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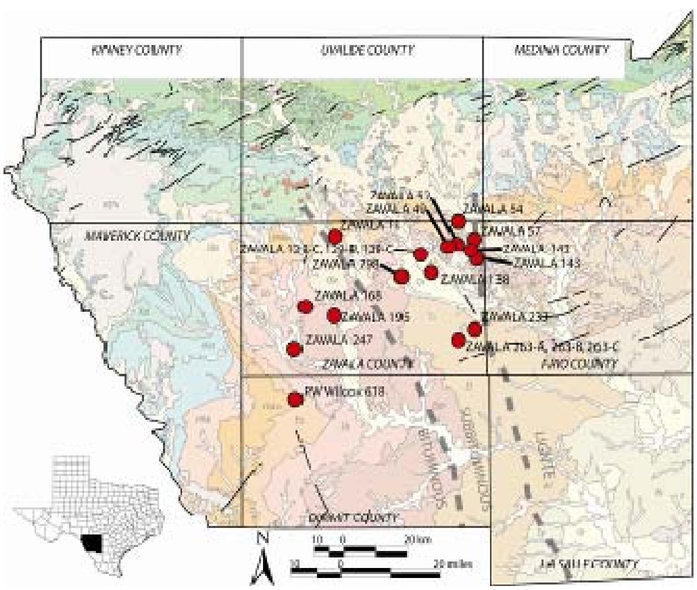
By Paul C. Hackley[1], Robert W. Hook[2,*], and Peter D. Warwick[1]

[1]U.S. Geological Survey, Reston, VA 20192
[2]Austin, TX 78746
*Contractor to U.S. Geological Survey



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INTRODUCTION

The reflectance of huminite in 19 cuttings samples was determined in support of ongoing investigations into the coal bed methane potential of subsurface Paleocene and Upper Cretaceous coals of South Texas. Coal cuttings were obtained from the Core Research Center of the Bureau of Economic Geology, The University of Texas at Austin. Geophysical logs, mud-gas logs, driller's logs, completion cards, and scout tickets were used to select potentially coal-bearing sample suites and to identify specific sample depths. The locations of the 16 boreholes from which the cuttings were collected are indicated in figure 1.

PROCEDURES

Sampled well cuttings were cast in epoxy and polished according to the procedures outlined in Pontolillo and Stanton (1994). One sample mount was made for each sample. Measurement of random huminite reflectance in immersion oil ($R_{o,\,r}$) was performed according to the ASTM D2798 protocol (ASTM, 2002) on a reflected light microscope. Reflectance determinations were made on the huminite maceral ulminite (fig. 2).

Calculation of maximum reflectance from measured random reflectance is according to Taylor and others (1998) ($R_{max}=R_{o,\,r}*1.061$). Rank classification is based on the calculated R_{max} and is as follows: 0.385-0.415 = subbituminous C, 0.415-0.49 = subbituminous B, from Taylor and others (1998, p. 100).

Maceral identification herein follows the nomenclature of the ICCP System 1994 (ICCP, 1998; 2001; Sýkorová and others, 2005) for the huminite and inertinite maceral groups, and Taylor and others (1998) for the liptinite maceral group. The cuttings samples all possess maximum reflectance values <0.50 %; therefore, the huminite maceral nomenclature is applied throughout this report (ICCP, 1998).

RESULTS

Reflectance

Mean random reflectance ($R_{o,\,r}$; measured) and maximum reflectance values (R_{max}; calculated) are reported in Table 1. Note that in all cases the number of determinations of reflectance per sample is below the number 100 specified by the ASTM standard because of the limited sample material available. The cuttings samples yield calculated maximum reflectance values ranging from 0.40-0.47, in the rank range of subbituminous C-subbituminous B. The highest value, 0.47, was calculated for sample *ZAVALA 195*, from the Cretaceous Olmos Formation (fig. 3), at a depth interval of 2830-2840 ft. A slightly lower maximum reflectance value of 0.43 was calculated for sample *ZAVALA 168*, also from the Olmos Formation. The rest of the cuttings samples are coals from the Paleocene-Eocene Wilcox Group (fig. 3). Values for maximum reflectance of the Wilcox samples range from 0.41-0.46. These data are consistent with the highest values in the range of reflectance measurements of Wilcox coals reported from neighboring counties (Breyer and McCabe, 1986) and elsewhere in Texas (Mukhopadhyay, 1989).

Petrographic Observations

The Wilcox cuttings samples are dominated by the huminite maceral attrinite (figs. 4A and 4B). Attrinite rarely polishes well in the sample mounts, yet still returns reflectance values consistent with subbituminous rank where determined on some better-polished homogeneous surfaces. Attrinite serves as the groundmass for the structured liptinite macerals sporinite and fragments of liptodetrinite and detrital resinite. Corpohuminite particles (fig. 4A) consistently yield reflectance values in the higher subbituminous A range (higher than ulminite in same sample). Highly reflecting unicellular (fig. 4A) and/or multicellular funginite are common. Mineral phases include common early pyrite framboids and, less frequently, late siderite. Clay is present as layers in all Wilcox samples. One sample (*ZAVALA 11*) contains ornately-preserved fusinite with cell lumens filled by resinite and/or exudates (fig. 5). The preserved fusinite is contained in a structureless groundmass of equally high reflectance macrinite.

The Cretaceous Olmos coal cuttings consist dominantly of fine-textured textinite and/or texto-ulminite (fig. 6) with minor attrinite, in contrast to the Wilcox samples which are dominated by attrital macerals.

DISCUSSION

The South Texas area contains the only shallow coals of elevated rank (as determined by the reflectance of huminite/vitrinite) within the overall lignitic Gulf Coast coal province. Reflectance data compiled by Barker and others (2000) ranges to as high as 0.50 % for Olmos coals in Maverick County to the west of Zavala, and values of 0.58 % are reported from Olmos coals south of the border in Mexico (Verdugo and Ariciaga, 1991). Furthermore, in Webb County, south of Zavala, values of 0.43-0.53 % are reported from the cannel coals of the Eocene Claiborne Group (Mukhopadhyay, 1989; Warwick and Hook, 1995; Barker and others, 2000). Mukhopadhyay (1989) speculated that the elevated reflectance values in the Eocene cannel coals probably are a result of locally increased heat flow or oxidation during early diagenesis.

SanFilipo (1999) reviewed available coal quality information for the Cretaceous-Eocene interval of the South Texas area and concluded that the region had possibly been subjected to a rank elevation when compared to coals from the rest of the Gulf Coast province. He attributed this to locally elevated residual heat associated with the Cretaceous Balcones igneous province (fig. 1) and/or Tertiary volcanic rocks in northern Mexico. Based on the available data, SanFilipo (1999) proposed the hypothetical location of rank isograds indicating a westward rank increase from lignite through bituminous in the Zavala County area (fig. 1). The data presented herein indicate that coals of subbituminous rank (as determined by reflectance) are present in a much wider area than originally proposed by SanFilipo (1999).

Barker and others (2003) attributed the apparent rank elevation in the South Texas area to an increased depth of burial relative to similar-age strata elsewhere in the Gulf Coast. They estimated maximum burial of Olmos coals to 7110-7500 ft based on mapped stratal thickness of the Paleocene to upper Oligocene section in the Río Grande Embayment (Barnes, 1976), and by examining reflectance versus depth compiled from throughout the Gulf province (Barker and others, 2003).

We concur with the interpretation of Barker and others (2003), in that increased depth of burial is most likely responsible for the apparent rank elevation in South Texas. When the reflectance data presented herein are plotted as a function of depth, a general trend toward increasing rank at depth is indicated, although there is considerable scatter in the data (fig. 7). More importantly, there is no apparent relationship between the X-Y spatial location of samples and reflectance value, such as would be the case if the speculative isograds of SanFilipo (1999) were in fact as originally drawn. In fig. 8A, the reflectance data are plotted as a function of depth and by their X-Y spatial location as shown in fig. 8B. Arbitrary geographic zones numbered 1-5 from east to west are indicated by color in figs. 8A and 8B. The zones are drawn similar to the trend of the speculative rank isograds presented by SanFilipo (1999). As is apparent from fig. 8A, sample depth appears to dominantly influence huminite reflectance, rather than spatial location, supporting the interpretation that increased depth of burial is responsible for the apparent rank elevation in the South Texas area for most of the samples. However, the two samples collected from the farthest points west (*ZAVALA 247 AND PW WILCOX 618*) are slightly elevated in reflectance compared to others collected from the same depth farther east. These two data points and the higher reflectance values of 0.50-0.58 % reported for the Olmos coals farther to the west and southwest of the present study area (Verdugo and Ariciaga, 1991; Barker and others, 2000) may reflect thickening of the post-Olmos Cretaceous section towards the southwest into the Maverick Basin. These areas would have been exhumed from deeper burial under the Sierra Madre Oriental piedmont than strata farther to the northeast (see Ewing, 2003, fig. 6, p. 20).

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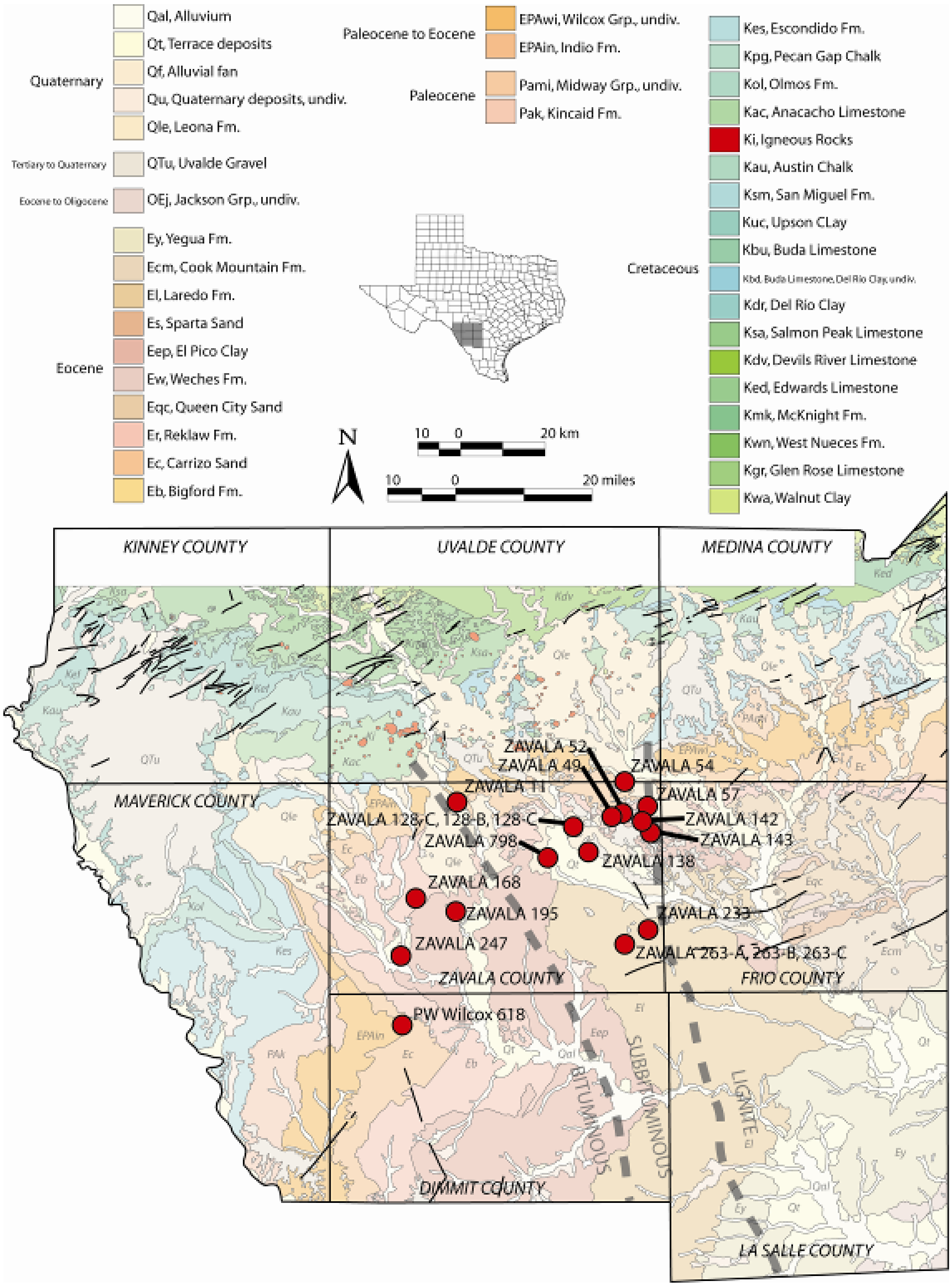

Figure 1. Geologic map of South-Central Texas, showing locations of wells from which cuttings samples were collected. Also shown are speculative coal rank isograds from SanFilipo (1999). Counties shown are shaded gray in inset map of Texas. Geology from Warwick and others (2002), compiled from Barnes (1992). Location of sample PW Wilcox 618 is approximate.

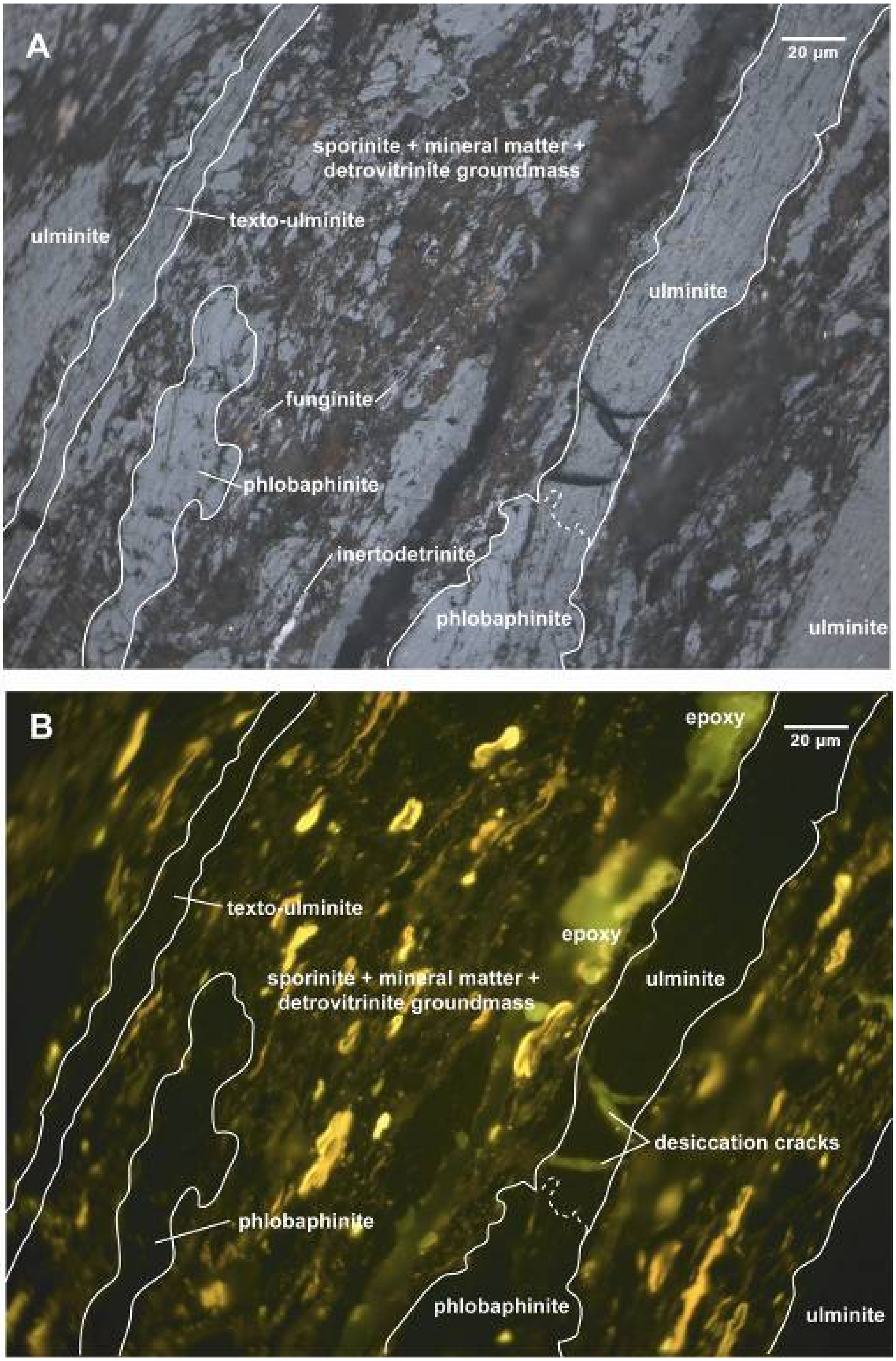

Figure 2. A) Layers of ulminite/texto-ulminite in a detrohuminite-dominated coal. Oil immersion, reflected white light. B) Same location as A, oil immersion under blue light fluorescence.

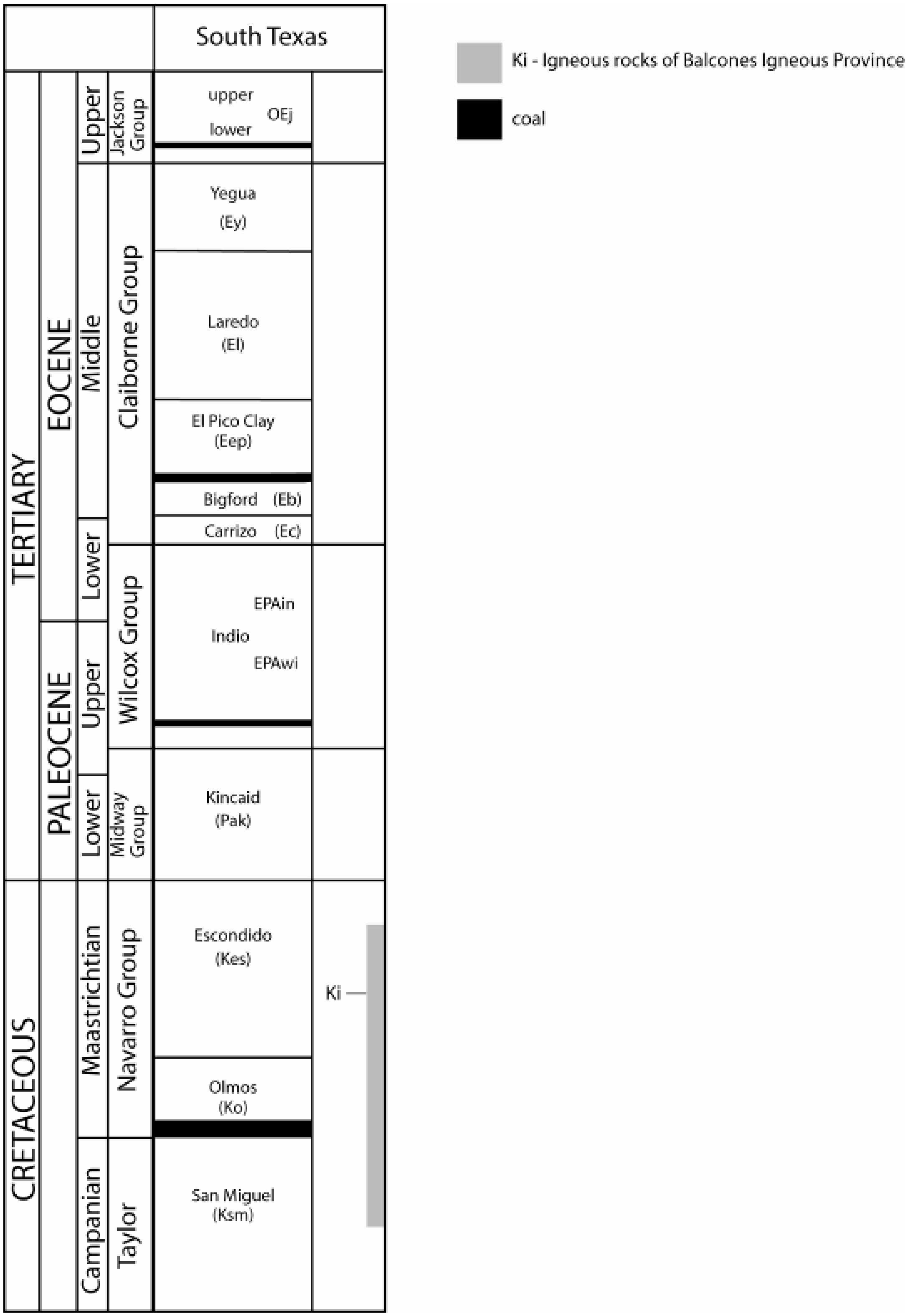

Figure 3. Generalized stratigraphic column for South Texas. From SanFilipo (1999).

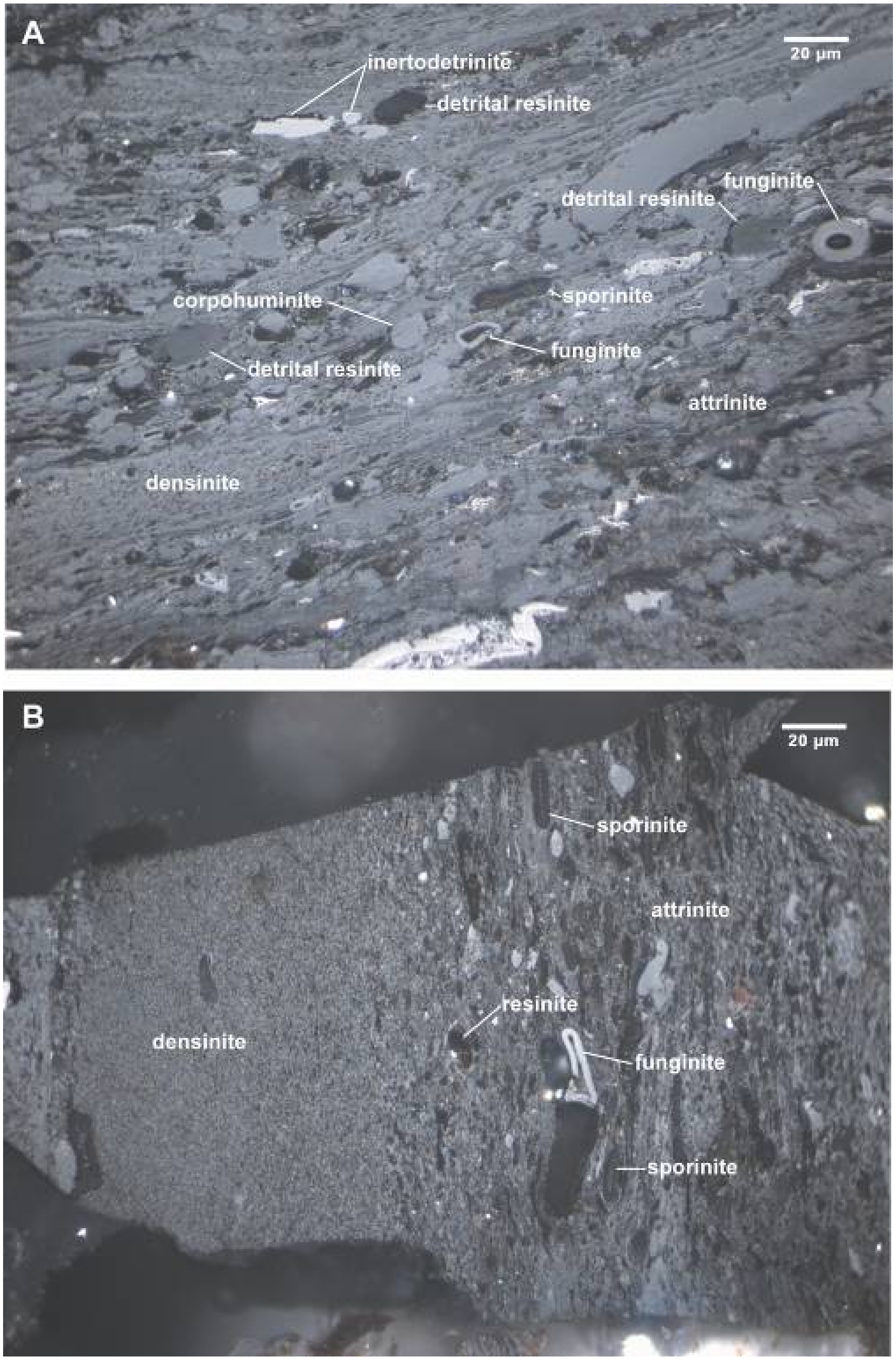

Figure 4. A) Photomicrograph of typical detrital character of coal cuttings in Wilcox samples. B) Photomicrograph of attrinite in Wilcox coal cuttings. Both A and B taken in oil immersion, reflected white light.

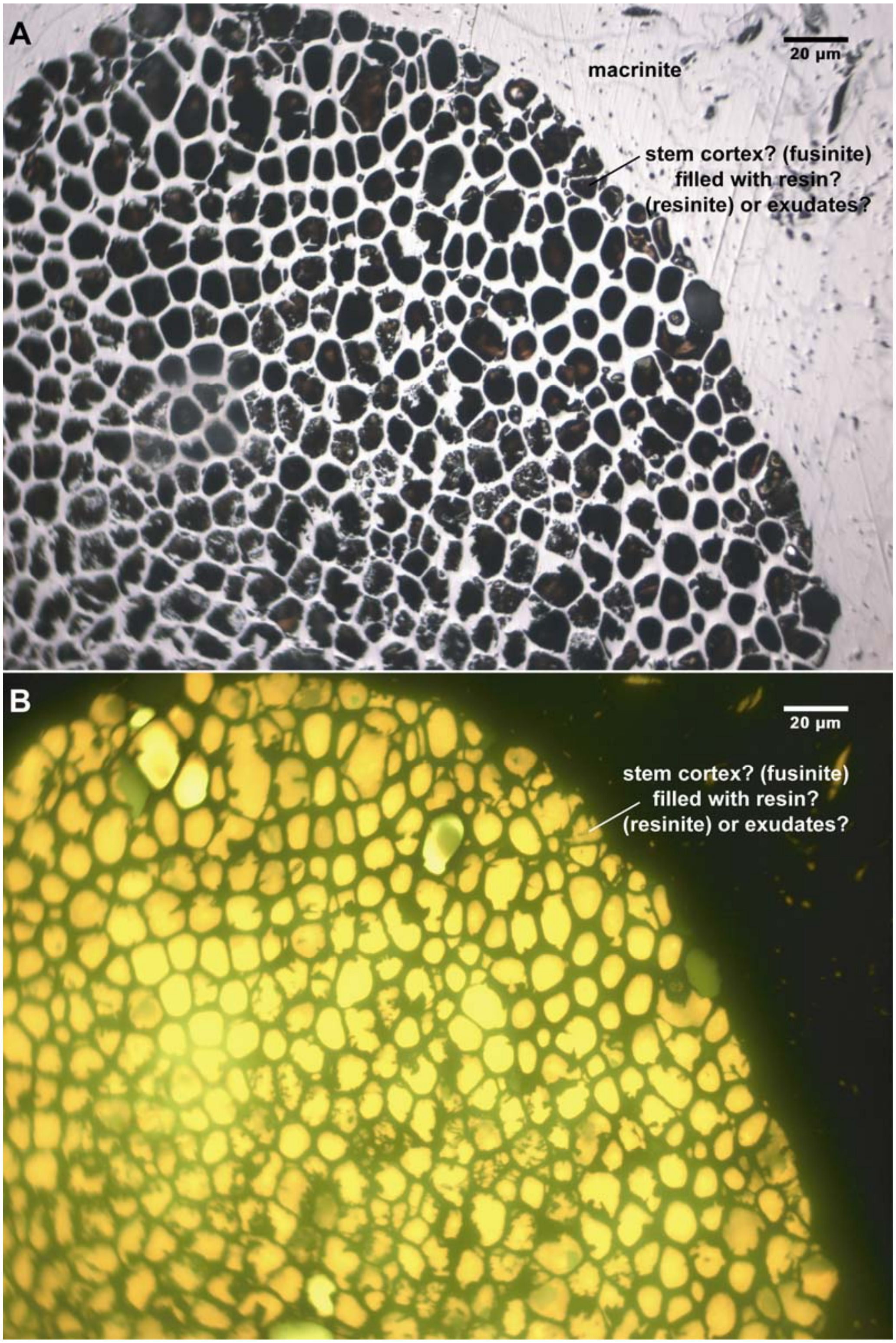

Figure 5. A) Ornately preserved fusinitized plant structure. The open cell lumens are filled with resin and/or exudates(?). Oil immersion, reflected white light. B) Same location as A, oil immersion under blue light fluorescence.

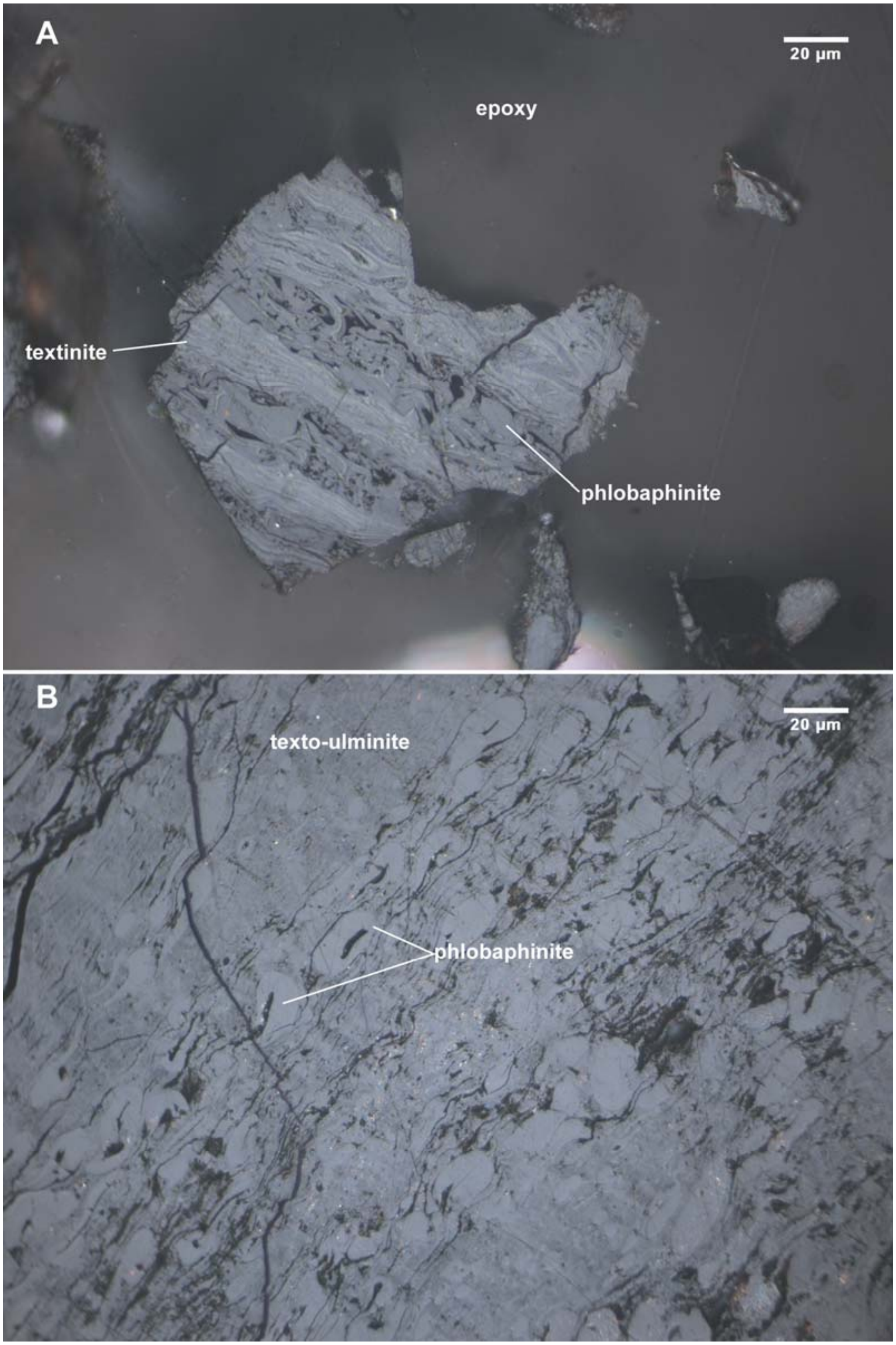

Figure 6. A) Fine-textured textinite in Cretaceous Olmos coal. B) Texto-ulminite and phlobaphinite in Cretaceous Olmos coal. Both A and B taken in oil immersion, reflected white light.

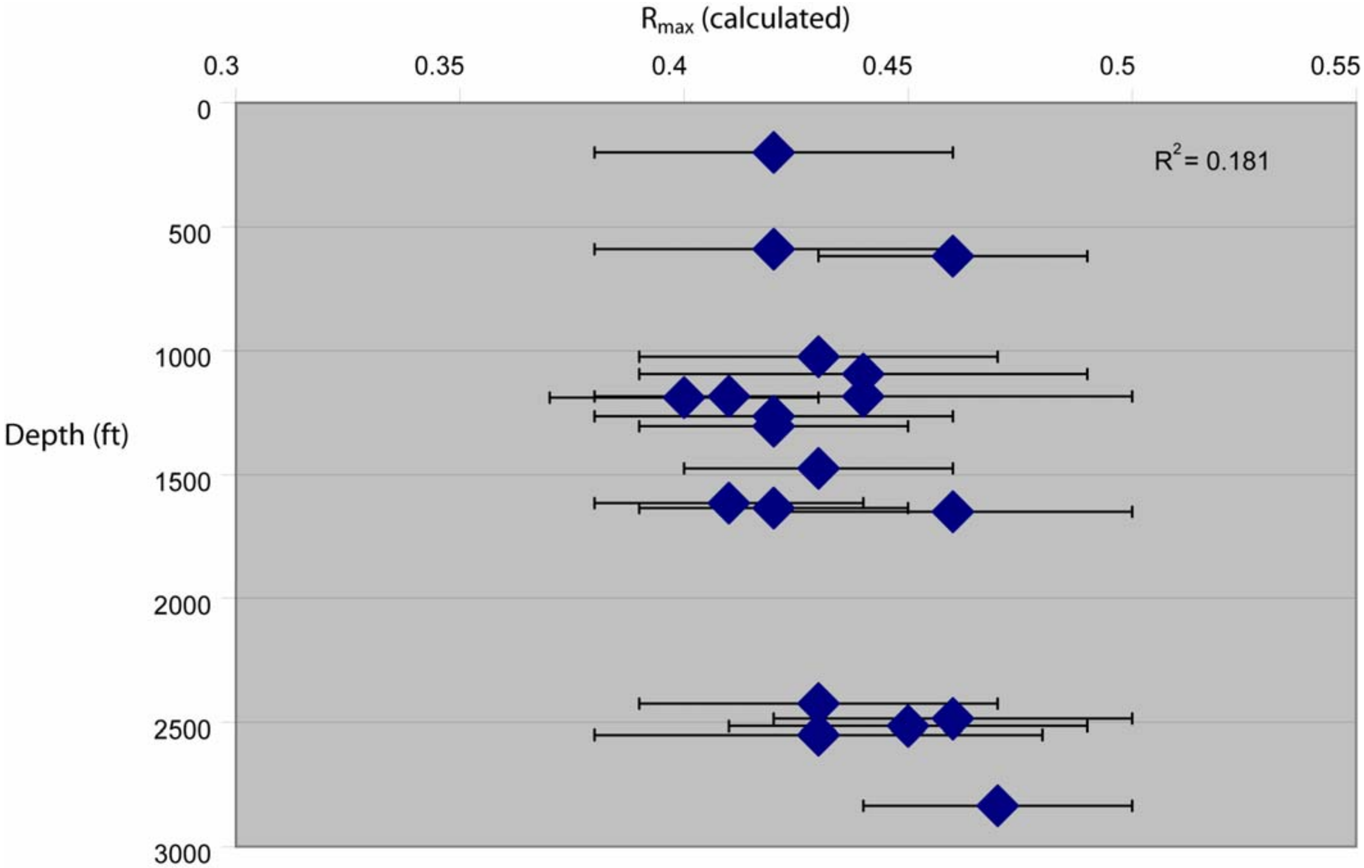

Figure 7. Plot of huminite reflectance as a function of depth. Error bars indicate +/- one standard deviation.

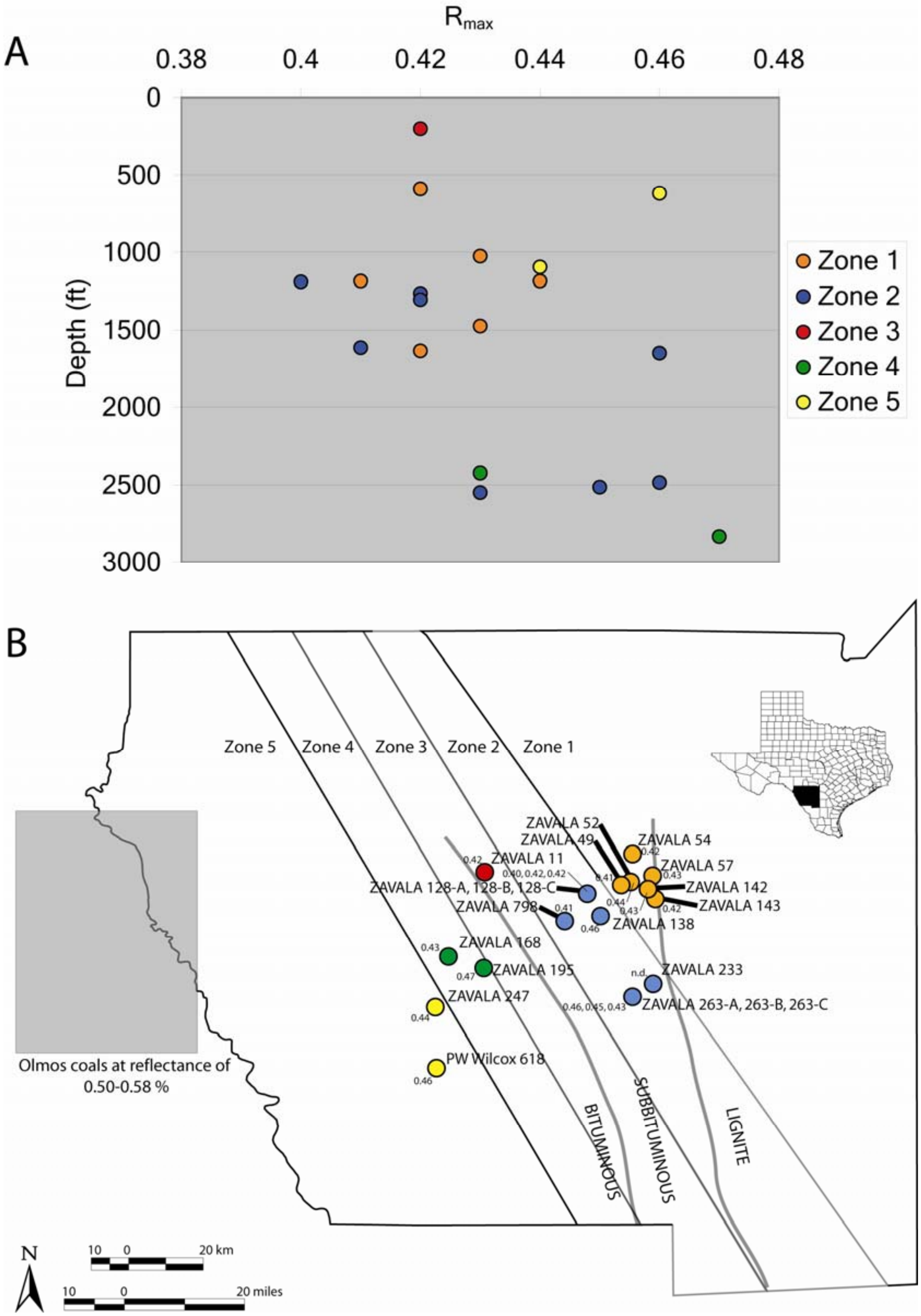

Figure 8. A) Plot of R_{max} as a function of depth for arbitrary geographic zones numbered 1-5 from east to west across Zavala and neighboring counties. B) Limits of zones in map view, sample locations, reflectance values, and speculative rank isograds of SanFilipo (1999). Gray rectangle shows area where Olmos coals have reported reflectance values of 0.50-0.58 % (Verdugo and Ariciaga, 1991; Barker and others, 2000). Counties shown are shaded black in inset map of Texas.

Table 1. Huminite reflectance values for cuttings samples, Zavala and Dimmit Counties, Texas.

Lease	Well No.	Sample ID	Depth (ft)	Unit	$R_{o,r}$	s.d.	n	R_{max} (calc.)	Rank
LORA LYLES	1	ZAVALA 11	180-215	WILCOX	0.39	0.04	50	0.42	subB
GILLIAM	6	ZAVALA 49	1180-1190	WILCOX	0.38	0.03	25	0.41	subC
GILLIAM	3	ZAVALA 52	1180-1190	WILCOX	0.41	0.06	45	0.44	subB
KINCAID	1	ZAVALA 54	560-620	WILCOX	0.40	0.04	50	0.42	subB
KINCAID	1	ZAVALA 57	1020-1030	WILCOX	0.41	0.04	50	0.43	subB
VOIGT	1	ZAVALA 128-A	1180-1200	WILCOX	0.38	0.03	50	0.40	subC
VOIGT	1	ZAVALA 128-B	1260-1270	WILCOX	0.39	0.04	30	0.42	subB
VOIGT	1	ZAVALA 128-C	1300-1310	WILCOX	0.40	0.03	15	0.42	subB
BOYKIN	1	ZAVALA 138	1620-1680	WILCOX	0.43	0.04	30	0.46	subB
A A STORY	2	ZAVALA 142	1460-1490	WILCOX	0.41	0.03	40	0.43	subB
A A STORY	1	ZAVALA 143	1630-1640	WILCOX	0.40	0.03	50	0.42	subB
C A MAEDGEN	1	ZAVALA 247	1081-1112	WILCOX	0.41	0.05	50	0.44	subB
W D GLASSCOCK	1	ZAVALA 263-A	2474-2504	WILCOX	0.43	0.04	30	0.46	subB
W D GLASSCOCK	1	ZAVALA 263-B	2504-2534	WILCOX	0.42	0.04	35	0.45	subB
W D GLASSCOCK	1	ZAVALA 263-C	2534-2564	WILCOX	0.41	0.05	30	0.43	subB
BARTLETT ELIZABETH C	1	ZAVALA 798	1600-1630	WILCOX	0.38	0.03	50	0.41	subC
KOTHMAN-BARNARD	n.d.	PW Wilcox 618	618	WILCOX	0.44	0.03	25	0.46	subB
MUNGER RANCH	1	ZAVALA 168	2421-2431	OLMOS	0.41	0.04	30	0.43	subB
ROSA WOLF	1	ZAVALA 195	2830-2840	OLMOS	0.44	0.03	50	0.47	subB
WEST G W (NATL BANK OF COMM)	1	ZAVALA 233	4265-4275	OLMOS	n.d.	n.d.	0	n.d.	n.d.

Abbreviations: s.d. = standard deviation, n = number of measurements, n.d. = no data.