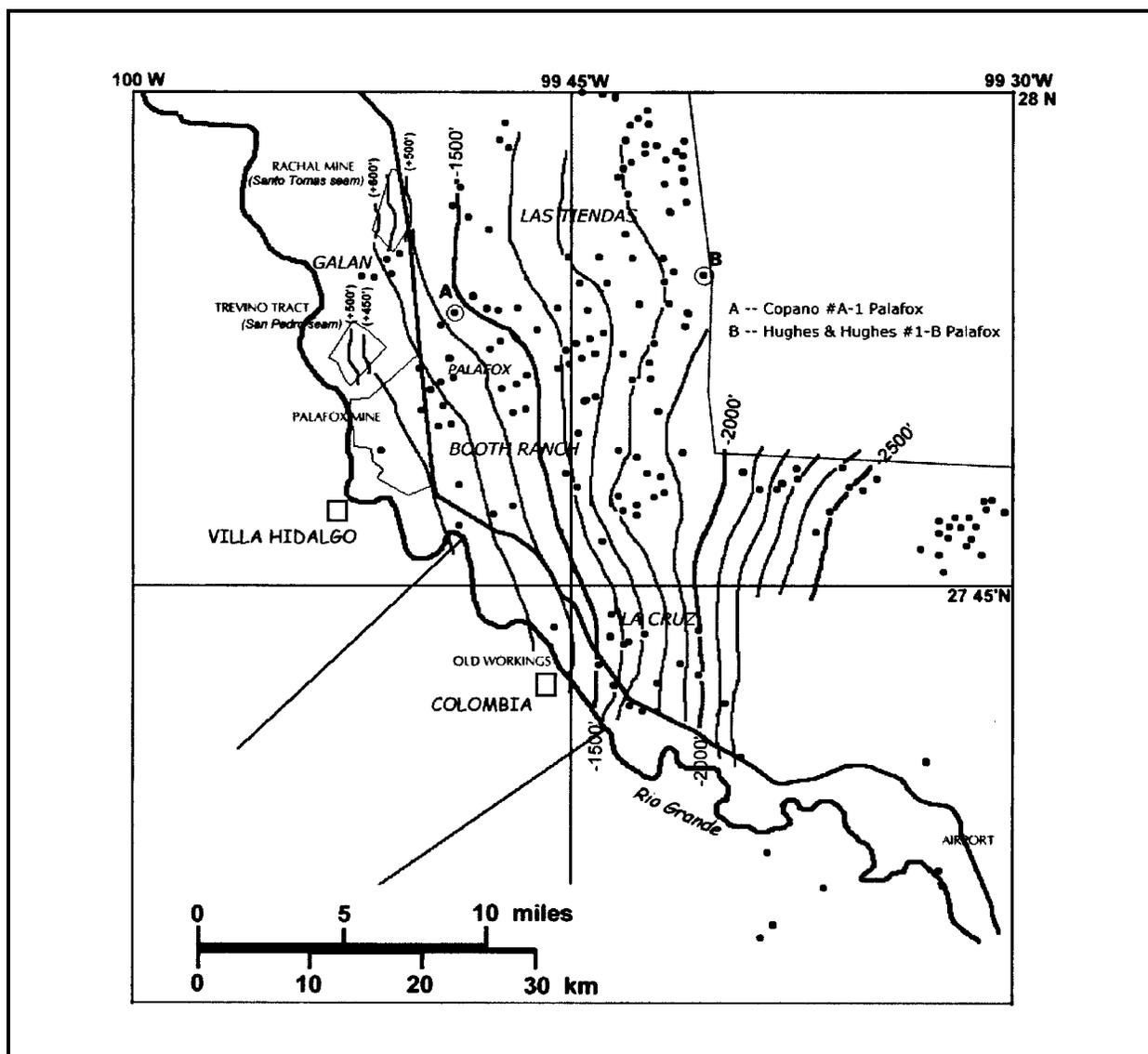
## **STRUCTURAL AND STRATIGRAPHIC SETTING OF THE SANTO TOMAS DISTRICT**

The coal beds of the Santo Tomas district lie within the Bigford Formation - El Pico Clay succession of the Rio Grande Embayment. These two formations correlate with the Queen City cycle of the Claiborne Group, and are early Middle Eocene in age (fig. 2). In South Texas, the Queen City sandstones were deposited in a mixed wave-dominated deltaic and barrier bar environment,

with a strike-oriented sandstone maximum in eastern Webb County about 30 miles east of Santo Tomas (Guevara and Garcia, 1972). Northwest of the sand maximum, the upper part of the cycle contains a low percentage of sandstone and much lagoonal shale; this has been called the El Pico Clay by Eargle (1968). The lower part of the cycle contains high percentages of sandstone (Bigford Formation as redefined by Eargle from Trowbridge, 1923), and rests directly on the Carrizo Formation and upper Wilcox sandstones with very little break. The downdip marine Reklaw formation passes westward into the Bigford shoreline sandstones.

The contact between Bigford Formation and El Pico Clay is gradational. Sandstones do occur in the El Pico "Clay", and may become more abundant northward away from the Rio Grande. The transitional beds between Bigford and El Pico are intimately associated with the San Pedro and Santo Tomas coal zones, as we will see.

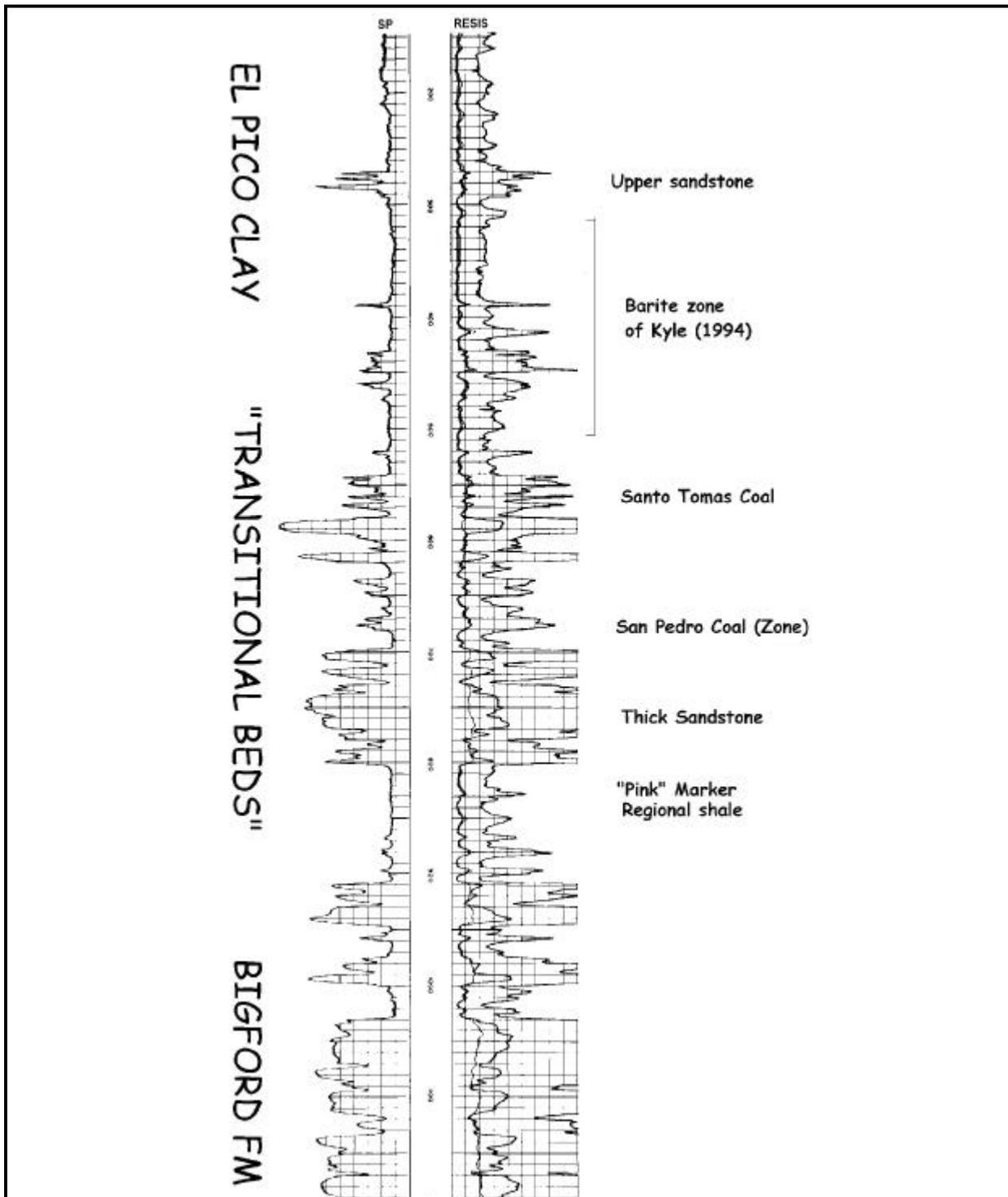
To better understand the location of the Santo Tomas coal deposits within the stratigraphic section, a pilot study was undertaken of well logs in the area around and east of the mines. The area has been extensively drilled for gas reserves in the Wilcox Group sandstones (Palafox field) and in the Olmos Formation (Las Tiendas, Booth Ranch, and La Cruz fields); gas has also been found in reefal Edwards carbonates in Galan field, just south of the Rachal Mine (fig. 3). Many of these well logs have been released, and most were logged to within a few hundred feet of the surface. A regional shale which correlates to the Middle Wilcox can be identified on all logs, and forms a good structural datum. The structure map (fig. 3) shows structural dip of 1.0-1.4 degrees to the



**Figure 3.** Subsurface structure, Top Middle Wilcox marker, Santo Tomas area. The contoured data on the Santo Tomas and San Pedro coal beds are from Warwick and Hook (1995). Gas field names are also shown.

east or east-northeast on the Middle Wilcox marker. This corresponds well to the 0.9-1.2 degrees of dip seen in the Trevino and Rachal mine areas (data from Warwick and Hook, 1995). From comparison of the Middle Wilcox data and the mine elevations, the Santo Tomas bed at the Rachal Mine lies  $1900 \pm 20$  ft above the Middle Wilcox marker. Less

certainly, the San Pedro seam at the Trevino lease lies about 1600-1650 ft above the marker, or 250-300 ft below the Santo Tomas. Elsewhere, however, the San Pedro is only 90 ft below the Santo Tomas. This suggests that the San Pedro beds are not



**Figure 4.** Electric log, Hughes & Hughes #1 Palafox Exploration "B", showing the correlation from surface mines to subsurface stratigraphy. Location of well shown on figure 3. Vertical log scale in ft.

wholly correlative, although there may be other solutions.

There is slight thickening of some stratigraphic units to the northeast, perhaps indicating structural growth on the Salado folds during Eocene time. However, the total amount of growth is not more than 100-150 ft.

The coal beds in the Rachal area can be confidently projected into the Copano #A-1 Palafox Exploration well, an Edwards test drilled in 1962 about 3 miles SSE of the Rachal mine (fig. 3). The correlation indicates that the coal beds correlate to a thin-bedded interval lying above a 60-ft thick sandstone and below a 100-ft thick shale unit. This shale ("Pink" Marker) can be observed on logs throughout the area mapped, and continues downdip at least to the Laredo airport (fig. 3). The sequence can be correlated to the east into the Hughes and Hughes #1-B Palafox Exploration well, where the overlying clay-rich sequence is also logged (fig. 4). The Pink Marker and the overlying sandstone can also be correlated to lithologic logs presented by Lonsdale and Day (1937) and Warwick and Hook (1995). Although the individual coal beds cannot be definitely located on the well logs (the coal may have some SP response?), the interval is reliably picked, and can be carried throughout the area. Downdip past the old workings towards Laredo, the interval becomes sand-rich and loses its thin-bedded, resistive character.

Due to the density of drilling in the Las Tiendas area of northwest Webb County, it should be possible, with detailed study of the subsurface logs, to more closely define the depositional geometry of the algal coals of the Santo Tomas district and estimate their resource potential.

As an added point of interest in the area, Kyle (1994, p. 41-46) has described a

significant surface occurrence of barite in the Pinto Creek drainage, just northeast of the Rachal mine. The barite occurs in clays that lie 80-250 ft above the Santo Tomas seam.

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