CHAPTER 4

Some speculations on coal-rank anomalies of the South Texas Gulf Province and adjacent areas of Mexico and their impact on coal-bed methane and source rock potential

By John R. SanFilipo

U.S. Geological Survey, 956 National Center, Reston, VA 20192

INTRODUCTION

There are two known occurrences of bituminous coal within the generally lignitic Gulf of Mexico Coal Province. One occurs in the Olmos Formation (Maastrictian) and the other occurs in the lower-middle part of the Claiborne Group (middle Eocene, fig. 1). Both occur within the Rio Grande vicinity of south Texas and Mexico, and each can be considered somewhat anomalous in rank in comparison with typical U.S. coals of similar age, which are generally less mature.

CRETACEOUS BITUMINOUS COALS

The Olmos Formation coals, which will not be visited on the field trip, occur in the Eagle Pass area of Maverick County, Texas, where a permit to mine is pending (Dos Republicas permit, fig. 2). This deposit extends into the Sabinas Basin of Mexico, where high-volatile C bituminous coal is being mined for electrical power generation by the Minera Carbonifera Rio Escondido (MICARE) for the Comission Federal de Electicidad (CFE) Carbon I and II projects (fig. 2). Core samples of these high-ash coals from the Eagle Pass area are typically about 7500 Btu/lb on an as-received (AR) basis and about 12,000 Btu/lb on a moist, mineral matter-free (MMmF) basis. Samples from Carbon I and II are reported to have an average (Rm?) vitrinite reflectance of 0.58% (Verdigo and Arciaga, 1991). These and other rank parameters for Sabinas Basin coals are somewhat higher than those for most shallow occurrences of Upper Cretaceous coals of the southern Rocky Mountain Province, for example the southern part of the San Juan Basin of New Mexico, but they are consistent with rank-elevated coals towards basin interiors or near igneous provinces on basin margins. The rank elevation of the Olmos Formation coals can probably be attributed to residual heat flow from slightly younger shallow intrusive activity of the Balcones igneous province, or much younger igneous activity within Mexico (fig. 2).

TERTIARY BITUMINOUS AND RELATED COALS

The second documented occurrence of bituminous coals in the Gulf Province is the Santo Tomas coal field in Webb County, Texas, which will be visited on the field trip. Here the Farco Mining Company (fig. 2) is mining high-volatile A bituminous coal from the lower-middle part of the Claiborne Group

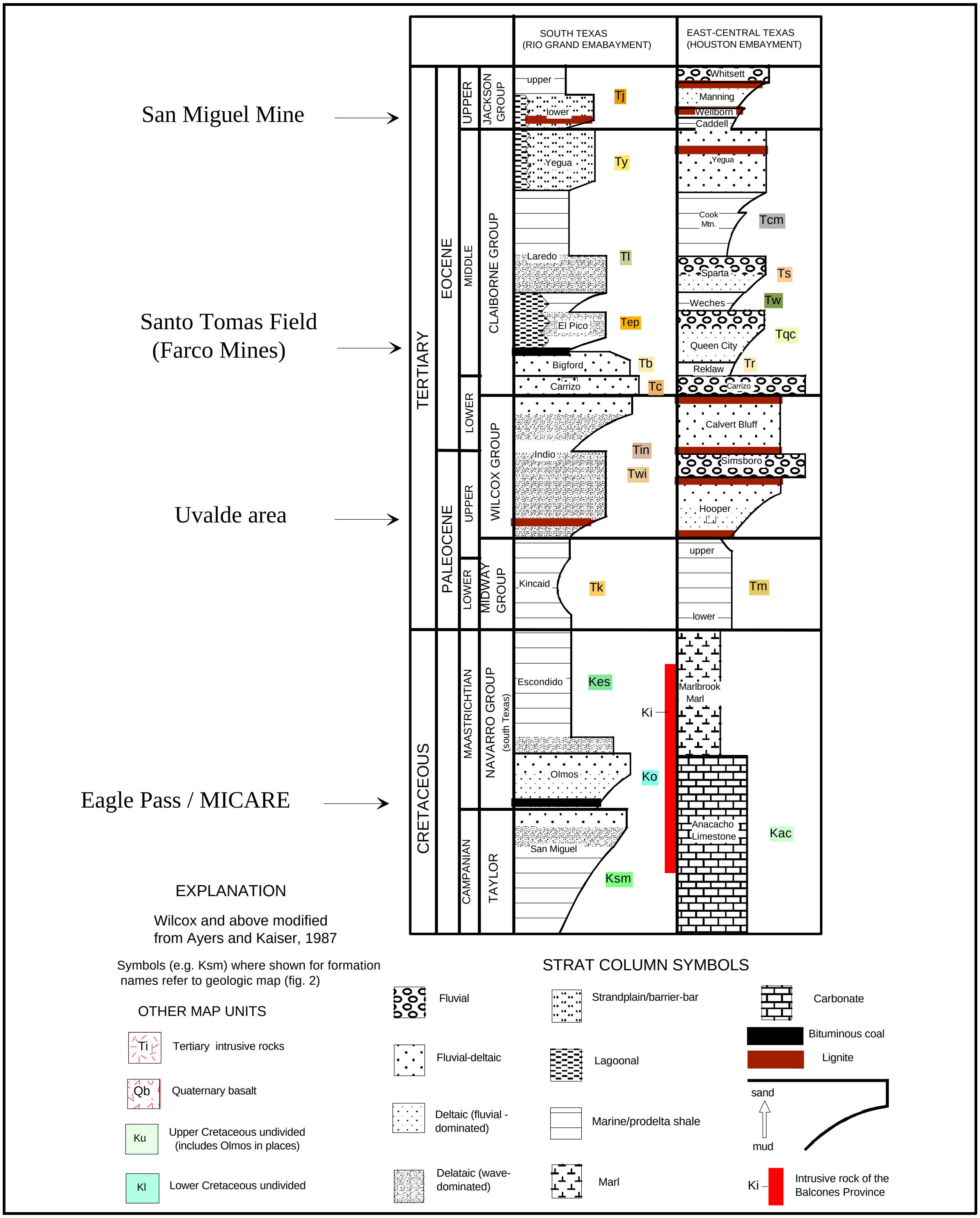

Figure 1. Generalized columnar section for south Texas coal areas and adjacent areas of Mexico.

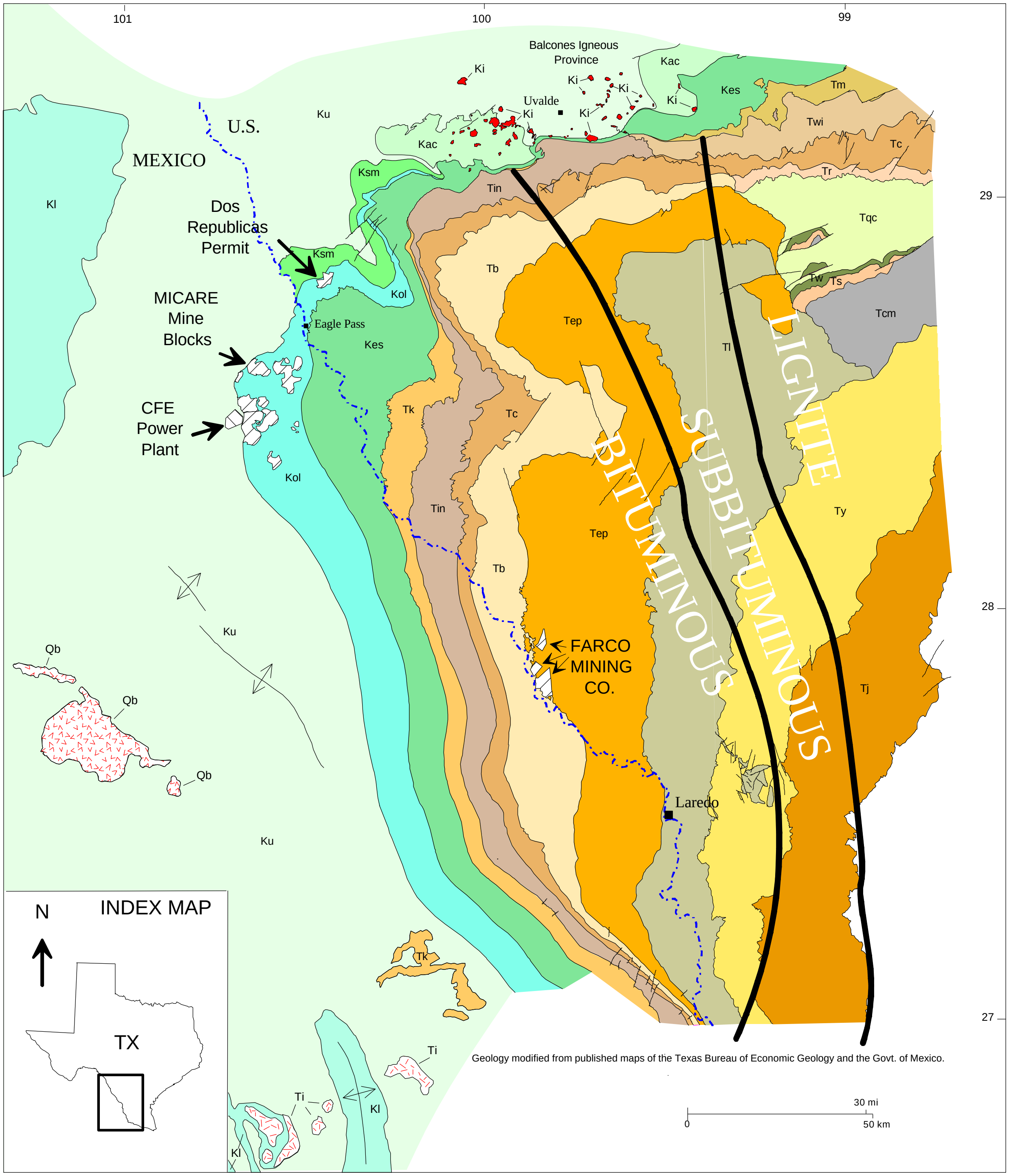

Figure 2. Regional geology and location of bituminous coal deposits of south Texas and adjacent areas of Mexico. See figure 1 for map units. Also shown are speculative boundaries of coal-rank changes.

for use in local cement plants and for export as lump coal for use in the Republic of Ireland. The coal occurs in two primary zones, the San Pedro and Santo Tomas zones, near the ill-defined contact of the Bigford and overlying El Pico Formations, about 3,000 ft stratigraphically higher than the Olmos Formation (fig. 1). Speculations on the cause of the relatively high rank of these coals are more problematic than those for the Olmos coals. Because these coals occur higher in the section than Wilcox Group coals from the same general area, which have traditionally been described as lignite (Maxwell, 1962, Breyer and McCabe, 1986), depth of burial would presumably not account for the rank elevation. Numerous lignite beds have also been described as intercalated within the San Pedro – Santo Tomas canneloid coals themselves (Lonsdale and Day, 1937), which would also presumably rule out depth of burial or local thermal gradients as the cause of rank elevation.

Based on these considerations, it would be logical to assume that the highly sapropelic nature and enriched liptinite content (reported to be 23% in Warwick and Hook, 1995) of these coals could account for their anomalously high heating value (~12,000 Btu/lb AR, 14,000 MMmF, figs. 3 and 4), without an added thermal factor. A re-examination of nearby Wilcox coals suggests, however, that a much wider area and stratigraphic range of South Texas has been subjected to elevation in rank, probably by local heat flow, than previously thought. Recalculating the Wilcox coal quality parameters for the Uvalde area (fig. 2) from Maxwell (1962, tables 30, 31, and 32) gives a range of MMmF Btu/lb from 10,494 to 11,893, (i.e. subbituminous A to high-volatile C bituminous). Note that sample no. 1-A from Maxwell's table 30, which is lignite on an MMmF basis, is clearly weathered, and some other samples from his tables appear to have lost moisture; normalizing to 15% moisture consistent with table 32 results in an apparent rank of subbituminous B to high-volatile C bituminous. Proprietary analytical data recently made available to the USGS for the National Coal Resource Assessment supports these determinations. Together they indicate that on the basis of heating value, the Wilcox coals range from subbituminous B just east of Uvalde to high-volatile bituminous A towards the west, although even the most mature of these coals is generally described as lignite in company drilling records. An average reflectance value of 0.37% (Rm; range 0.30-0.45%) reported by Breyer and McCabe (1986) from an area just east of Uvalde is somewhat equivocal, but consistent with subbituminous coals of the Powder River Basin of Wyoming (R.W. Stanton, USGS, personal communication). These values can be compared with some previously unpublished rank parameters and standard analysis of the Santo Tomas and San Pedro coal zones and typical Wilcox lignites from the Sandow mine near Austin, approximately 250 mi northeast of the Santo Tomas field, in figures 3 and 4.

To the author's knowledge, no published analysis of the intercalated "lignites" of the Bigford-El Pico interval exist. One highly weathered sample of a banded, somewhat splintery, stray bed that occurs within the San Pedro interval about 40 ft above the main bed at the Farco Trevino Mine has been analyzed by the USGS with equivocal results (sample SP-UN-96-1, figs. 3 and 4). On a Btu basis, this coal would seem to be classified as lignite; however, an average Rmax of 0.74% and extremely high

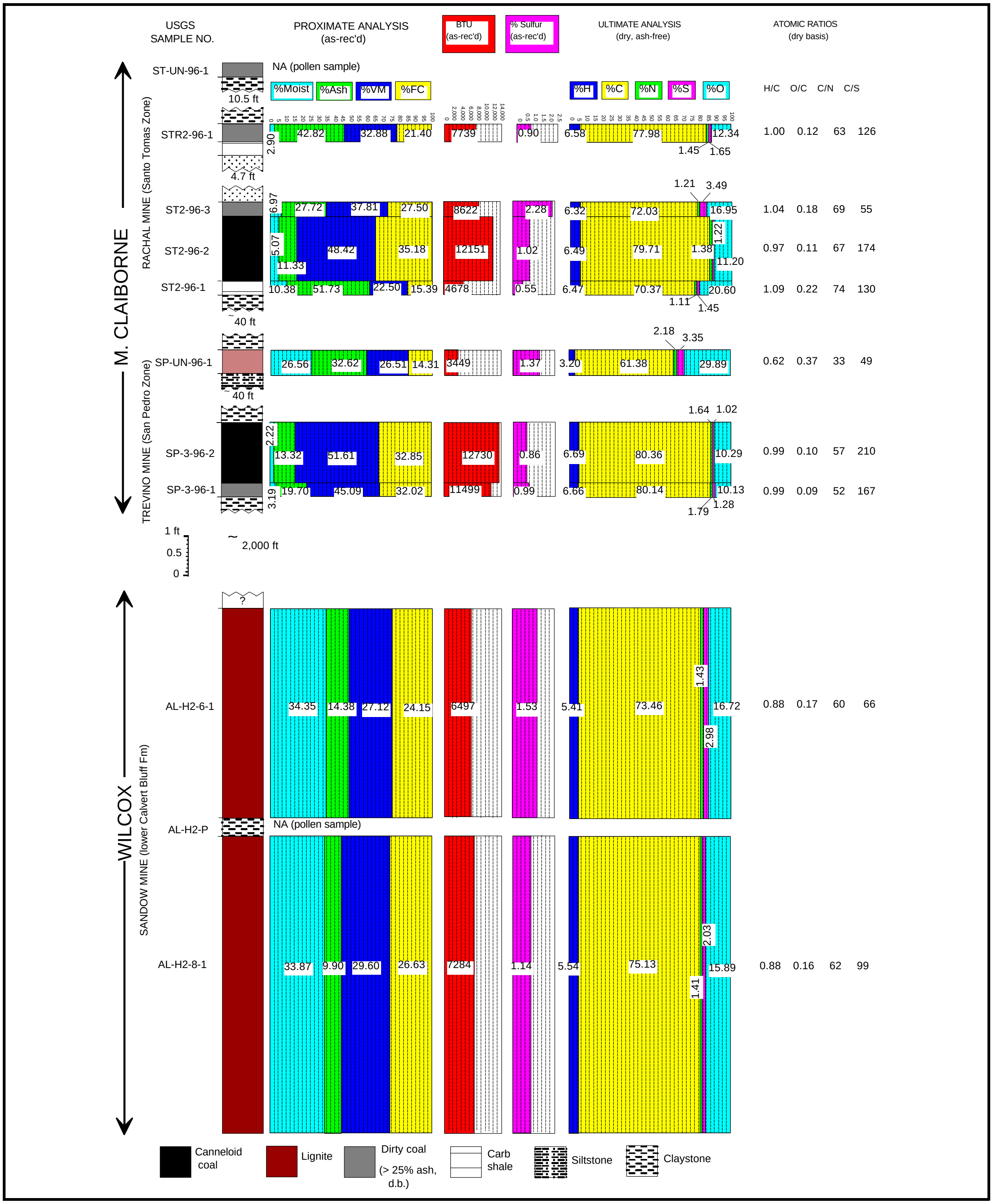

Figure 3. Standard analysis and elemental ratios for selected samples from the Santo Tomas coal field (middle Claiborne) and Sandow Mine (Wilcox).

volatile-matter content imply a rank more similar to the canneloid coals. Other maturation parameters (apparent specific gravity, residual moisture, agglomerating character, etc.) are more consistent with Wilcox lignite, although the weathered nature of the sample is readily apparent form the high oxygen content, and none of these results can be considered definitive. The higher reflectance value for the stray bed versus the main San Pedro – Santo Tomas beds as shown in figure 4 may be attributable to weathering-related diminution of the vitrinite suppression typical in canneloid coals. This sample fluoresces when examined under blue light and shows algal cell structures similar to the San Pedro and Santo Tomas canneloid coals (P.D. Warwick, USGS, personal communication).

EXTENT OF THE COAL-RANK ANOMALY AND ITS POSSIBLE IMPACT ON HYDROCARBON GENERATION

As previously stated, it now appears that a much wider area of South Texas has been subjected to coal-rank elevation than has previously been recognized. Early versions of the "Coal Fields of the United States" map (e.g. Campbell, 1908, through Trumball, 1960) showed small pods of bituminous coal within the overall lignite trend, and no intervening subbituminous halos. The area of hypothesized rank elevation was slightly expanded for a preliminary revision to this map (Tully, 1996), without the benefit of most of the new data or rank recalculations cited herein. Based on the information currently available, additional revisions to the map that will show a much wider and more graduated area of rank elevation in South Texas are being proposed, as shown in figure 2. Any such revisions are speculative, however, without analysis of fresh samples of the intercalated stray beds in the El Pico – Bigford interval and additional reflectance values and analyses from the Wilcox, Jackson and Yegua intervals (figs. 1 and 2).

Coal-bed methane (CBM) shows have been recorded in some gas wells in Maverick and Dimmit counties, and a number of gas fields occurring in the general area produce from Olmos and Wilcox sandstones (see Ewing this volume). The extent of the coal-rank variation within South Texas can therefore be considered particularly important from the consideration of the CBM and conventional source-rock potential. The H/C and O/C ratios from figures 3 and 4 are plotted on a Van Krevelen diagram in figure 5, along with data for Olmos Formation coals derived from various sources (Evans,1974, table 5; Miller and others, 1998; and unpublished USGS files). A few examples of Jackson Group coals, which are generally not discussed in this paper, but will be seen on the field trip, are also shown for completeness; these are from unpublished USGS sampling of the San Miguel Mine. As to be expected, the Wilcox, Olmos, and Jackson coals plot within the type III kerogen path, and the less humic Santo Tomas and San Pedro coal zones plot closer to the type II field. The Santo Tomas coals, which appear slightly more oil prone on the diagram, yielded 52 gal/ton oil and 5672 SCF per ton gas from low-temperature distillation done by the U.S. Bureau of Mines (Ashley, 1919). Rock-Eval pyrolysis for one Santo Tomas sample by Mukhopadhyay (1989, fig. 28a), which yielded 66% total organic carbon and very high and low hydrogen and oxygen indices respectively, placed these coals directly on the type II kerogen field.

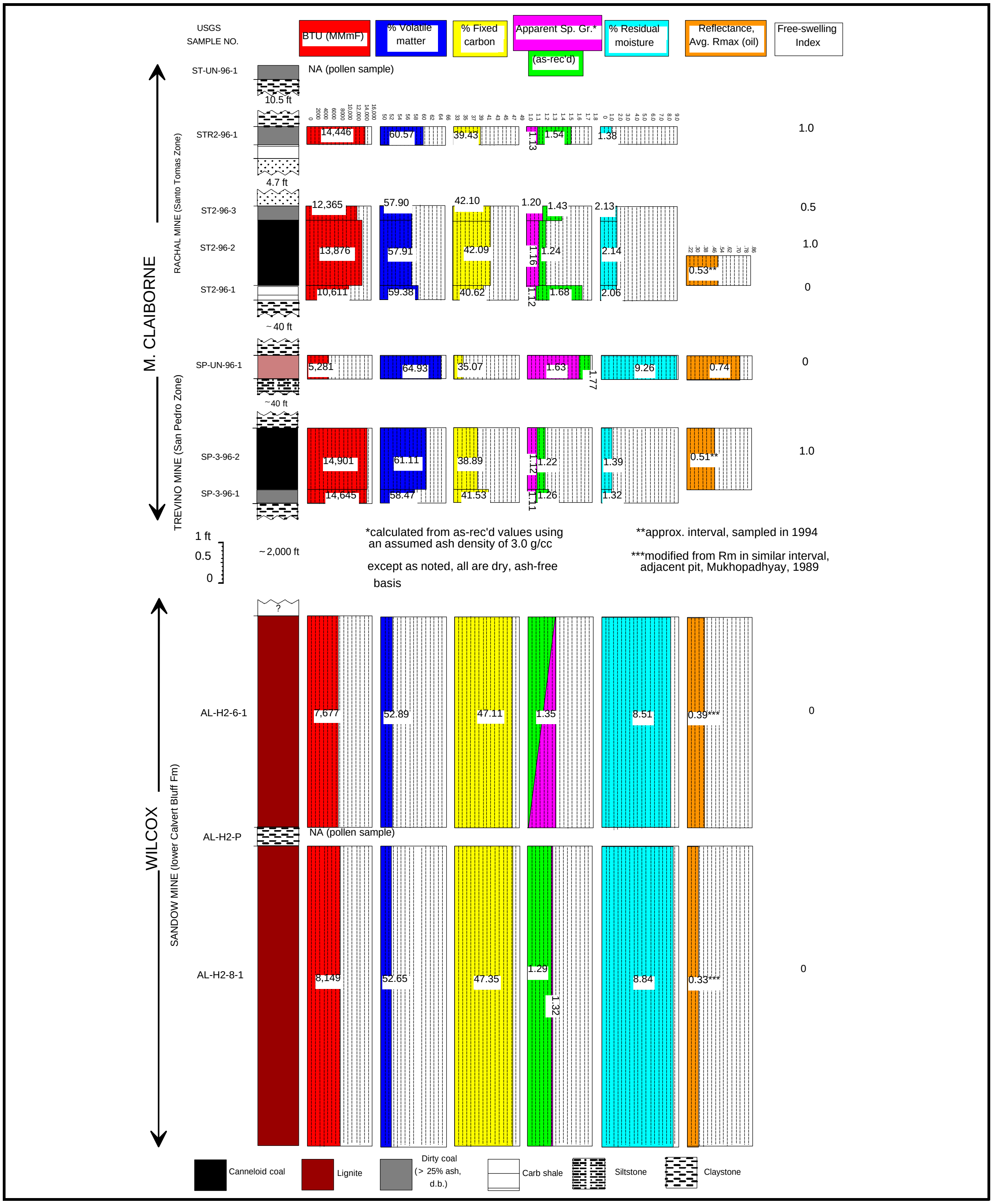

Figure 4. Selected rank parameters for selected samples from the Santo Tomas coal field (middle Claiborne) and Sandow Mine (Wilcox).

The remarkable ease of ignition that enables these coals to be exported in considerable quantities for domestic use is further evidence of their oil-generating potential. Most of the Olmos data shown on figure 5 approaches the lower limits of hydrocarbon generating maturity. In addition to being somewhat oil-prone in composition, these coals may lack the permeability to adsorb gas or produce CBM commercially.

The Olmos Formation data shown on figure 5 is generally consistent with that of a somewhat more mature humic coal than the other samples. Available coal-quality data for the Olmos Formation is, however, scarce and somewhat questionable. The data shown on figure 5 from the MICARE mine samples (Miller and others, 1998) shows consistently lower oxygen values than the other Olmos samples, and thus more apparent maturation, placing them well beyond fluid hydrocarbon generation thresholds. While this conceivably could reflect increasing rank towards local igneous activity, it seems more probable that this is an analytical bias. Other data from the MICARE mines (Verdigo and Arciaga, 1991, table 2) show higher average oxygen values, but the reporting basis is not clear. The Dos Republicas sample analysis appears to be reliable, but these and other recent analyses from the Eagle Pass area show a very wide range of ash, and corresponding elemental values where available, that may be attributable to sampling techniques. The "old Eagle Pass" samples on figure 5 came from a variety of mine sources sampled before 1912 (see Evans, 1974), including unwashed and washed samples, with some apparent drying, and possibly weathered. The available data on heating value for the MICARE coals is also inconclusive in this regard. The Olmos data shown on figure 5 represent an attempt to select "typical" samples with relatively similar ash values from the various data sets, with the exception of the "old" samples, where the widest range is shown. The two San Miguel samples selected for the diagram are probably slightly atypical, in that they are at the higher end of the recorded heating values for USGS samples from that mine. These and the Sandow samples shown on the diagram fall in the relatively less mature end of the humic pathway as expected. All of the oxygen values used for figure 5 are by difference rather than direct measurement, with the possible but unlikely exception of the "old Eagle Pass" samples.

No elemental data is currently available to the USGS for Wilcox, Yegua, or Jackson coals from the higher rank areas shown in figure 2. Based on their location, at least some of the reported CBM shows in the area are without question from Olmos Formation coals. It appears likely that a considerable area of Wilcox coals may also have reached thermal-gas-generating maturity in the South Texas area. Although highly speculative, based on the extent of Tertiary volcanism in nearby areas of Mexico, it appears that Yegua and Jackson coals could have been similarly elevated in rank as far south as Falcon Reservoir (about 90 mi southeast of Laredo, fig. 2). In a detailed study of the petrology and organic geochemistry of Texas coals, Mukhopadhyay (1989) suggested that many Texas coals are enriched in liptinite relative to other coals of similar rank and may have generated liquid hydrocarbons earlier on the maturation pathways than is normally expected. Although very few of his samples are from South Texas, where the maturation potential would seem highest, he suggests (p. 102) that some of the oil produced from the

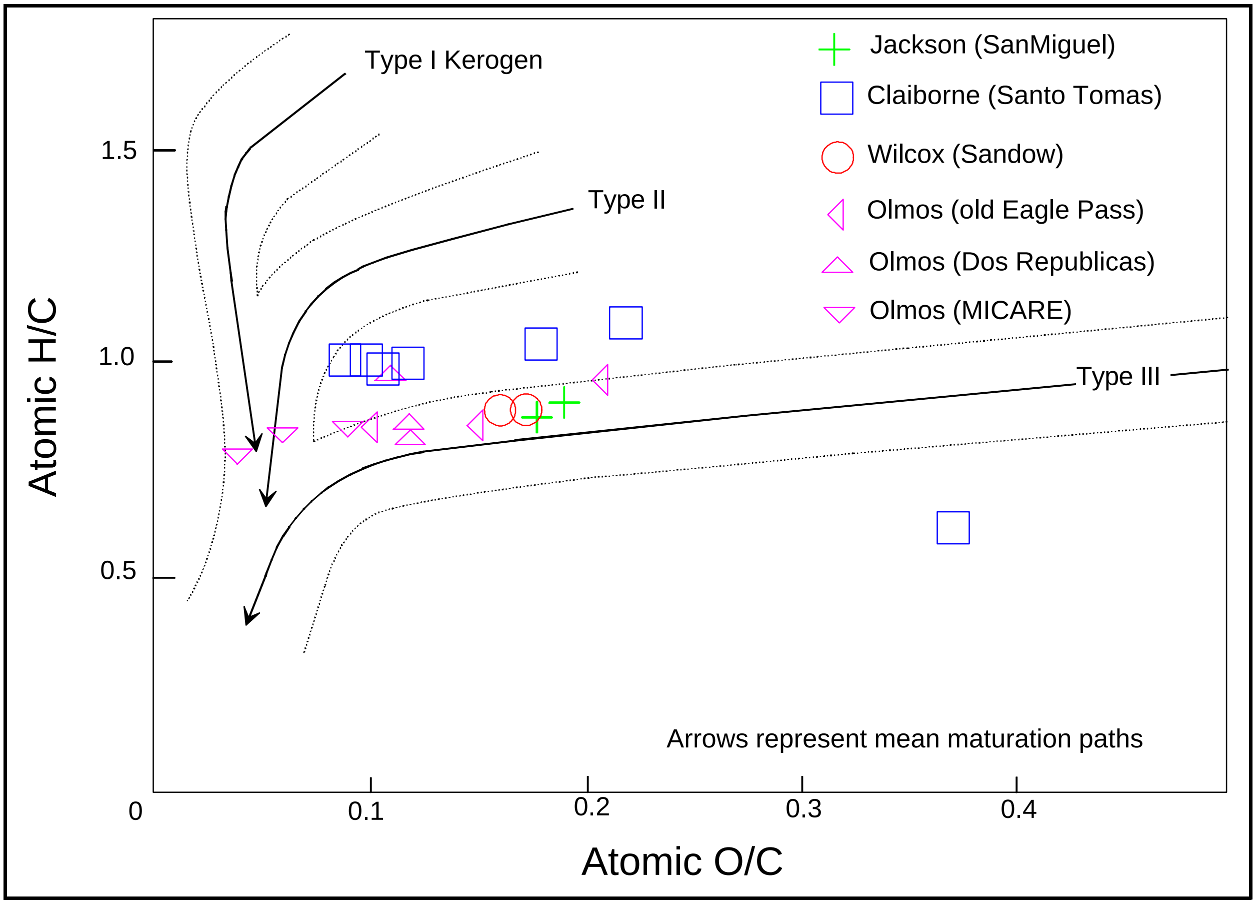

Figure 5. Van Krevelen-type diagram for various coal types of South Texas and vicinity.

Wilcox and Claiborne intervals of South and East Texas may be sourced in the Wilcox.

One potential constraint on commercial CBM viability in South Texas may be the thickness of the coal beds, which for individual beds is generally less than ten feet thick. There are multiple beds in each of the coal-bearing intervals, however, and in general coal thicknesses beyond shallow (i.e. mineable) depths have not been thoroughly investigated. It should be noted that nothing in this paper addresses the potential for early or late biogenic gas occurrences in Texas coals, which should be considerable based on recent activity in the Powder River Basin of Wyoming. It is also worth noting that although the coal-bearing facies of the Olmos Formation is mapped with an eastward pinch-out into marine rocks a few miles southwest of Uvalde (fig. 2), anecdotal evidence presented in Maxwell (1962, p. 90) suggests that Cretaceous coal-bearing rocks may be present somewhat farther east and north.

CONCLUSIONS

Available information based on limited and poorly controlled sampling and analysis suggests that the coal rank anomalies recognized in the Olmos Formation and middle Claiborne Group of South Texas and adjacent areas of Mexico may extend to a considerably wider area and stratigraphic range. Additional sampling and analysis of the entire interval from the Upper Cretaceous Olmos Formation through the upper Eocene Jackson Group would be useful in refining the known extent of rank variation. Coal-bed desorption and drill-stem or more sophisticated down-hole testing would help determine the methane-producing potential of these coals. Biomarker and stable isotope studies of hydrocarbons produced from more conventional reservoirs in the area may also provide useful information on the source-rock potential of these coals.

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