STATE OF ARKANSAS

ARKANSAS GEOLOGICAL SURVEY
BEKKI WHITE, DIRECTOR AND STATE GEOLOGIST

INFORMATION CIRCULAR 40

GEOCHEMISTRY AND THERMAL MATURITY ANALYSIS OF THE FAYETTEVILLE SHALE AND CHATTANOOGA SHALE IN THE WESTERN ARKOMA BASIN OF ARKANSAS

Peng Li (Arkansas Geological Survey, Little Rock, AR)

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Texas Christian University Energy Institute, Fort Worth, TX)

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Forward

Statement of Purpose

The recent development of natural gas from unconventional shale reservoirs in Arkansas has provided abundant clean energy resources for the state and the nation. Thousands of new jobs have been created in Arkansans due to the successful exploration and development of the Fayetteville Shale gas resource. The Arkansas Geological Survey (AGS) routinely conducts research on fossil fuel projects in the state and provides that information to the Arkansas Legislature, state and federal agencies, academia, and the energy industry. The results of AGS research projects are compiled and published through a series of publication venues and the agency website www.geology.arkansas.gov.

AGS Information Circular 40 is a technical report that focuses on the exploration potential of the Fayetteville and Chattanooga Shale reservoirs in the western-central portion of Arkansas. The study area for this report lies west of the current exploration and development of the Fayetteville Shale resource and thus represents a region that may contain additional shale-gas reserves. Information Circular 40 specifically examines the details of petroleum geochemistry and thermal maturation of the Fayetteville and Chattanooga Shale reservoirs and integrates that information into subsurface geologic models. This report is scientific in character and the primary audience for the report is industry and academic professionals that have a background in petroleum geology.

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Acknowledgments

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This report is a collaborative effort between the Arkansas Geological Survey and Daniel Jarvie, Consulting Geochemist with Worldwide Geochemistry LLC. of Humble, Texas.

Geochemistry and Thermal Maturity Analysis of the Fayetteville Shale and Chattanooga Shale in the Western Arkoma Basin of Arkansas

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Introduction

This report investigates the shale-gas potential of the Mississippian Fayetteville Shale and the Devonian Chattanooga Shale in the western Arkoma Basin of Arkansas. In order to assess the generation potential of these shales, well cutting samples were collected at the Norman F. Williams Well Sample Library in Little Rock and processed at Humble Geochemical Services, now Weatherford Laboratories, for organic geochemical and thermal maturity analysis. The data generated for this report include total organic carbon (TOC) content, Rock-Eval pyrolysis, vitrinite reflectance (R_o), and visual kerogen measurements. These data are placed in a geological context with stratigraphic top and thickness models of selected formations. The authors have modeled these data sets in a series of geochemical, thermal maturity and geologic maps as Plates 1-6 that are also included in a separate folder on the CD.

Background

The Upper Mississippian Fayetteville Shale is composed mainly of black, fissile, concretionary, clay-rich shale. Dark gray, fine-grained limestones are commonly interbedded with shales along the Ozark uplift, but the formation becomes progressively more shaley and less limey in the subsurface sequences to the south (Figure 1). The Wedington Sandstone Member tends to be restricted to western and northwestern Arkansas based on surface exposures and subsurface well penetrations. The Wedington Member is near the top of the formation and consists of gray to brown, fine-grained, sometimes calcareous sandstone (McFarland, 2004). Much of it was deposited in a shallow water marine environment, for at many places it bears ripple marks of short wave length and oscillation ripples (Croneis, 1930). Conventional natural gas has been produced from the Wedington Member in several gas fields of northwestern Arkansas located in Washington, Franklin and Crawford Counties (Arkansas Oil and Gas Commission, 2008).

The Fayetteville Shale is the current focus of a regional shale-gas exploration and development program within the central and eastern Arkoma Basin of Arkansas. As of February 2010, the cumulative production of the Fayetteville Shale has totaled approximately 900 Bcf. However, there is little to no commercial gas production from the Fayetteville Shale in the west-central portion of the Arkoma Basin of Arkansas, which is the study area for this report.

The Upper Devonian Chattanooga Formation consists of two members, the basal Sylamore Sandstone Member and the overlying Chattanooga Shale Member. The Chattanooga Shale is often considered a deeper and secondary shale-gas exploration

target compared to the overlying and highly productive Fayetteville Shale in the central Arkoma Basin of Arkansas. The upper shale member was deposited in a deepwater

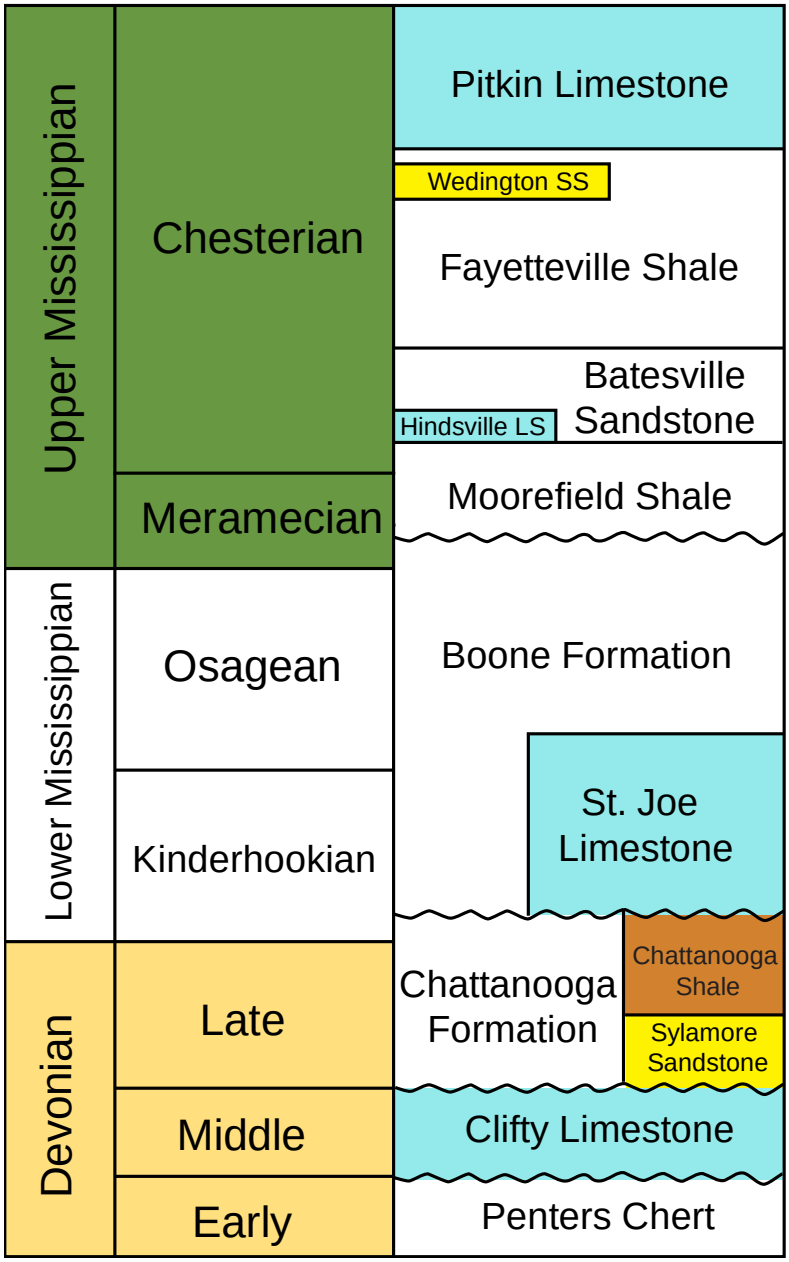

Figure 1. Devonian and Mississippian stratigraphy in the Arkoma Basin of Arkansas (modified from McFarland, 2004).

euxinic and marine environment that is characterized by thin organic-rich beds (typically several tens of feet in thickness) that are black to brownish in color due to the high organic matter content, finely disseminated pyrite (Duncan, 1983), and possibly charring during petroleum generation or oil cracking.

The lower Sylamore Sandstone Member was deposited in a shallow water, marine environment and consists of brown to white, fine- to coarse-grained quartz arenite (Carr, 1987). Locally, the Sylamore Sandstone is conglomeratic with cherty fragments most likely derived from the underlying Penters Chert.

Gas production from the Chattanooga Shale has been limited to one vertical well, the Eschbach 1-12 located in Sec. 12, T9N, R26W of Franklin County. This well was fracture stimulated and completed by SEECO Inc. in March of 2006. As of June 2009, the Eschbach 1-12 has a cumulative production of 54,350 Mcf.

Well records obtained from the Arkansas Oil & Gas Commission in January 2010 indicate that 133 wells have been completed in the Sylamore Sandstone and the cumulative production for 110 of these wells is 6,223,635 Mcf.

Samples

Well cutting samples from 14 deep gas wells were collected at the Norman F. Williams Well Sample Library in Little Rock, Arkansas. Well samples that were analyzed are from gas wells that were drilled in Sebastian, Crawford, Franklin and Logan Counties. Samples are dominated by shale lithology from the Fayetteville and Chattanooga Formations.

Wire line logs for 35 wells (Table 1), including the 14 wells that were sampled for geochemical and thermal maturity analysis, were used to determine the stratigraphic tops of the Fayetteville and Chattanooga Formations.

Geochemical Modeling of Total Organic Carbon Data

Total Organic Carbon (TOC) values were examined in 14 wells at specific depth intervals (Appendix 1). The depths of samples collected from the Fayetteville and Chattanooga zones are indicated for each well (Table 1; Appendices 1-14). Mean TOC values for the Fayetteville and Chattanooga Formations are calculated for each well that contains a data set. TOC values were interpolated from well to well using a nearest neighbor statistical method and these values are contoured using PETRA® software. TOC models are coupled with contoured vitrinite reflectance (R_o) values for the Fayetteville and Chattanooga Formations and are presented as two-component statistical geologic maps (Plates 1-2).

Geochemical Modeling of Vitrinite Reflectance Data

Vitrinite reflectance (R_o) data were measured using standard reflected light microscopy techniques. Many of the samples that were analyzed are selected stratigraphically above, through, and below the Fayetteville and Chattanooga Formations in order to obtain a vertical maturation profile for a given well (Appendices 1-14). Mean R_o values for the Fayetteville and Chattanooga Formations were also calculated for each well that contains a data set. R_o values are statistically interpolated and contoured between well bores for the Fayetteville and Chattanooga Formations using PETRA®

Table 1. Well list for geochemical and geological modeling with stratigraphic tops and bases of the Fayetteville and Chattanooga Shales.

Well Name	API	Section	Township	Range	County	Fayetteville		Chattanooga	
						Top (ft)	Base (ft)	Top (ft)	Base (ft)
USA #1*	03033100150000	22	8N	31W	Crawford	6,090	6,145	6,435	6,475
Price #1-11*	03047101970000	11	7N	28W	Franklin	8,952	9,070	9,325	9,410
Swain #1-36	03047300410000	36	8N	28W	Franklin	9,212	9,322	9,600	N/A
Ross #3	03047101010000	19	8N	28W	Franklin	8,065	8,180	8,380	8,460
Heinrichs #1	03047101620000	34	8N	27W	Franklin	9,185	9,335	9,555	9,610
C.E. Isom #1*	03083000100000	12	6N	27W	Logan	10,920	11,100	11,400	11,500
Arkansas Federal #1*	03083100030000	22	7N	23W	Logan	11,292	11,605	11,985	12,015
Chismville #3-16	03083104950000	16	6N	27W	Logan	10,574	10,695	10,996	11,086
USA #1-24	03083108830000	24	7N	25W	Logan	10,608	10,814	11,145	11,202
Gronwald #1-19	03083103690000	19	7N	26W	Logan	8,965	9,120	9,435	9,535
Hefley #1-31	03083100290000	31	7N	27W	Logan	10,550	10,672	10,970	11,055
Miller #1	03083109280000	35	8N	26W	Logan	N/A**	N/A**	10,485	10,550
McKendree's Chapel #23-1	03083100970000	23	8N	25W	Logan	8,110	8,295	8,605	8,635
Trusty #1-31	03083100650000	31	8N	24W	Logan	9,300	9,565	9,800	9,860
Knight "D" #1	03083102310000	15	8N	24W	Logan	9,350	9,623	N/A	N/A
Ahne #1-9	03083100740000	9	8N	24W	Logan	8,895	N/A	N/A	N/A
Henderson #1-9	03083700140000	9	8N	23W	Logan	9,000	N/A	N/A	N/A
Lancaster #1-10	03083100220000	10	8N	23W	Logan	8,925	N/A	N/A	N/A
Western Coal&Mining #1*	03131000070000	36	7N	32W	Sebastian	7,400	7,428	7,720	7,807
Joe Nixon #1*	03131000220000	33	8N	29W	Sebastian	7,730	7,820	7,980	8,060
Skinner #1*	03131000810000	4	6N	31W	Sebastian	9,020	9,075	9,280	9,335
Johnson-Bedford #1*	03131100100000	10	5N	31W	Sebastian	N/A**	N/A**	11,442	11,589
Hatfield #1*	03131100140000	31	8N	30W	Sebastian	7,290	7,380	7,700	7,740
Bell #1-25*	03131100980000	25	6N	31W	Sebastian	N/A**	N/A**	10,815	10,895
Hales 1-29*	03131102080000	29	6N	32W	Sebastian	N/A**	N/A**	14,590	14,690
Gordon, Fannie I. #1*	03131102680000	9	8N	32W	Sebastian	5,295	5,350	5,592	5,615
Larco #1*	03131102740000	21	8N	32W	Sebastian	6,625	6,680	6,905	6,940
USA #1-10*	03131300470001	10	6N	29W	Sebastian	9,165	9,280	9,580	9,665
Creekmore-West #1	03131100210000	33	7N	30W	Sebastian	9,247	9,343	9,675	9,807
USA #2-6	03131100890000	6	7N	30W	Sebastian	8,720	8,805	9,057	9,095
Reserve #1-36	03131107270000	36	7N	31W	Sebastian	8,880	8,935	9,240	9,338

Nelch #1	03131101360000	34	7N	31W	Sebastian	8,630	8,680	8,995	9,076
USA #22-1	03131102640000	22	7N	31W	Sebastian	7,226	7,294	7,615	7,670
Chaffee #1-27	03131107380000	27	7N	31W	Sebastian	8,332	8,405	8,732	8,816
T.H. Gilchrist #1	03131300110000	33	7N	32W	Sebastian	8,087	8,118	8,394	8,505

*: 14 wells with geochemical data (see Appendices 1-14)

**: Fayetteville Shale is not present.

software. The interpolated R_o data can be more clearly understood by examining the two-component statistical maps which integrate TOC and R_o data together as shown on Plates 1-2.

Structural Contour Map of the Top of the Fayetteville Formation and Chattanooga Shale Member

Structural contour maps for the top of the Fayetteville Formation and Chattanooga Shale Member were constructed for the study area (Plates 3-4). Stratigraphic interpretation for formation tops was accomplished by conventional well log analysis (Table 1).

The stratigraphic top for both the Fayetteville Formation and Chattanooga Shale Member forms a south-dipping surface that becomes progressively deeper toward the frontal Ouachita thrust belt. In the study area, the formation top for the Fayetteville Shale ranges in depth from about 5,000 to 13,000 ft subsea, which is much deeper compared to the producing wells drilled east of the study area. Fayetteville shale-gas production in the east-central Arkoma Basin of Arkansas generally ranges from a measured depth of 1,500 to 6,500 ft. In the study area, the stratigraphic top of the Chattanooga Shale ranges between about 5,000 and 14,000 ft subsea.

Down-to-basin normal faults are present in the Mississippian sequences within south Sebastian County, which lead to the absence of all or part of the Fayetteville Shale in some of the wells that were examined. These faults are not shown on the structural contour maps because of the limited extent of well control in the study area coupled with a paucity of available seismic data in the public domain.

Isopach Map of the Fayetteville Formation and Chattanooga Shale Member

Gross thicknesses for the Fayetteville Formation and the Chattanooga Shale Member were statistically interpolated between wells and are shown in two isopach maps (Plates 5-6).

The Fayetteville Shale is highly variable in thickness throughout the study area, in part due to structural attenuation that is described above. A stratigraphic thickness of only 30-55 ft is determined near the Oklahoma-Arkansas state line in Sebastian County; however, the sequence becomes progressively thicker toward the eastern extent of the Arkoma Basin. Well penetrations from eastern Logan County indicate the Fayetteville Shale ranges up to 275 ft or more in thickness. The Fayetteville Formation is generally divided into an upper shale unit, the Wedington sandstone if present, and a middle to lower shale sequence (Croneis, 1930; Ratchford et al., 2006).

In the primary gas producing region of the Fayetteville Shale, the gross thickness of the pay zone is an important factor to assess the resource potential. The pay zone interval of the Fayetteville Shale is defined as the intervening stratigraphic sequence located between the uppermost and lowermost stratigraphic horizons that have hydrocarbon generation potential. The pay zone interval is typically an organic-rich facies positioned in the middle to lower part of the formation and contains a characteristic high gamma ray and high resistivity well log response compared to overlying shales that have little or no gas potential (Ratchford et al., 2006). For this study, the Fayetteville Formation is undifferentiated due to its relatively limited thickness throughout the study area. In general, the Chattanooga Formation is much thinner than the Fayetteville Formation and thickens to the south. The Sylamore Sandstone member appears to be

absent in the wells studied for this project based on conventional well log analysis. The Chattanooga Shale Member ranges in stratigraphic thickness from approximately 20 to 150 ft in the study area.

Log Character

Fayetteville Shale well log response is characterized by high gamma ray (> 75 API) signatures for the middle-lower shale unit (up to 300 API) due to the abundance of organic matter which has a strong affinity for radioactive nuclides. The resistivity signature is typically low for the upper shale unit (< 15 ohm-meters), but becomes very high (up to 800 ohm-meters) for the lower organic-rich facies when it contains gas. Well log response for the Chattanooga Formation is characterized by consistently high gamma ray (> 200 API) signatures for the entire shale sequence.

Thermal Maturity Profiles

Ratchford et al. (2006) documented that the vitrinite reflectance values (R_o %) of the Fayetteville Shale collected in the eastern Arkoma Basin and Mississippi Embayment of Arkansas fall within a range of 1.93% to 5.09% corresponding to the dry gas window. In this eastern region, the mean R_o value for the Fayetteville Shale pay zone is 2.84%. They provided two explanations for the abnormally high thermal maturities observed in the study area. The first explanation involves a northward migrating front of heated orogenic fluids that were displaced from the advancing Ouachita orogenic belt located south of the Arkoma Basin. The second explanation is attributable to continental rifting

and structural attenuation of the crust in the Reelfoot Rift which culminated with emplacement of synkinematic igneous intrusions during the Cretaceous.

Outcrop and subsurface samples of the Chattanooga Shale have been examined by Carr (1987) in northwestern Arkansas. He stated that R_o values from outcrop samples on the north Arkansas structural platform average 0.70%, while samples from well cuttings in the western Arkoma Basin range from 1.42% at a depth of 2,750 ft to a maximum of 5.65% from a depth of 14,690 ft.

For this study, the authors collected well cuttings of shale-rich samples from Pennsylvanian through Devonian stratigraphic units that were derived from well penetrations in the western Arkoma Basin of Arkansas. Analysis of these samples was conducted to assess the degree of thermal maturation for potential shale-gas exploration targets. Measured R_o values from the shale samples vary from 1.29% to 5.05% with a corresponding depth range of 1,860 to 14,695 ft. The R_o values measured from the Fayetteville samples range from 2.99% at a depth of 9,065 ft to 3.78% at a depth of 11,425 ft, whereas measured R_o values from the Chattanooga Shale range from 2.45% at 6,475 ft to 3.66% at 9,625ft.

The high “absolute values” of thermal maturity in the Arkoma Basin are thought to be the result of heat transfer via fluid migration from the Ouachita thrust belt during the incipient phase of the Ouachita orogeny and may also be partially attributable to Atokan syndepositional normal faults (Houseknecht et al., 1992; Ratchford et al., 2006). Thermal maturation profiles were created as a tool to assess vertical and lateral thermal maturity gradients in north-south and east-west directions (Figure 2). The general vertical relations displayed in this plot are not unexpected, although some control points

in Sebastian County show abnormally lower levels of thermal maturity than expected. That is, all counties display a general increase in R_o values with depth. Thermal maturity gradients increase from north-to-south and from west-to-east throughout the Arkoma Basin of Arkansas, which is consistent with prior observations (Houseknecht, et al., 1992; Byrnes and Lawyer, 1999). Houseknecht et al. (1992) suggested that the heat transport is through fluid flow and would most likely be directed from the deepest part of the Arkoma Basin and follow divergent flow paths in shelf (pre-orogeny) versus foreland basin facies. Fluid flow would most likely be directed northward (up depositional dip) within Cambrian through basal Atokan strata that were deposited on a tectonically stable shelf prior to formation of the foreland basin. Atokan and Desmoinesian foreland basin strata were deposited by westward progradation of clastic deposition and fluid flow would most likely be directed eastward for two reasons. First, the presence of down-to-the-south normal faults would likely have focused fluid migration along flow paths parallel to their east-westerly strike. Second, the Atoka Formation is lithologically sandier in the eastern part of the Arkoma Basin compared to the western part (Zachry and Sutherland, 1984). Facies-controlled permeability conduits would tend to concentrate flow up depositional dip into sandier facies within the eastern part of the basin.

Organic Geochemistry

TOC Analysis

Total Organic Carbon **(**TOC) data provides valuable information about the source rock potential of the Fayetteville and Chattanooga Shales. TOC is the present-day measurement of the organic richness of the shale and, as such, represents the residual

TOC remaining after generation of variable amounts of liquid and gaseous products. To be considered a potential hydrocarbon source rock, a clastic rock is suggested to contain

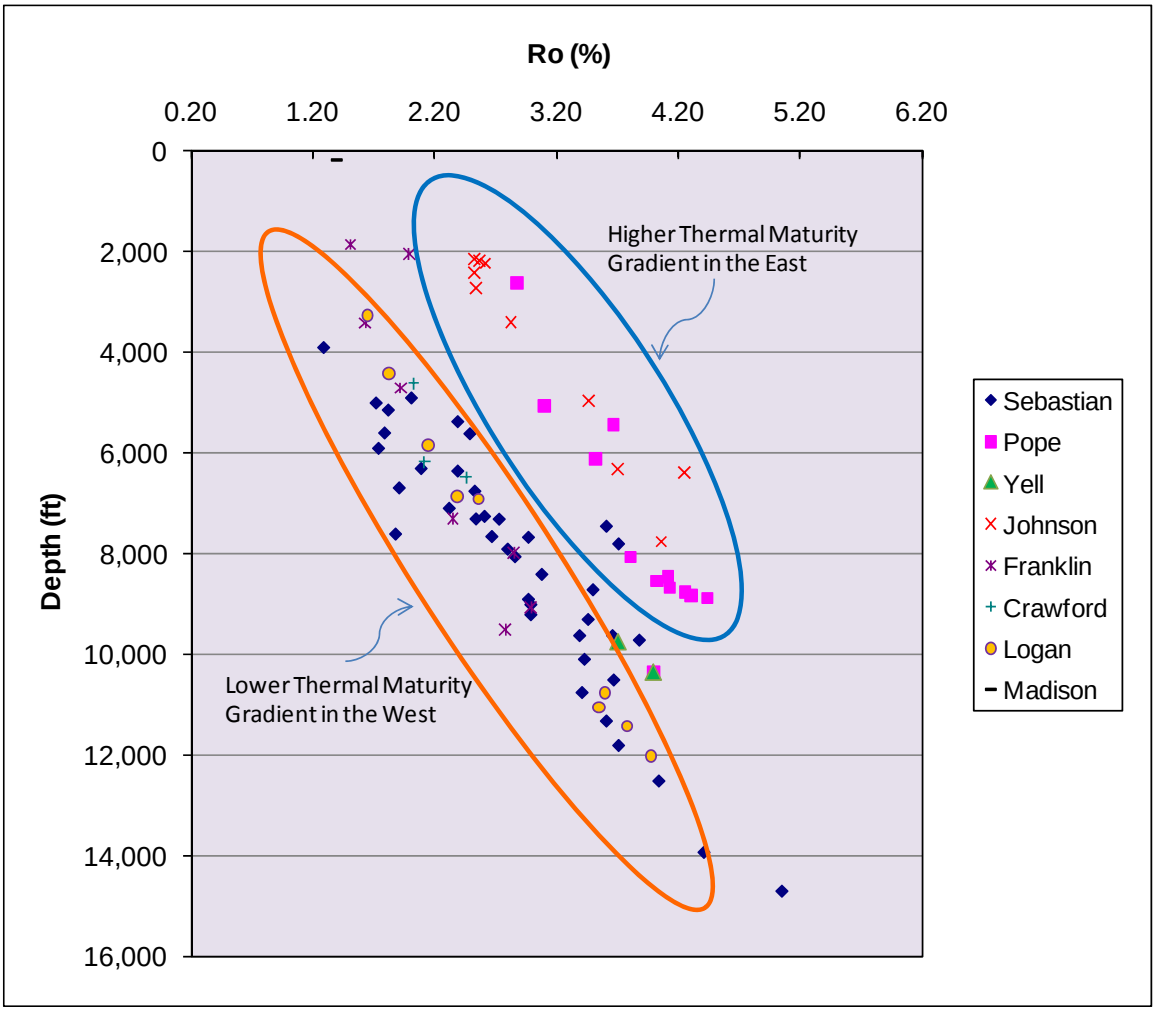

Figure 2. Measured vitrinite reflectance data designated by county within the study area. Note that thermal maturity gradients appear to increase from north-to-south and from west-to-east in the western Arkoma Basin of Arkansas (see Plates 1 and 2).

at least 0.5% organic carbon (Tissot and Welte, 1984). Various authors have suggested TOC values of at least 1.0% or higher (Baker, 1962; Jarvie, 1991). TOC values determined by commercial laboratories appear to be lower for well cuttings compared to

those from core samples. It has been determined that well cuttings generally represent about 1.3 to 2.5 times lower TOC values than comparable core chips (Jarvie et al., 2007). In addition, the TOC values are lower for the units which have been subject to high thermal maturity processes. At greater than about 1.6% R_o, TOC values in the Barnett Shale of Texas are reduced by about 35% of their original values (Jarvie et al., 2007). We can expect the Fayetteville and Chattanooga Shales to have a TOC reduction by at least 30-40% given the fact that they have comparable or higher thermal maturities compared to the Barnett Shale.

Ratchford et al. (2006) stated that TOC values calculated for the Fayetteville Shale pay zone in the eastern Arkoma Basin and Mississippi Embayment region of Arkansas average 2.03% with a range of 1.28 to 2.78%. According to Carr (1987) TOC values of the Chattanooga Shale in northwestern Arkansas range from 0.8 to 4.2% with a mean value of 3.2%. Li and Ratchford (2008) previously reported Chattanooga TOC values from 0.25 to 7.29%, with a mean value for all samples of 2.88%.

In this study, TOC values were measured from approximately 462 well cutting samples collected from Pennsylvanian through Devonian stratigraphic units including both the Fayetteville and Chattanooga Shales. TOC values for the Fayetteville average 2.28%, ranging between 0.32 and 5.51% (Figure 3). Although the Fayetteville Formation was not differentiated into upper and lower members, TOC values for the lower Fayetteville beds are typically higher than those of the upper Fayetteville beds. TOC values for the Chattanooga Shale range from 0.34 to 6.86% with a mean value of 2.88% (Figure 4). Comer and Hinch (1981) and Carr (1987) reported similar TOC values of 3.5% and 3.2% respectively for the Chattanooga Shale on a transect from the Ozark

Uplift to the Arkoma Basin. Both the Fayetteville and Chattanooga's TOC values do not appear to vary widely within a given geographic location. These two shale units contain sufficient TOC to be considered significant hydrocarbon source rocks.

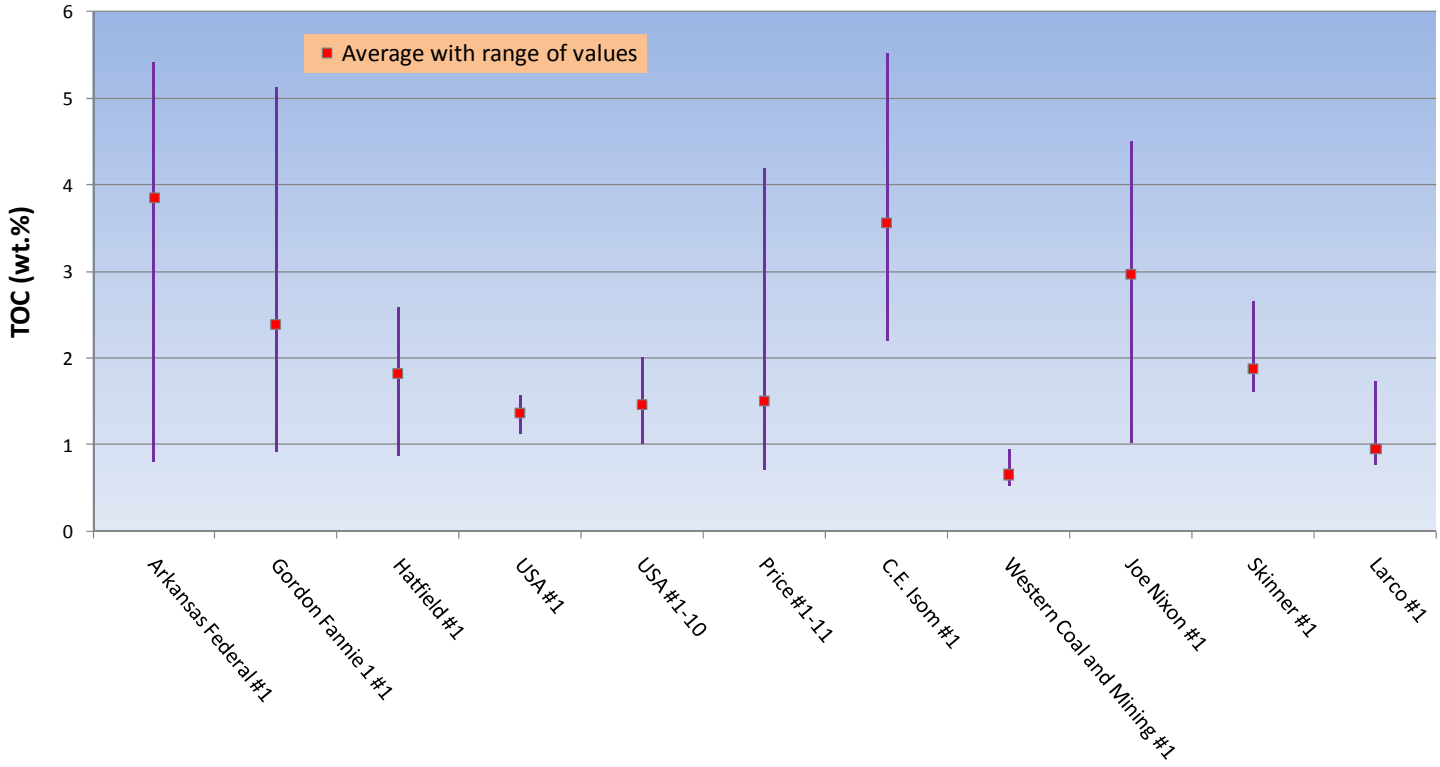

Figure 3. Total organic carbon content data for each well with the Fayetteville Shale in the western Arkoma Basin of Arkansas.

Working with cuttings is always a challenge for evaluation of the true potential of source rocks and becomes more important when those source rocks are targets for unconventional shale-gas exploration. Cuttings are prone to have a variety of contamination effects particularly from mixing with intervals of varying organic richness. The most illustrative example of this is when a coal seam or lens is encountered and carries on for hundreds of feet in cuttings. This is particularly problematic when lean

non-source or even lean source intervals are encountered as a little bit of organic rich contamination can increase TOC values to levels suggesting higher quality than is truly

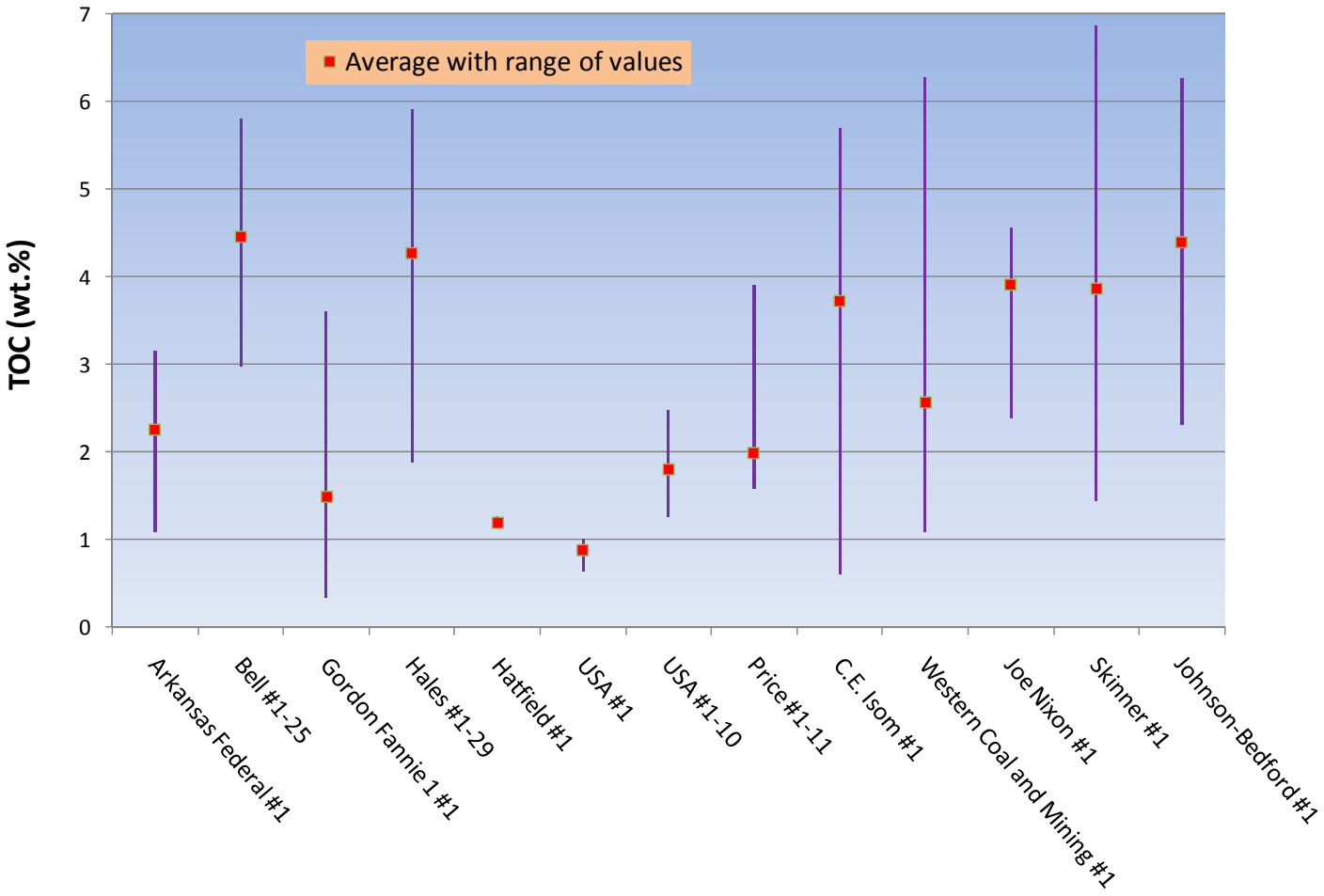

Figure 4. Total organic carbon content data for each well with the Chattanooga Shale in the western Arkoma Basin of Arkansas.

present. Such contamination requires careful hand selection of cuttings to ensure that no such crossover contamination occurs. However, even this approach is not always a solution. For example, in the core region of the Barnett Shale gas play, organic-lean carbonates are black and give the appearance of Barnett Shale. Visual hand picking of cuttings does not work, nor does testing with acid, as some Barnett Shale intervals have

high carbonate contents. In the Barnett Shale it was concluded that cuttings from mature areas had an average TOC of about 3.21%; core samples from the same areas had values of about 4.50% on average (Jarvie et al. 2007). As such, we have investigated a number of options for this decrease, e.g., oxidation, without success. One such solution, however, is merely dilution of organic rich cuttings with organic lean cuttings. If we take a 4.50% Barnett Shale core and mix it with 10, 20, 30 and 40% cavings from an organic-lean carbonate of 0.20% TOC, the TOC is reduced to about 3.21% at level of contamination of about 30% (Figure 5). Mixing with a 1.00% TOC interval would reduce the TOC to 3.45% at 30% contamination and would require 50% cavings contamination from a 1.00% interval. Overall it appears that about 30% cavings contamination is occurring on average through a shale interval.

On the other hand, passing through an organic rich interval into a lean interval would have the opposite effect. For example, using a TOC value of 4.50% for the Barnett Shale and assuming an underlying carbonate has about 0.20% TOC, at 10, 20, 30, and 40% cavings contamination, the TOC of the organic lean carbonate would increase to 0.63, 1.06, 1.49, and 1.92% TOC (Figure 6). Again, a value of around 20-30% caving contamination looks reasonable, but could certainly be higher or lower depending on sample collection, bit selection, and other factors.

There are certainly a variety of contamination issues when working with cuttings. Oil-based muds certainly will elevate all parameters except T_{max}, which will be lowered; such samples require solvent extraction before analysis. Other additives ranging from lignite to fibrous organics will also affect all values. Coaly additives will certainly have a very dramatic impact on TOC. Usually additives derived from anthropogenic sources

will cause much higher S_3 values as well as affect all other parameters. Additives such as gilsonite and Soltex ® (a sulfonated asphalt used to reduce shale sloughing) affect S_2 pyrolysis yields more than the free oil (S_1) values as they decompose only under

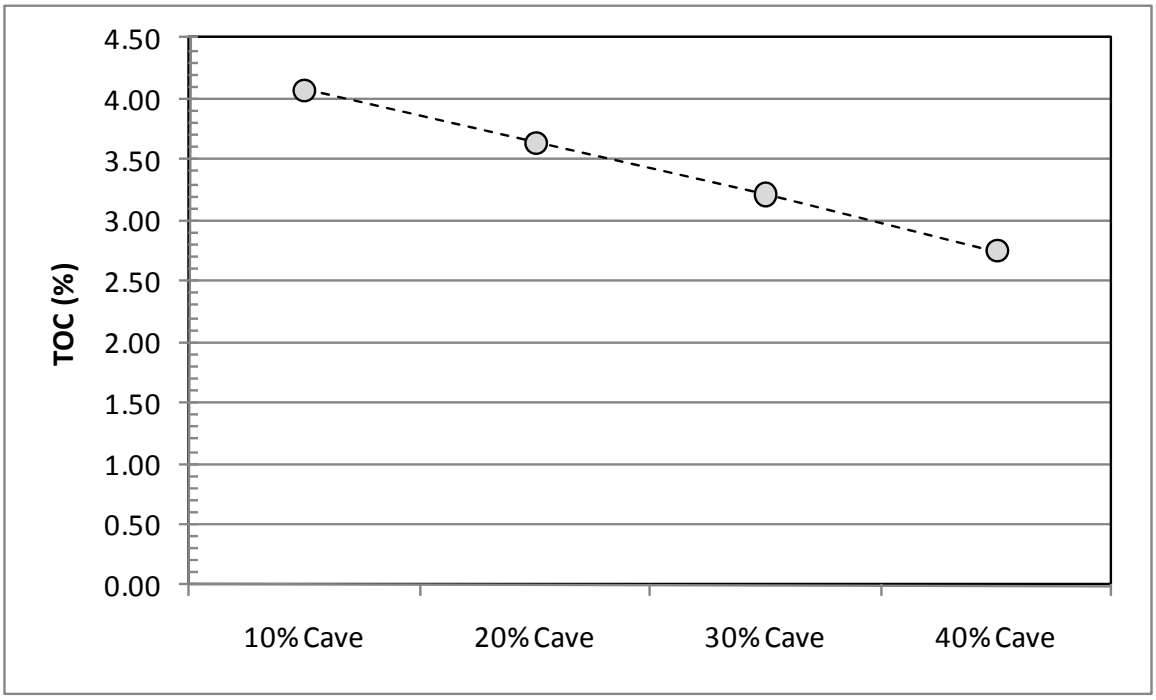

Figure 5. Effect of organic lean cavings contamination on cuttings from an organic rich interval. This example is from the Barnett Shale where TOC values from cuttings average about 3.21%, whereas core averages about 4.50%. Such a decrease in TOC values would require about 30% cavings contamination from an organic lean (0.20% TOC) interval overlying the shale.

pyrolysis temperatures. Other forms of contamination are nearly impossible to remove such as those caused by the chemical binding of mud additives to the surfaces of well cuttings from various stratigraphic horizons. This condition can alter the geochemical properties and the analytical results of well cutting samples. Despite these limitations it

is still valuable and quite useful to evaluate geochemical properties from cuttings keeping in mind underlying issues with data quality.

Regarding TOC values and the relationship to Rock-Eval data, it is useful to recognize that a portion of TOC is derived from the residual free oil and kerogen in a sample, referred to as pyrolyzable carbon (PC) (Espitalié et al., 1984). The remaining

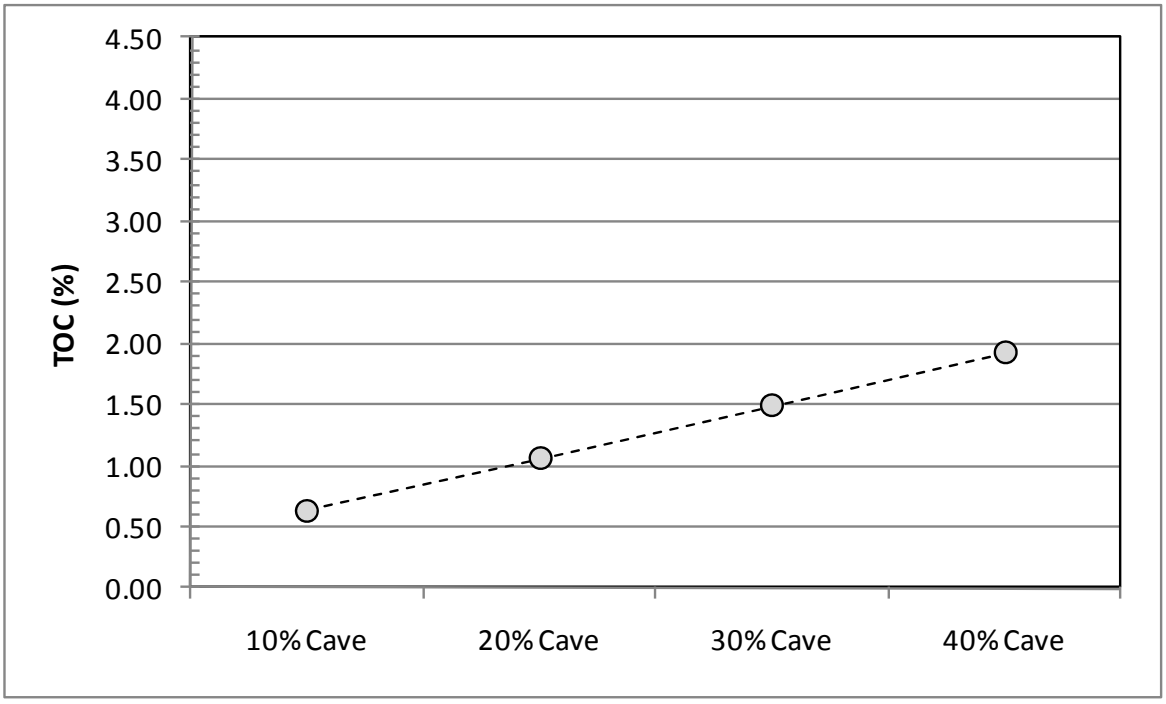

Figure 6. Effect of organic rich cavings contamination on cuttings from an organic lean interval. This example is from the Barnett Shale where an underlying carbonate has only 0.20% TOC but with 10, 20, 30, or 40% cavings contamination from a 4.50% TOC shale, the TOC values increase to higher values and could suggest a source interval when absolutely none is present.

portion is dead carbon (DC), which is spent organic carbon plus remnant non-generative organic carbon. If a given sample contains S_1 and S_2 hydrocarbons, then a reasonable estimate for the average carbon content is 83%. As such, an S_1 of 1 and an S_2 of 1 would only contribute 0.17% organic carbon to a TOC value of 1.00%; the remainder being a

spent or dead carbon residue. From this one can easily calculate the impact of PC on TOC values.

A simple formula for TOC using this terminology is:

$TOC = 0.083 \times (S_1+S_2) + 0.10 \times DC$

Or $PC = 0.083 \times (S_1+S_2)$

(Note: because TOC is parts per hundred, i.e., %, and S_1 and S_2 are in mg/g or parts per thousand, they must be adjusted to parts per hundred by multiplying by 0.10; assuming 83% carbon in hydrocarbons, a value of 0.083 is the multiplying factor).

The review of TOC values for individual wells are given as follows:

Arkansas Federal #1 (See Appendix 1)

TOC values in the Fayetteville Shale and Chattanooga Shale are very well behaved with Rock-Eval data that has no indication of drilling contamination. TOC values do not appear to be reduced by any mixing of cuttings and represent high quality data. The low hydrogen indices (HI) and low S_1/TOC values suggest no problem with contamination.

*Bell #1-25 (*See Appendix 2)

This well data is reasonably well behaved although the TOC values grade to higher values at greater depths including a very high value of greater than 9% just below the Chattanooga Shale that could be explained by a sampling lag.

There is indication of some form of contamination in both HI and S_1/TOC values. As seen in the well of *Arkansas Federal #1* above, typical HI and S_1/TOC values at such

high levels of thermal maturity would likely be less than 20 for either HI or S_1/TOC. Very high values of S_1/TOC indicate some form of thermally distillable additive, not likely diesel as the S_1 values are modest, but some additive that decomposes under Rock-Eval S_1 conditions (300^{o}C distillation temperature). Elevated pyrolysis yields (S_2) would cause the HI value to be higher, and contamination can carry over into the S_2 peak when waxes, resins, asphaltic, or coaly materials are added to the well bore to aid drilling operations.

The organic rich sample below the Chattanooga Shale also has an unusually high S_1/TOC value and represents contamination as does the equally high HI value. As such, the TOC values in intervals with some form of drilling additive are lower by about 0.83%. Thus, the sample at the depth of 11,020-030 ft would be quite lean having a TOC value without the S_1 and S_2 carbon of about 0.66%. TOC values below that interval are high with no apparent contamination.

Gordon Fannie I. #1 (See Appendix 3)

There is no additive contamination indicated in this well so TOC values are from indigenous sediments. TOC values in the Fayetteville Shale increase with depth suggesting cuttings diluted from overlying lean horizons. Chattanooga Shale samples appear to have some offset in TOC values. It reflects on the low TOC values of 0.52% and 0.34% in the Chattanooga Shale while a high value of 3.4% at 5,620-30 ft just below the Chattanooga suggests sampling lags.

Hales #1-29 (See Appendix 4)

In the uppermost sections of this well there appears to be some form of intermittent contamination based on the high S_1/TOC ratios and the high HI values, especially in relation to the high level of thermal maturity. TOC values are running about 0.20% to 0.60% higher due to this unknown contamination. While there is some contamination in the Chattanooga Shale, it is not very high. It is identifiable, however, by the higher S_1 and S_1/TOC values that are inconsistent with the high thermal maturity. As such, S_1 contamination only causes minor increases in TOC values in organic rich shales. This is because an S_1 value of 1.00 mg HC/g rock only contains 0.08% TOC. In a shale with 4-6% TOC, this has very low impact on its residual TOC value. In this well, TOC values in the Chattanooga Shale also grade to higher values with depth suggesting caving contamination. The highest TOC occurs about 20 ft below the base of the Chattanooga Shale indicating a sampling lag and cross contamination of cuttings.

Hatfield #1 (See Appendix 5)

There is no obvious drilling fluid or additive contamination in this well as the HI and S_1/TOC values are quite low. Nor does there appear to be a significant TOC baseline above the Fayetteville Shale where TOC values are less than 1.00%. TOC values of the Fayetteville Shale increase with depth showing the gradual change in concentration of cuttings from the Fayetteville as opposed to overlying organic lean sediments. TOC values of the Chattanooga Shale are modest and do not increase with depth. There is no obvious explanation for these values other than it is a leaner section of the Chattanooga Shale than seen elsewhere in the basin.

C.E. Isom #1 (See Appendix 6)

This well data appears to be very high quality with no apparent contamination from additives or drilling fluids. TOC values are excellent in the Fayetteville Shale grading to higher values with depth. Chattanooga Shale values are also excellent and reach a maximum value in the middle of the sampling interval.

Johnson-Bedford #1 (See Appendix 7)

There is no apparent contamination from additives or drilling fluids in this well. TOC values exceed 1.00% through the Chattanooga Shale interval and increase with depth. There are hundreds of feet with higher TOC values below the Chattanooga Shale that could be attributable to cross contamination or sample collection error at the drill site.

There is one organic rich interval below the Chattanooga Shale at 12,090-12,120 ft with a 4.75% TOC value, but there is no apparent additive or drilling fluid contamination in the data and this interval shows a high gamma ray response suggesting that this high TOC value is correct.

Larco #1 (See Appendix 8)

These cuttings appear to be clean and free of most contamination, although TOC values are near 1.00% as a base value. TOC values of the Fayetteville Shale are lean, although values increase slightly through and below it.

Joe Nixon #1 (See Appendix 9)

This well has high quality data throughout the sampling interval with no apparent contamination. Samples actually have higher TOC values in single intervals just above the shales of interest. Ten feet above the top of the Fayetteville Shale is a 3.59% TOC value and similarly, 10 and 20 ft above the Chattanooga Shale are high TOC values. In the case of the Fayetteville Shale there is one value that is 3.46% below the shale.

Price #1-11 (See Appendix 10)

These well cuttings data are high quality with grading up of TOC values at the bases of the Fayetteville and Chattanooga Shales. This also suggests at least 10 to 20 ft of carryover of cuttings into the underlying intervals.

Skinner #1 (See Appendix 11)

These data are high quality with a carryover of cuttings over approximately 20 ft. However, there may be possibly as much as 80 ft of carryover of cuttings based on the TOC values through and below the shale. There is a missing TOC value below the Chattanooga Shale so it is not possible to identify any grading up of values. However, the values at the base of the Chattanooga Shale are excellent reaching 6.86% over the 9,320-30 ft interval.

USA #1 (See Appendix 12)

There is some contamination apparent in this well below the Fayetteville Shale from 6,190–280 ft where the S_1/TOC values exceed 100 mg HC/g TOC and HI values

exceed 100 mg HC/g TOC. However, this contamination does not appear to have any effect on either the overlying Fayetteville Shale or underlying Chattanooga Shale data. TOC values grade upward slightly through and below each shale. Such contamination that would increase the HI and S_1/TOC values would have minimal impact on the overall organic richness. This is because even the sum of S_1 and S_2 is 3.96 mg HC/g rock, this computes to an addition to the TOC value of only 0.33% (assuming hydrocarbons are 83% carbon). As such, the contamination was likely some form of organic liquid as it disappears from the system over a very short interval.

USA #1-10 (See Appendix 13)

The overall TOC values are higher than expected with all being over 1.00% for the entire non-shale intervals analyzed. TOC values grade up slightly in both the Fayetteville and Chattanooga Shales, but no increase occurs below either shale. No contamination is obvious in these data with low HI and S_1/TOC ratios.

Western Coal and Mining #1 (See Appendix 14)

These cuttings are clean and free of extraneous contamination based on the low S_1, S_1/TOC, and HI values throughout the sampling interval. TOC values increase below the Fayetteville Shale from 20 to about 60 ft deeper with the highest values occurring 20-30 ft below the base of the Fayetteville Shale. TOC values of the Chattanooga Shale are not much above background values except at the base of the shale where values reach 5-6% TOC. There is also a TOC value over 4% in the 10-20 ft interval below the base of the Chattanooga Shale comparable to the Johnson-Bedford #1 well.

Kerogen Type

The derivation of the originally deposited organic matter affects both the quantity and quality of the hydrocarbons generated. Kerogen is often classified as type I, II, III and IV based on its elemental composition in terms of hydrogen (H) and oxygen (O) content relative to the carbon (C) content. Type I and II generate most of the world's oil, and type III generates primarily gas, condensate, and some waxy oil. Type IV generates only small amounts of methane and CO_2. In type I kerogen, the percentage of oil-prone convertible carbon in TOC is high (generally greater than 70 wt. %), illustrating its high potential to generate oil. Type II kerogen contains between 30–70 wt. % convertible carbons in TOC. Type II source rocks with a higher percentage of convertible carbon have more oil than gas potential. Type III kerogen has a lower potential to generate hydrocarbons than either type I or type II kerogens due to its lower relative hydrogen content. The percentage of convertible carbon contained in the TOC is less than 30 wt. %. Type IV kerogen has a very low H/C ratio and a high O/C ratio and possesses no hydrocarbon-generating potential.

Type I kerogen is usually formed in relatively fine-grained, organic-rich, anoxic muds deposited in quiet, oxygen-deficient, shallow-water environments (e.g. lacustrine settings such as lagoons and saline or freshwater lakes). Type II kerogen can potentially be formed in any environment, but in marine settings a major source is mixture of autochthonous organic matter from phytoplankton (and also possibly zooplankton and bacteria) together with an allochthonous contribution of higher plant material. Type III kerogen is essentially formed from vascular plants and contains much identifiable plant debris, so vitrinite macerals often predominate. Type IV kerogen is composed largely of

inertinite, with minor amounts of vitrinite, probably formed from higher plant matter that has been severely oxidized on land and then transported to its deposition site (Killops and Killops, 2005) or from forest fire chars.

Comer (1985) reported that the kerogen type of the Chattanooga Shale in the proximity of the Ozark Uplift is mixed type II and type III. Li and Ratchford (2008) reported that the Chattanooga Shale contains amorphous and herbaceous kerogen, which suggests oil-prone marine organic matter with an influx of terrestrial supply. The visual kerogen analysis by Ratchford et al. (2006) showed that the kerogen composition of the Fayetteville Shale in the eastern Arkoma Basin is dominated by amorphous and micronized lipids, which suggests primarily type II organic matter of marine origin. In the Mississippi Embayment the kerogen of the Fayetteville Shale is typically characterized by terrestrial indigenous/recycled vitrinite (type III) with less than 30% of amorphous organic matter. A small number of well cutting samples from the Chattanooga and Fayetteville Shales were analyzed for kerogen type in this study (Table 2). Only one sample of the Chattanooga Shale in Johnson County has a similar kerogen type as reported by Comer (1985). Both amorphous and herbaceous kerogens were evenly mixed in this Chattanooga sample, which suggests an oil-prone marine organic matter origin with an influx of terrestrial supply. The Fayetteville samples were primarily represented by amorphous kerogen, but a few samples are dominated by terrestrial kerogen.

Table 2. Visual kerogen analysis of the Fayetteville and Chattanooga Shales in western Arkoma Basin of Arkansas.

Well API	Well ID	County	Section	Township	Range	Elevation (ft)	Depth 1 (ft)	Depth 2 (ft)	Formation	Color	TAI	% Source Material							% Kerogen Composition							Vitrinite			
												Amorphous Debris	Finely Dissem. OM	Herb. Plant Debris (Vit.)	Woody Plant Debris	Coaly Fragments	Algal Debris	Palynomorphs	Indigenous Vitrinite	Caved Vitrinite	Recycled/Oxidized Vitrinite	Inertinite	Solid Bitumen	Drilling Additive/Contamination	Amorphous Kerogen	# of Readings	Total Sample Ro (%)	# of Indigenous Readings	Indigenous Ro (%)
03047100830000	Federal 1-15	Franklin	15	11N	29W	1,376	1,980	2,110	Faye./Chatt.	DBDG	3.7	8	2	89				1	14	1	70	5			10	40	1.97	30	1.99
03071106210000	Storms 1-33X	Johnson	33	11N	23W	864	2,120	2,160	Fayetteville	DGBL	4.0	95	3	2				tr	1	tr	1	3	3		92	40	2.52	35	2.53
03071106210000	Storms 1-33X	Johnson	33	11N	23W	864	2,160	2,210	Fayetteville	DGBL	4.0	13	2	83				2	30	tr	45	10	tr		15	40	2.55	36	2.57
03071106210000	Storms 1-33X	Johnson	33	11N	23W	864	2,210	2,250	Fayetteville	DGBL	4.0	19	3	76				2	10	tr	55	15			20	40	2.66	30	2.62
03071106210000	Storms 1-33X	Johnson	33	11N	23W	864	2,550	2,600	Chattanooga	DGBL	4.0	44	2	53				1	20	tr	30	5			45	40	2.48	32	2.53
03115105300000	Mitchell 30-33	Pope	30	7N	18W	329	8,810	8,850	Fayetteville	DGBL, BLK	4, 5	74	5	21				tr	5	tr	15	5	10	5	60	40	4.25	33	4.31
03115105300000	Mitchell 30-33	Pope	30	7N	18W	329	8,850	8,900	Fayetteville	DGBL, BLK	4, 5	90	3	7				tr	2	tr	5	3	5		85	40	4.43	38	4.44

Notes:
DBDG: Dark Brown-Dark Gray
DGBL: Dark Gray-Black
BLK: Black
tr: Trace
TAI: Thermal Alteration Index

Rock-Eval Pyrolysis

Rock-Eval pyrolysis is used to identify the type and maturity of organic matter and to detect petroleum potential in sediments. The Rock-Eval pyrolysis method consists of a programmed temperature heating of a small sample (~ 100 mg) to quantitatively and selectively determine (1) the free hydrocarbons contained in the sample and (2) the hydrocarbon- and oxygen-containing compounds (CO_2) that are volatized during the cracking of the unextractable organic matter in the sample (kerogen). In summary, the four basic parameters obtained by pyrolysis (Espitalié et al.,1977; Tissot and Welte, 1984) are as follows:

S_1 = the amount of free hydrocarbons (gas and oil) in the sample (in milligrams of hydrocarbon per gram of rock). S_1 normally increases with depth.

S_2 = the amount of hydrocarbons generated through thermal cracking of nonvolatile organic matter. S_2 is an indication of the quantity of hydrocarbons that the rock has the potential of producing should burial and maturation continue.

S_3 = the amount of CO_2 (in milligrams CO_2 per gram of rock) produced during pyrolysis of kerogen. S_3 is an indication of the amount of oxygen in the kerogen and is used to calculate the oxygen index.

T_{max} = the temperature at which the maximum release of hydrocarbons from cracking of kerogen occurs during pyrolysis (top of S_2 peak). T_{max} is an indication of the stage of maturation of the organic matter.

Additional information is also routinely generated to evaluate source rock potential through the use of TOC and Rock-Eval data in order to calculate a hydrogen

index (HI) and oxygen index (OI) number. A summary of these two indices are described below from the work of Espitalié et al. (1977):

HI = The hydrogen index is the normalized hydrogen content of a rock sample. Kerogen type is partially derived from this information and the hydrogen index decreases as the sample matures.

OI = The oxygen index is the normalized oxygen content of a rock sample and is one of several tools used for kerogen typing.

In this study, Rock-Eval pyrolysis of the Fayetteville and Chattanooga Shales indicates that almost all of the samples have very low remaining hydrocarbon generation potentials (Rock-Eval S_2 yields). This suggests that a high degree of conversion has occurred that is indicative of a high thermal maturity regime assuming an original type II oil prone kerogen. Such low S_2 values are consistent with high thermal maturity of hydrocarbons in the dry gas window. It is noted that calculated R_o values that are based on T_{max} are not reliable when the pyrolysis (S_2) peak is very low and this constitutes the majority of samples in this study. T_{max} is determined from the temperature at peak evolution of pyrolysis hydrocarbons; when samples are highly mature, there is no pyrolysis peak and the T_{max} value cannot be determined accurately. Therefore, calculated R_o and T_{max} values in this study are not useful for thermal maturity assessments. Measured R_o values are a more reliable parameter to be utilized for determining thermal maturity of these highly converted shales. Based on the measured R_o values in the study area, all of the shales are in the dry gas window where pyrolysis yields will be very small. As a confirmation of such high thermal maturity, low HI values of less than 100 mg HC/g

TOC are indicative of samples in the gas window and with values less than 50 mg HC/g TOC indicative of the dry gas window. HI values for the Chattanooga average 15 mg HC/g TOC and for the Fayetteville 20 mg HC/g TOC, placing both in the dry gas window.

Interpretation, Conclusions and Recommendations

The shale-gas potential of the Fayetteville Shale and Chattanooga Shale was examined in the western part of the Arkoma Basin of Arkansas. A combination of techniques were employed to achieve this objective including the geochemical processing of 462 well cutting samples collected from the Norman F. Williams Well Sample Library in Little Rock, Arkansas. Analytic methods and geologic techniques that were utilized to assess the shale-gas potential include: total organic carbon (TOC) analysis, Rock-Eval pyrolysis, vitrinite reflectance (R_o), visual kerogen measurements, geochemical and thermal maturity modeling of subsurface data, and development of structure contour and isopach maps.

Integrated analysis of the methodology discussed above suggests that both the Fayetteville Shale and the Chattanooga Shale are excellent source rocks and would likely be capable of generating and possibly storing dry gas. The analytical focus of this project is the determination of organic richness, thermal maturity, kerogen type identification, hydrocarbon generation potential, stratigraphic thickness, and depth to the pay zone. The integration of this information is used as a tool to assess the economic potential of natural gas within the Fayetteville Shale and Chattanooga Shale of west-central Arkansas.

A review of the Fayetteville Shale is presented first and the reader is referred to Plates 1, 3 and 5 for discussion herein. The isopach map of Plate 5 illustrates the progressive eastward thickening of the Fayetteville Formation which suggests that the Fayetteville depocenter is located east of the study area where shale-gas production has been established since 2005. Consequently, the most prospective region for thicker stratigraphic intervals for exploration and development lies in the eastern part of the study area. The authors suggest that the most prospective stratigraphic thicknesses occur in the vicinity of Range 26 W through Range 24 W with corresponding thicknesses that approximate 150 to 275 ft.

Plate 1 is a two-component map consisting of the interpolated values of total organic carbon (TOC) and vitrinite reflectance (R_o) for the Fayetteville Shale. Examination of Plate 1 illustrates that the southwestern portion of the study area contains lower TOC values and higher thermal maturities in excess of R_o = 3.0%. The higher thermal maturities coupled with thinner stratigraphic horizons and lower TOC values limit the economic viability of the southwestern portion of the study area. The west-central and north-western portions of the study area contain more suitable thermal maturities in the range of R_o = 2.0 to 3.0%, but this region also has lower TOC values and thinner stratigraphic intervals (< 100 ft). The northeastern to east-central portions of the study area provide the best opportunity for regional exploration of the Fayetteville Shale in that it contains suitable TOC values, in the approximate range of 2.0 to 3.5% and thermal maturities in the R_o range of 2.75 to 3.5%. The southeastern portion of the study area contains suitable TOC values, but is hindered by excessive thermal maturities in excess of R_o = 3.5% and the depth to pay zone is in excess of 10,500 ft (Plate 3).

Development of deeper natural gas targets are technologically achievable in the southeastern part of the study area, however, the well costs tend to be higher and thus limit the economic viability of unconventional natural gas wells depending on gas price.

A review of the Chattanooga Shale is presented below and the reader is referred to Plates 2, 4 and 6 for discussion herein. The isopach map shown on Plate 6 illustrates that the Chattanooga Shale is fairly thin (< 100 ft) throughout most of the study area and reaches a maximum thickness along the southwestern and south-central regions. Consequently, any commercial exploitation of shale gas resources from the Chattanooga Shale will most likely be focused along the southern flank of the central and western portions of the study area. The foregoing discussion of the computer models in Plates 2, 4 and 6 and interpretations of the exploration potential of the Chattanooga Shale resource are thus limited to these regions.

The southwestern portion of the study area is structurally complex and well log analysis and modeling of geologic information is difficult due to structural omission and duplication of stratigraphic units. Computer modeling and statistical interpolation of stratigraphic top information suggest an approximate thickness of 90 to 150 ft along the southern flank of the central and western regions of the study area (Plate 6). The two-component map of Plate 2 is a statistical interpolation of TOC and R_o values for the Chattanooga Shale. Plate 2 illustrates that the Chattanooga Shale is a viable source rock with TOC values in excess of 3.5%, but thermal maturities are high in the R_o range of 3.5 to 4.25%. The structure contour map of Plate 4 shows a progressive and southward deepening of the Chattanooga Formation which is also proximal to the frontal Ouachita thrust belt. Integrative analysis of Plates 2, 4 and 6 suggests that the overall economic

viability of the Chattanooga Shale is marginal in the study area due to excessive drilling depths greater than 9,500 ft and high thermal maturities greater than 3.5% R_o. Structural complications of the Chattanooga Shale can also be expected along the southern flank of the study area due to the folding and faulting of the stratigraphic section and these factors will likely increase drilling and completion costs.

Finally, the information in this report should provide a geologic framework for future study of shale-gas reservoirs in the western Arkoma basin of Arkansas. Additional recommended work that was not conducted in the current study, but is germane to economic evaluation of shale-gas reservoirs include the following types of geologic analyses: determination of stratigraphic seal integrity, mineralogy determination of the pay zone including a thorough analysis of clay types as related to hydraulic stimulation procedures, determination of the maximum principal stress direction in the subsurface, analysis of inherent microfractures that are present in the shale including the density, orientation, and identification of fracture filling minerals, subsurface mapping of organic-rich facies throughout the pay zone, structural analysis of compressional and extensional faults with specific attention given to structural attenuation or duplication of the pay zone. The raw geochemical and thermal maturity data are provided in Appendices 1-14 of this report and as a series of electronic files on the CD, which permits the data to be easily imported into future projects that may be of interest to geologic researchers.

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Appendix1. Geochemical and thermal maturity analyses for the well cutting samples from the Arkansas Federal #1

ARKANSAS FEDERAL #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-4168-165165	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11300	11310	11305	Fayetteville	cuttings	NORM	4.17	2.57	0.20	0.33	0.45	377	*	-1.00			8	11	1	5	0.38
06-4168-165166	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11310	11320	11315	Fayetteville	cuttings	NORM	5.20	3.23	0.21	0.27	0.40	384	*	-1.00			5	8	1	4	0.44
06-4168-165167	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11320	11330	11325	Fayetteville	cuttings	NORM	5.28	3.26	0.13	0.17	0.46	371	*	-1.00			3	9	0	2	0.43
06-4168-165168	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11330	11340	11335	Fayetteville	cuttings	NORM	3.82	2.37	0.12	0.19	0.39	302	*	-1.00			5	10	0	3	0.39
06-4168-165169	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11340	11350	11345	Fayetteville	cuttings	NORM	5.42	3.37	0.14	0.18	0.45	302	*	-1.00			3	8	0	3	0.44
06-4168-165170	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11350	11360	11355	Fayetteville	cuttings	NORM	5.09	3.35	0.19	0.28	0.55	406	*	0.15			6	11	1	4	0.40
06-4168-165171	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11360	11370	11365	Fayetteville	cuttings	NORM	3.29	2.35	0.14	0.19	0.44	331	*	-1.00			6	13	0	4	0.42
06-4168-165172	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11370	11380	11375	Fayetteville	cuttings	NORM	4.97	3.39	0.16	0.21	0.40	302	*	-1.00			4	8	1	3	0.43
06-4168-165173	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11380	11390	11385	Fayetteville	cuttings	NORM	4.32	2.51	0.12	0.18	0.44	302	*	-1.00			4	10	0	3	0.40
06-4168-165174	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11390	11400	11395	Fayetteville	cuttings	NORM	2.46	1.60	0.14	0.18	0.30	323	*	-1.00			7	12	1	6	0.44
06-4168-165175	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11400	11410	11405	Fayetteville	cuttings	NORM	2.27	1.46	0.17	0.26	0.37	347	*	-1.00			11	16	1	7	0.40
06-4168-165176	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11410	11420	11415	Fayetteville	cuttings	NORM	4.90	3.52	0.18	0.21	0.43	329	*	-1.00			4	9	0	4	0.46
06-4168-165177	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11420	11430	11425	Fayetteville	cuttings	NORM	4.89	3.45	0.18	0.37	0.51	302	*	-1.00	3.78	C	8	10	1	4	0.33
06-4168-165178	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11430	11440	11435	Fayetteville	cuttings	NORM	4.04	2.89	0.14	0.28	0.37	372	*	-1.00			7	9	1	3	0.33
06-4168-165179	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11440	11450	11445	Fayetteville	cuttings	NORM	0.80	0.53	0.09	0.13	0.18	302	*	-1.00			16	23	1	11	0.41
06-4168-165180	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11450	11460	11455	Fayetteville	cuttings	NORM	3.71	2.57	0.10	0.16	0.35	357	*	-1.00			4	9	0	3	0.38
06-4168-165181	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11460	11470	11465	Fayetteville	cuttings	NORM	2.78	2.04	0.10	0.10	0.29	302	*	-1.00			4	10	0	4	0.50
06-4168-165182	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11470	11480	11475	Fayetteville	cuttings	NORM	1.99	1.37	0.15	0.16	0.22	359	*	-1.00			8	11	1	8	0.48
06-4168-165183	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11800	11830	11815		cuttings	NORM	0.97	0.64	0.11	0.05	0.13	301	*	-1.00			5	13	0	11	0.69
06-4168-165184	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11830	11860	11845	Chattanooga	cuttings	NORM	0.90	0.62	0.07	0.04	0.13	302	*	-1.00			4	14	0	8	0.64
06-4168-165185	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11860	11890	11875		cuttings	NORM	1.92	1.84	0.11	0.04	0.24	416	*	0.33			2	12	0	6	0.73
06-4168-165186	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11970	11980	11975		cuttings	NORM	0.63	0.24	0.06	0.06	0.08	302	*	-1.00			10	13	1	10	0.50
06-4168-165187	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11980	11990	11985		cuttings	NORM	1.09	0.52	0.15	0.15	0.09	302	*	-1.00			14	8	2	14	0.50
06-4168-165188	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	11990	12000	11995		cuttings	NORM	1.91	1.39	0.17	0.12	0.22	-2	*	-1.00			6	12	1	9	0.59
06-4168-165189	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	12000	12010	12005		cuttings	NORM	2.86	2.61	0.25	0.15	0.42	389	*	-1.00			5	15	0	9	0.62
06-4168-165190	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	12010	12020	12015		cuttings	NORM	3.15	3.09	0.37	0.22	0.33	302	*	-1.00	3.98	D	7	10	1	12	0.63
06-4168-165191	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	12020	12030	12025		cuttings	NORM	0.92	0.29	0.06	0.03	0.08	302	*	-1.00			3	9	0	7	0.67
06-4168-165192	Arkoma	03083100030000	SUN OIL COMPANY	ARKANSAS FEDERAL	1	LOGAN	AR	12030	12040	12035		cuttings	NORM	0.76	0.60	0.08	0.04	0.09	-2	*	-1.00			5	12	0	11	0.67

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

ARKANSAS FEDERAL #1
Geochemical Log

AGC Project - Arkoma Basin, Arkansas

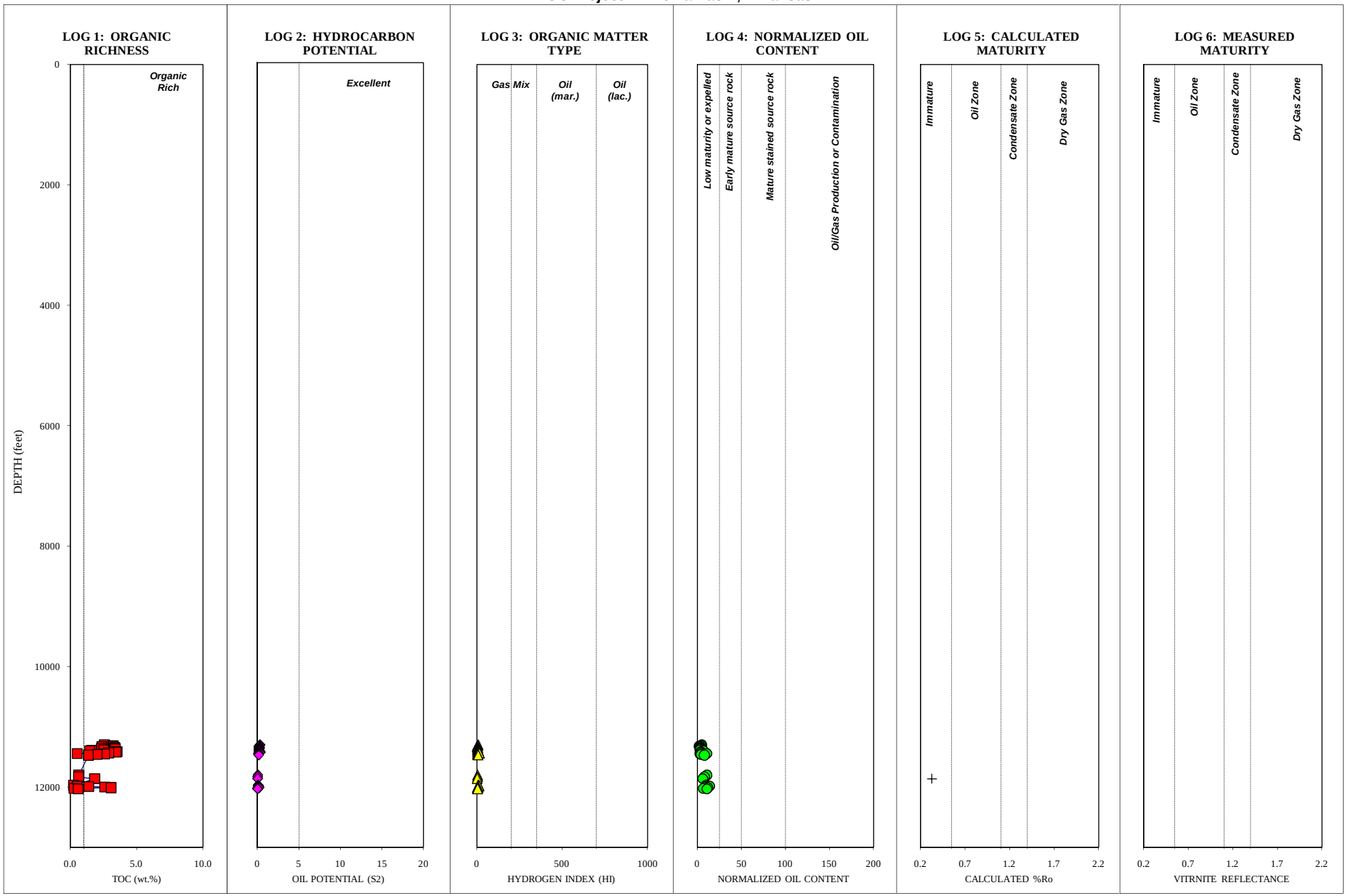

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

ARKANSAS FEDERAL #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

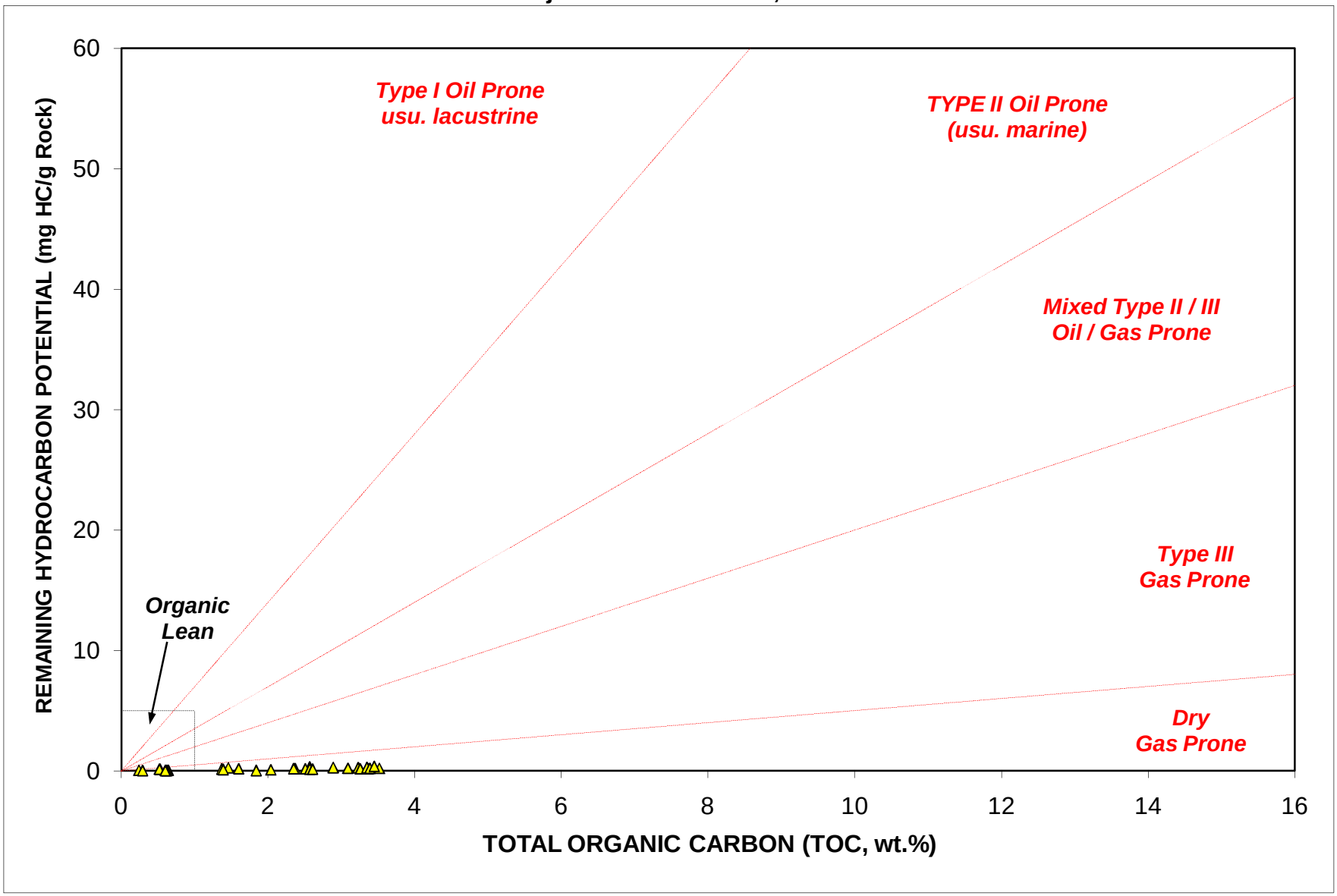

Figure 2. Kerogen Quality

Humble Geochemical Services Division

ARKANSAS FEDERAL #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

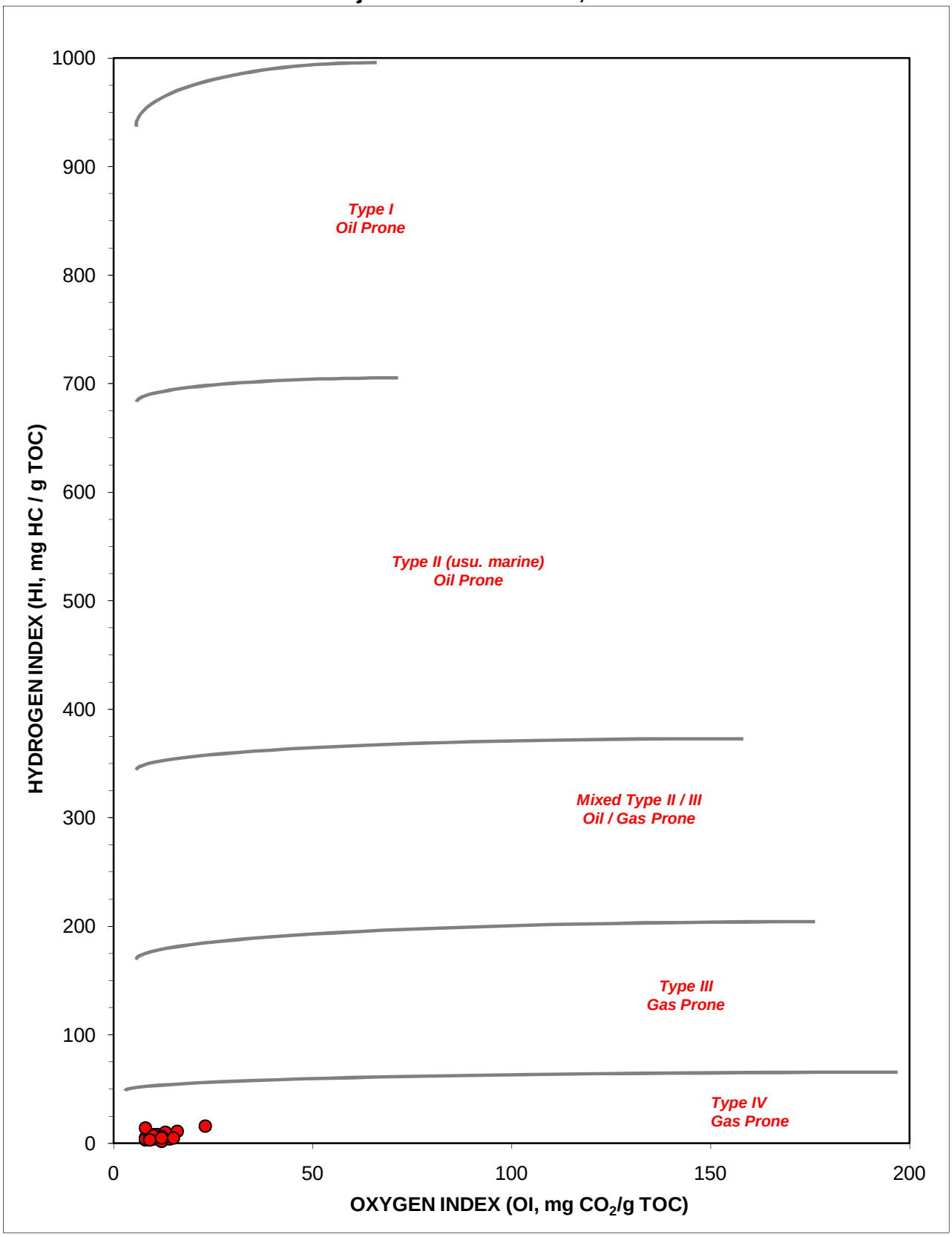

Figure 3. Kerogen type

ARKANSAS FEDERAL #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

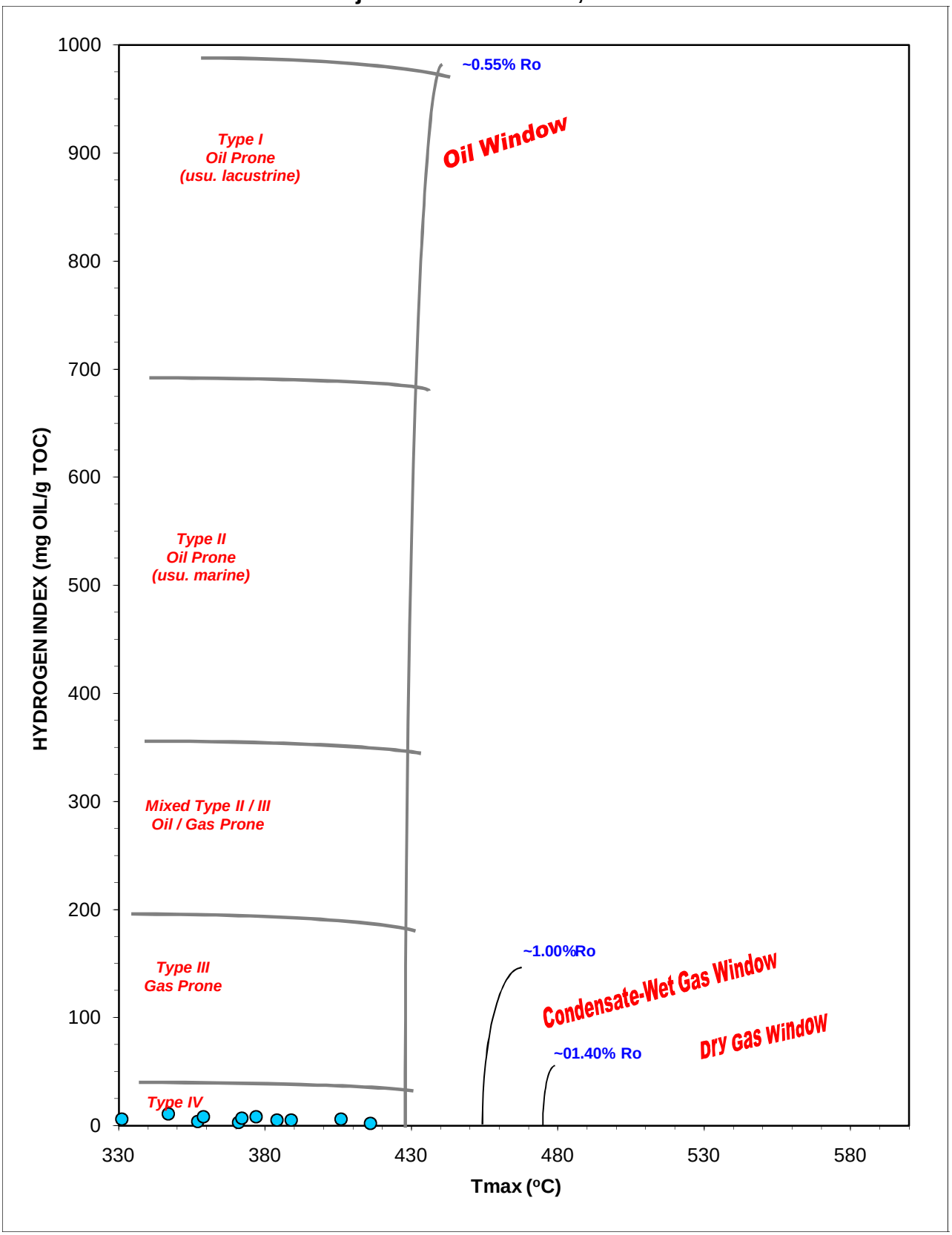

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

ARKANSAS FEDERAL #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

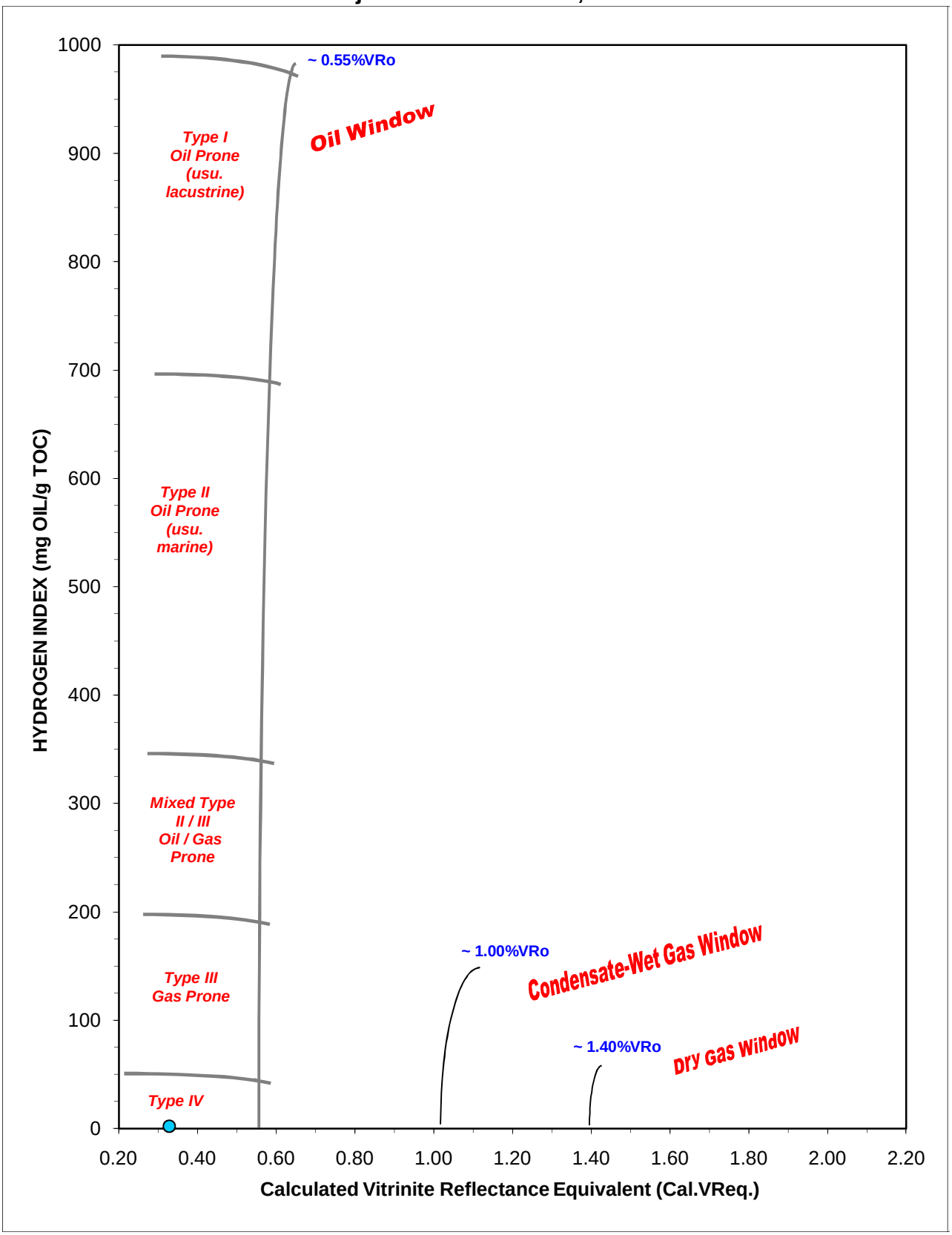

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

ARKANSAS FEDERAL #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

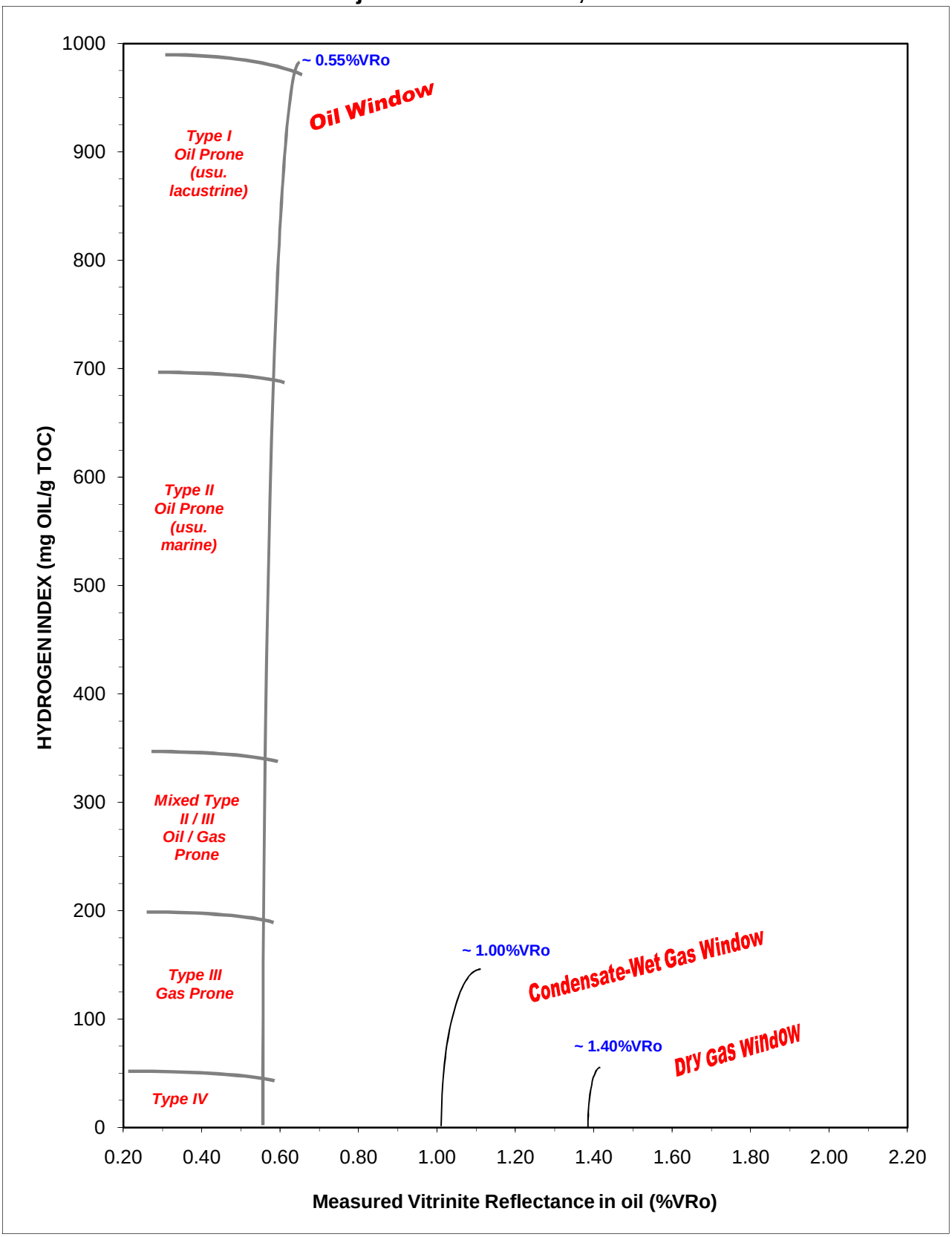

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

ARKANSAS FEDERAL #1

AGC Project - Arkoma Basin, Arkansas

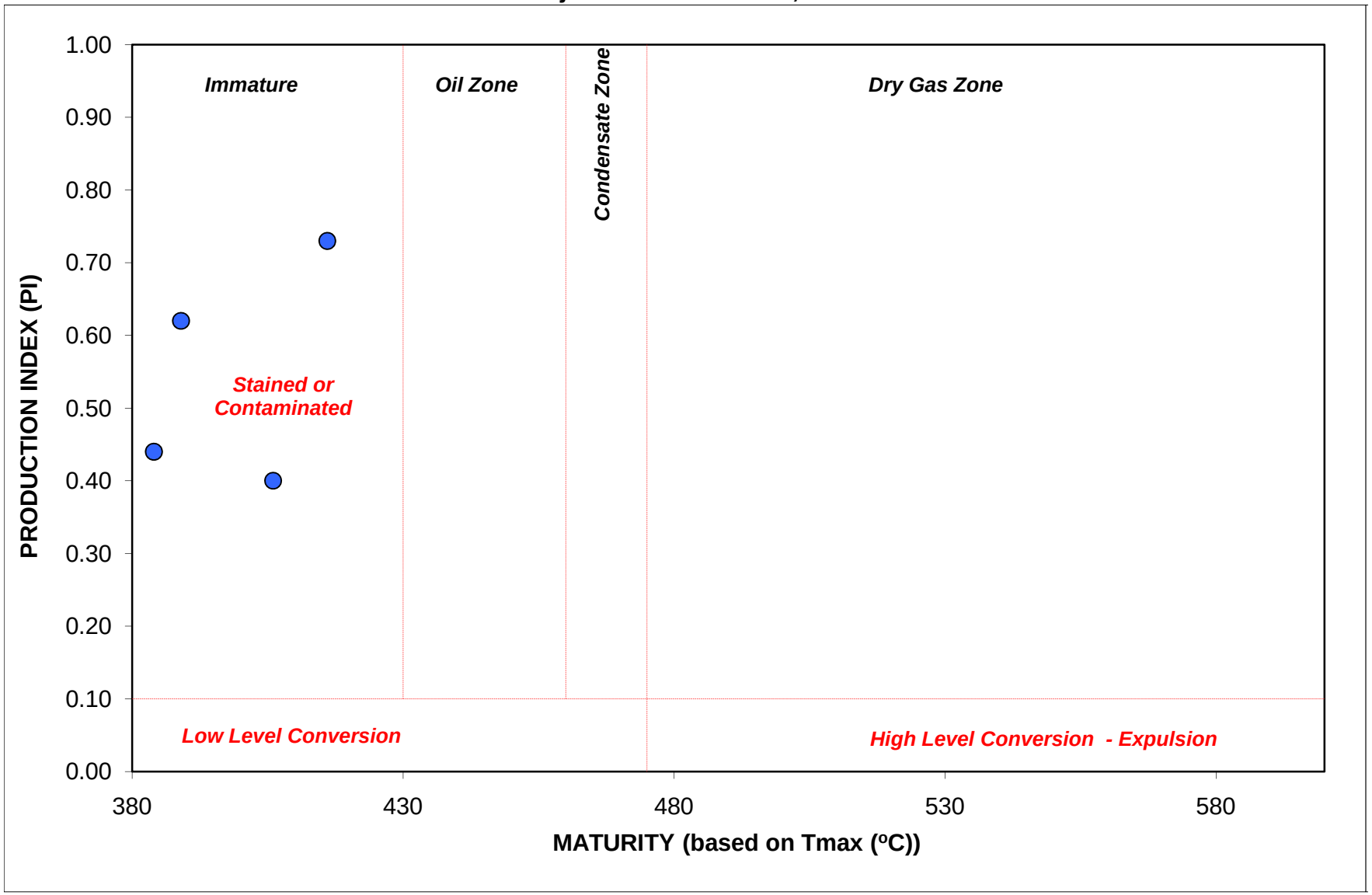

Figure 5a. Kerogen conversion and maturity (based on Tmax).

ARKANSAS FEDERAL #1

AGC Project - Arkoma Basin, Arkansas

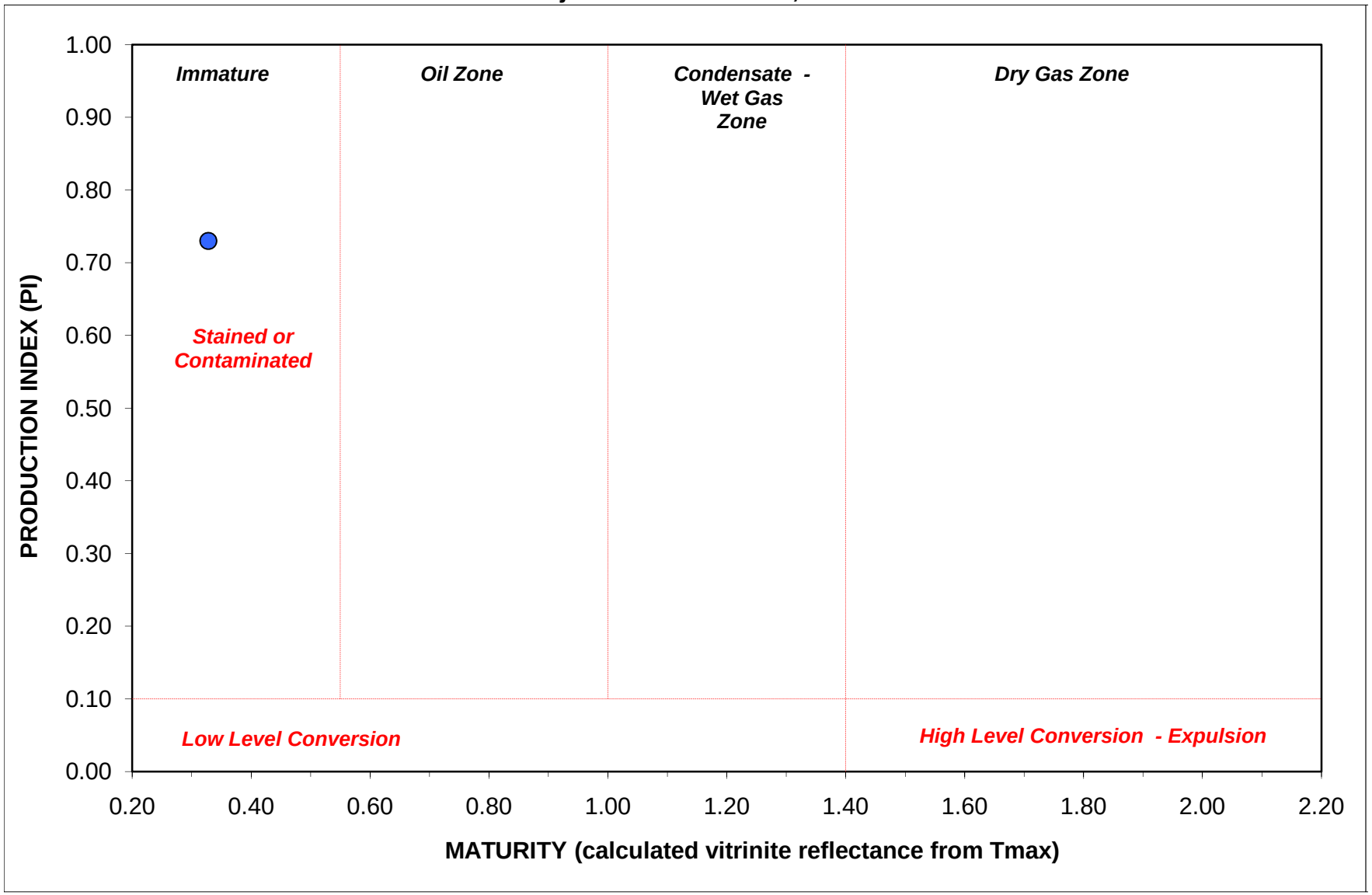

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

ARKANSAS FEDERAL #1

AGC Project - Arkoma Basin, Arkansas

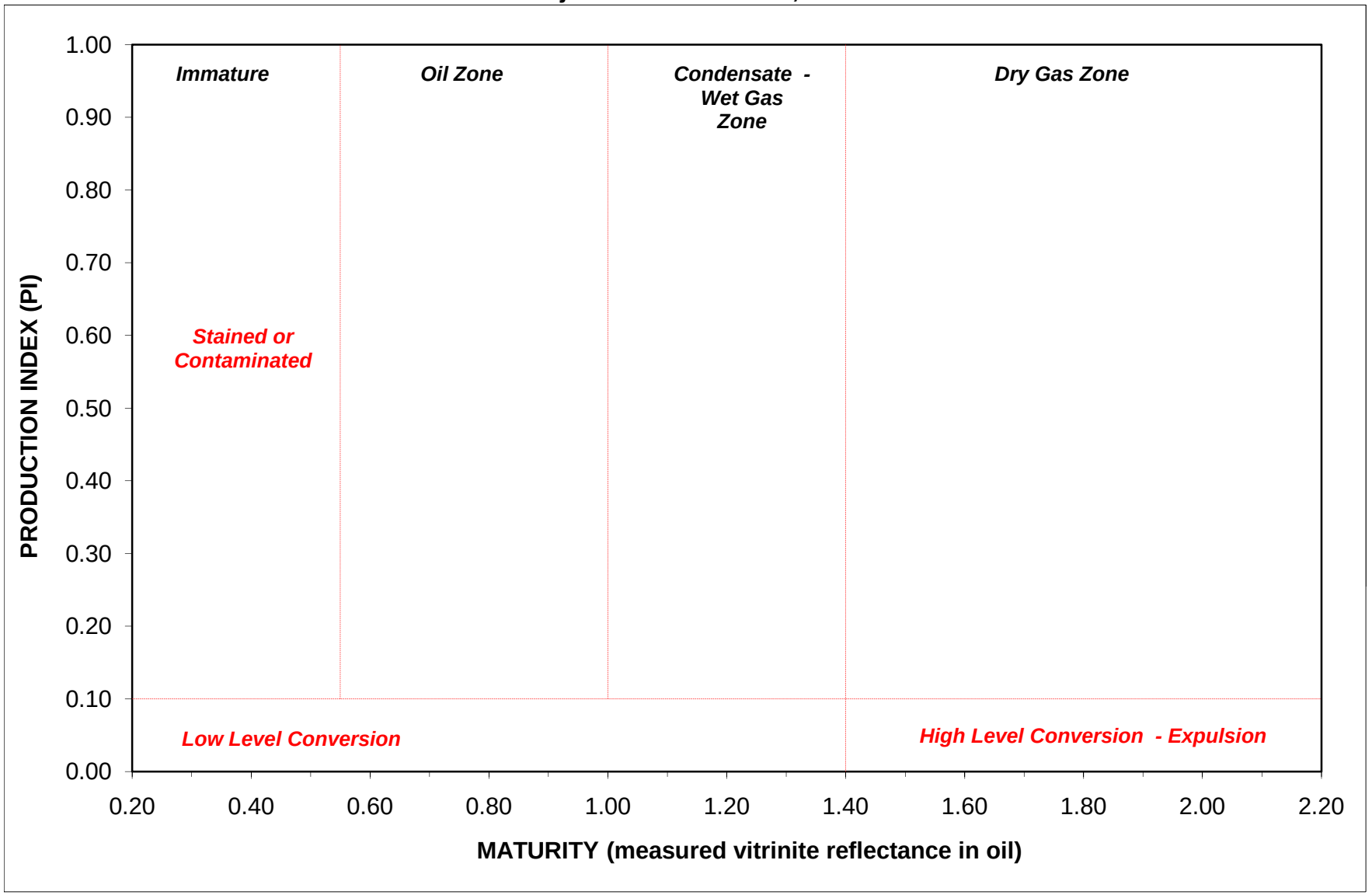

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 2. Geochemical and thermal maturity analyses for the well cutting samples from the Bell #1 - 25

BELL #1 - 25

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-163652	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	4510	4540	4525		cuttings	pWR	2.30	2.00	1.25	1.51	1.27	365		-1.00			66	55	1	54	0.45
06-3936-163653	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	5900	5920	5910		cuttings	pWR	1.49	1.02	0.26	0.17	0.50	377	*	-1.00	1.74	D	11	34	0	17	0.60
06-3936-163654	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	7600	7620	7610		cuttings	pWR	1.64	1.27	1.51	2.31	0.65	355		-1.00	1.88	D	141	40	4	92	0.40
06-3936-163655	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	9200	9220	9210		cuttings	pWR	1.83	1.26	0.17	0.23	0.36	415	*	0.31	2.99	D	13	20	1	9	0.43
06-3936-163656	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	11300	11340	11320		cuttings	pWR	6.69	1.03	3.52	1.20	0.32	337		-1.00	3.61	D	18	5	4	53	0.75
06-3936-163657	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	11810	11840	11825		cuttings	pWR	0.68	0.22	0.55	0.06	0.25	369	*	-1.00			9	37	0	81	0.90
06-3936-163658	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	12000	12010	12005		cuttings	pWR	0.39	0.17	0.10	0.02	0.15	0	*	-1.00			5	38	0	26	0.83
06-3936-163659	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10500	10510	10505		cuttings	pWR	1.73	1.61	4.49	6.62	0.45	343		-1.00			383	26	15	260	0.40
06-3936-163660	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10510	10520	10515		cuttings	pWR	1.58	1.65	8.49	3.30	0.38	320		-1.00			209	24	9	537	0.72
06-3936-163661	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10520	10530	10525		cuttings	pWR	3.83	3.71	1.39	1.76	0.60	368		-1.00			46	16	3	36	0.44
06-3936-163662	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10530	10540	10535		cuttings	pWR	2.01	1.77	0.59	0.67	0.45	375		-1.00			33	22	1	29	0.47
06-3936-163663	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10540	10550	10545		cuttings	pWR	2.15	1.86	0.53	0.57	0.38	382		-1.00			27	18	2	25	0.48
06-3936-163664	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10550	10560	10555		cuttings	pWR	2.16	2.00	1.05	1.48	0.42	381		-1.00			69	19	4	49	0.42
06-3936-163665	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10560	10570	10565		cuttings	pWR	2.27	2.27	2.80	2.36	0.44	411		0.24			104	19	5	123	0.54
06-3936-163666	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10570	10580	10575		cuttings	pWR	2.54	2.33	4.25	2.72	0.44	383		-1.00			107	17	6	167	0.61
06-3936-163667	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10580	10610	10595		cuttings	pWR	1.77	1.56	0.76	0.87	0.41	378		-1.00			49	23	2	43	0.47
06-3936-163668	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10610	10640	10625		cuttings	pWR	1.44	1.27	0.62	0.74	0.32	359		-1.00			51	22	2	43	0.46
06-3936-163669	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10640	10670	10655		cuttings	pWR	1.60	1.42	0.67	0.79	0.28	419		0.38			49	17	3	42	0.46
06-3936-163670	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10670	10700	10685		cuttings	pWR	2.07	2.03	0.59	0.47	0.24	407	*	0.17			23	12	2	29	0.56
06-3936-163671	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10700	10730	10715		cuttings	pWR	1.82	1.67	0.42	0.55	0.25	417		0.35			30	14	2	23	0.43
06-3936-163672	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10730	10760	10745		cuttings	pWR	1.29	0.90	0.54	0.49	0.27	418	*	0.36			38	21	2	42	0.52
06-3936-163673	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10760	10790	10775		cuttings	pWR	1.93	1.53	0.98	1.11	0.44	403		0.09			58	23	3	51	0.47
06-3936-163674	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10790	10810	10800		cuttings	pWR	1.92	1.68	0.74	0.71	0.45	400		-1.00			37	23	2	39	0.51
06-3936-163675	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10810	10820	10815	Chattanooga	cuttings	pWR	2.98	2.61	0.50	0.66	0.52	408		0.18			22	17	1	17	0.43
06-3936-163676	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10820	10830	10825	Chattanooga	cuttings	pWR	4.15	3.52	0.45	0.30	0.35	383	*	-1.00			7	8	1	11	0.60
06-3936-163677	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10830	10840	10835	Chattanooga	cuttings	pWR	4.13	3.93	0.46	0.47	0.42	399	*	-1.00			11	10	1	11	0.49
06-3936-163678	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10840	10850	10845	Chattanooga	cuttings	pWR	5.38	5.07	0.23	0.27	0.44	383	*	-1.00			5	8	1	4	0.46
06-3936-163679	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10850	10860	10855	Chattanooga	cuttings	pWR	5.00	4.71	0.24	0.19	0.39	371	*	-1.00			4	8	0	5	0.56
06-3936-163680	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10860	10870	10865	Chattanooga	cuttings	pWR	3.98	3.38	0.49	0.33	0.37	379	*	-1.00			8	9	1	12	0.60
06-3936-163681	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10870	10880	10875	Chattanooga	cuttings	pWR	3.66	3.60	0.07	0.05	0.43	371	*	-1.00			1	12	0	2	0.58
06-3936-163682	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10880	10890	10885	Chattanooga	cuttings	pWR	5.80	5.14	2.19	0.29	1.02	370	*	-1.00			5	18	0	38	0.88
06-3936-163683	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10890	10900	10895	Chattanooga	cuttings	pWR	5.01	5.43	1.37	0.27	0.89	375	*	-1.00			5	18	0	27	0.84
06-3936-163684	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	10900	10910	10905		cuttings	pWR	9.71	4.83	0.36	0.19	0.43	329	*	-1.00			2	4	0	4	0.65
06-3936-163685	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	11020	11030	11025		cuttings	pWR	1.49	1.03	5.41	4.64	0.42	328		-1.00			311	28	11	363	0.54
06-3936-163686	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	11030	11040	11035		cuttings	pWR	2.63	0.13	0.26	0.07	0.28	389	*	-1.00	5.30	D	3	11	0	10	0.79
06-3936-163687	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	11040	11050	11045		cuttings	pWR	3.93	0.16	0.31	0.21	0.26	436	*	0.69			5	7	1	8	0.60
06-3936-163688	Arkoma	03131100980000	ARKLA EXPL CO	BELL	1-25	SEBASTIAN	AR	11050	11060	11055		cuttings	pWR	2.29	0.52	0.31	0.26	0.31	405	*	0.13			11	14	1	14	0.54

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

BELL #1 - 25

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

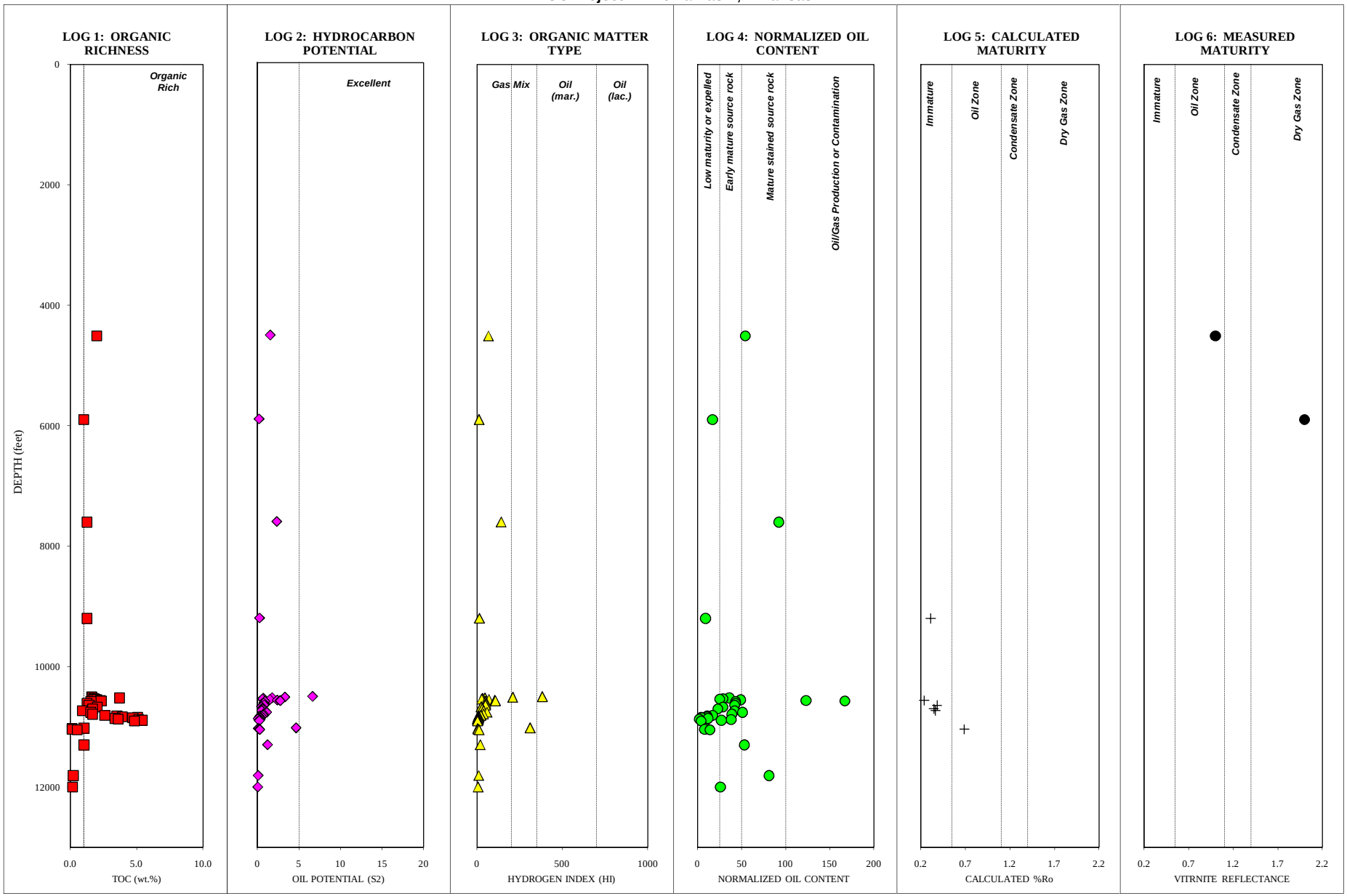

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

BELL #1 - 25

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

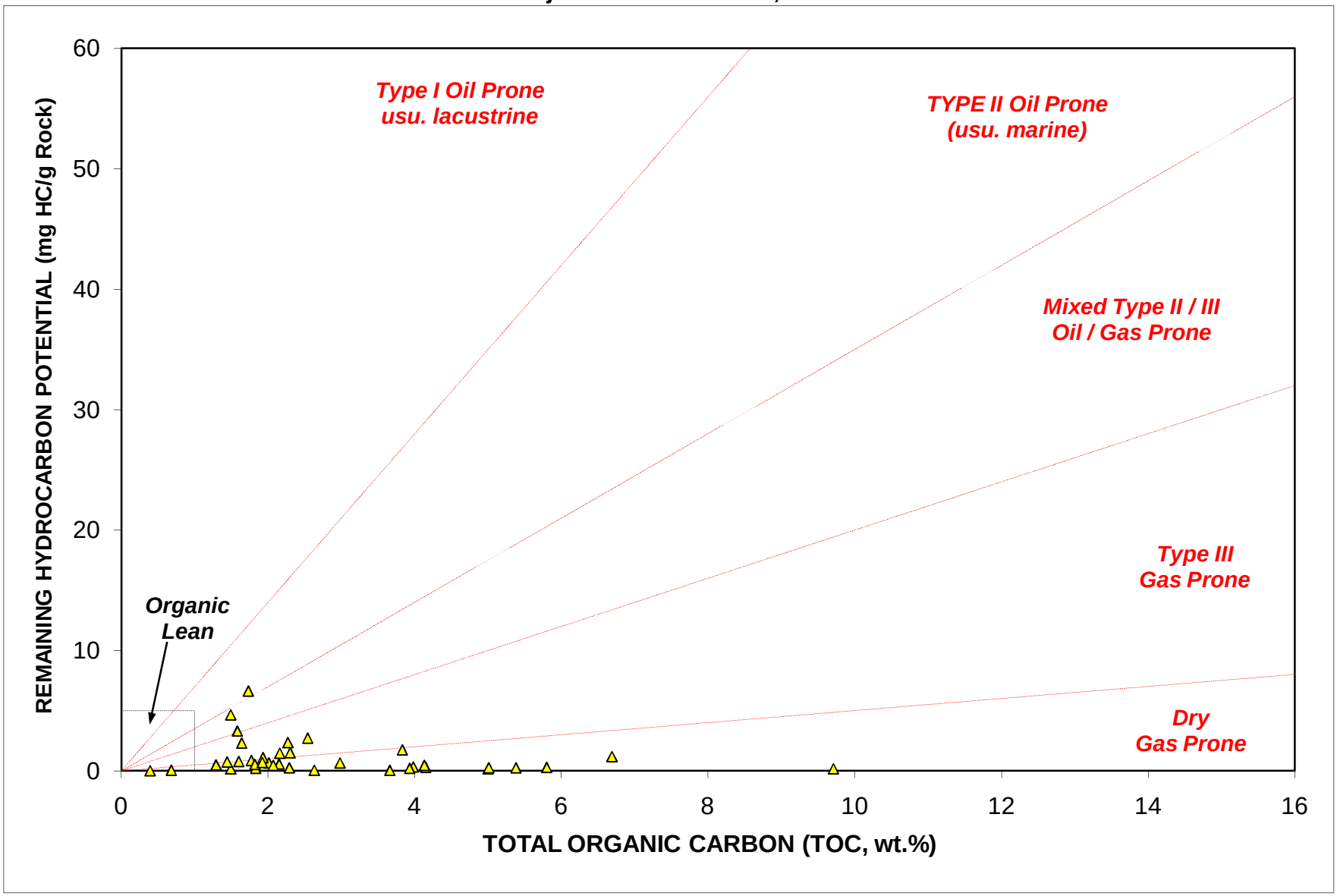

Figure 2. Kerogen Quality

BELL #1 - 25

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

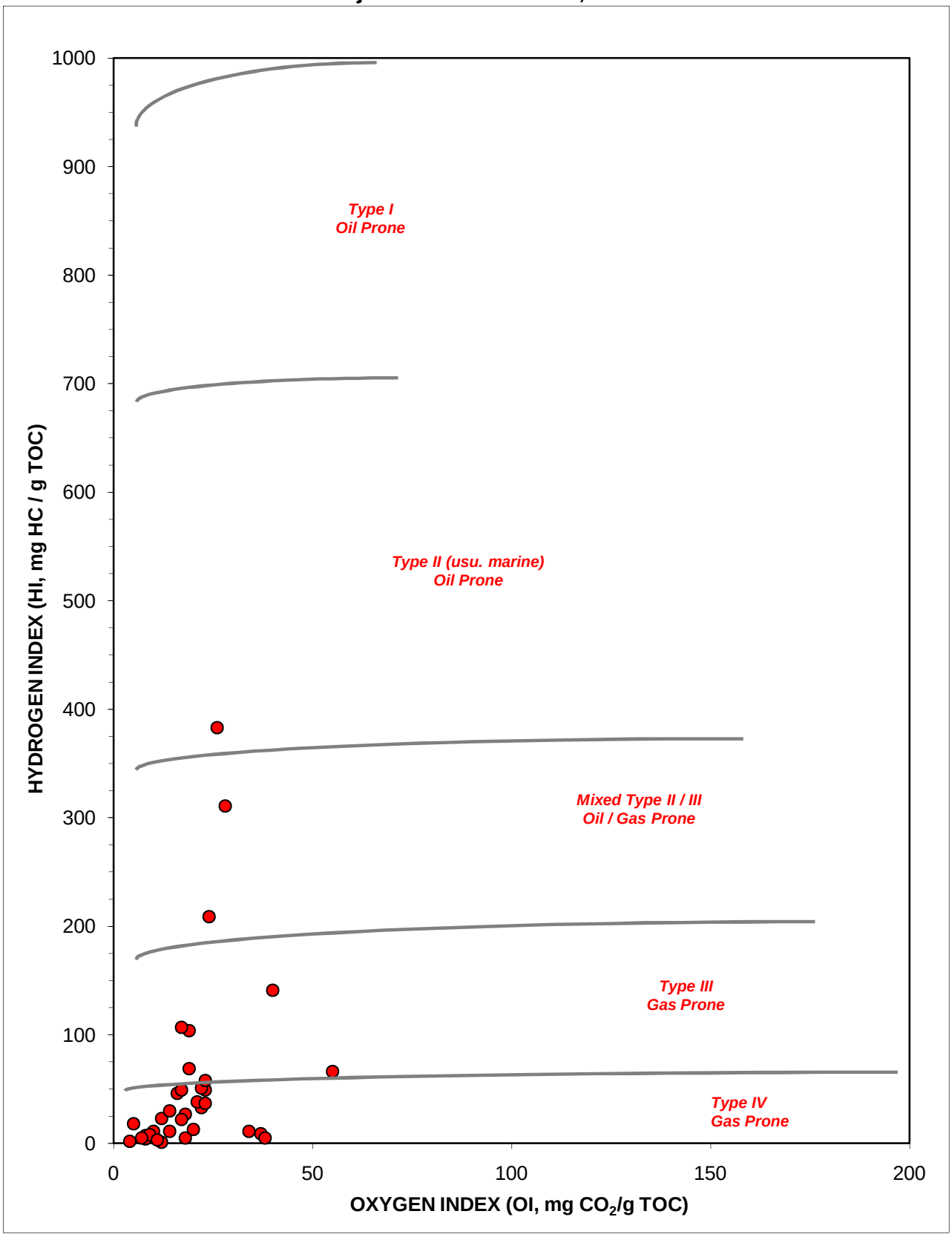

Figure 3. Kerogen type

BELL #1 - 25

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

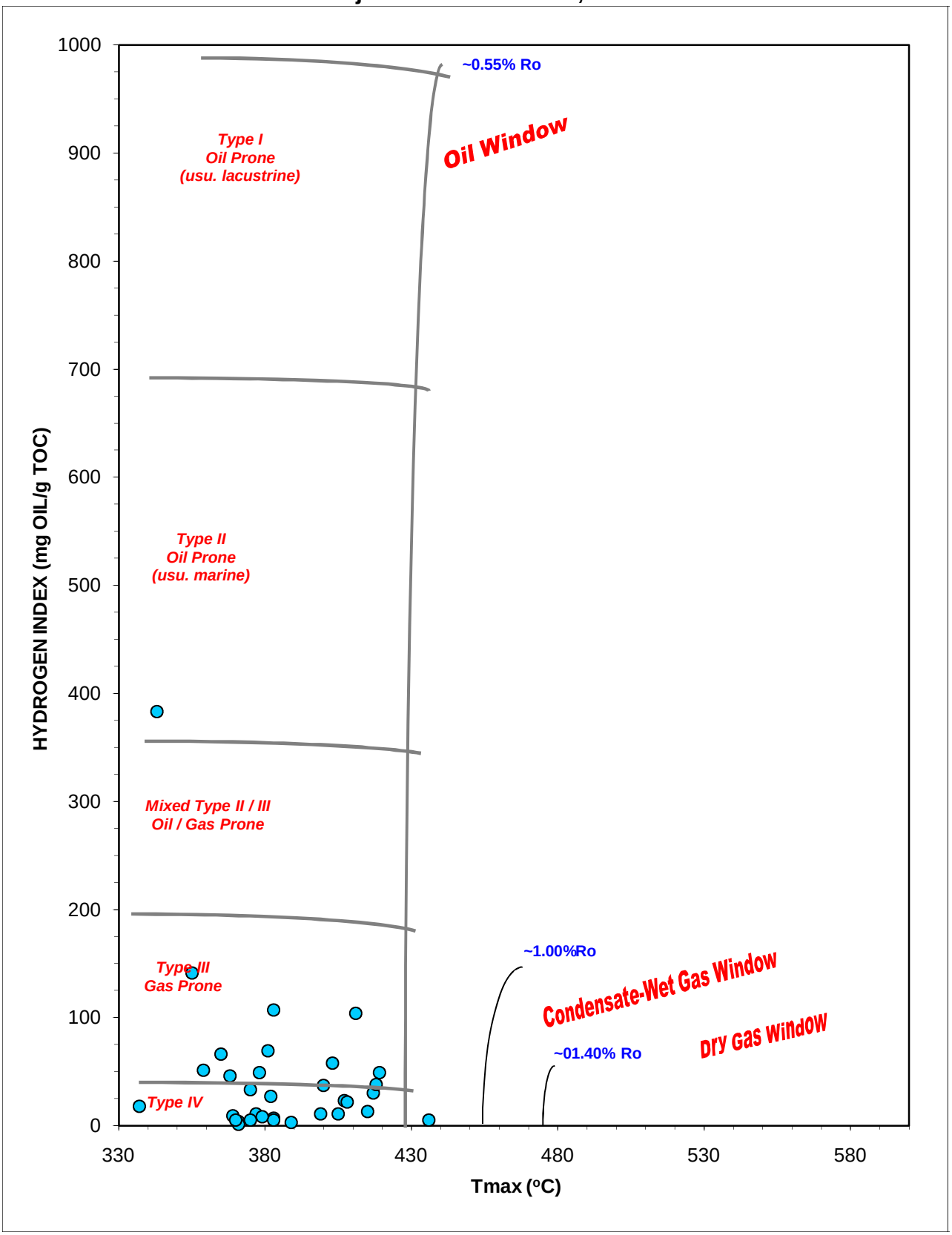

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

BELL #1 - 25

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

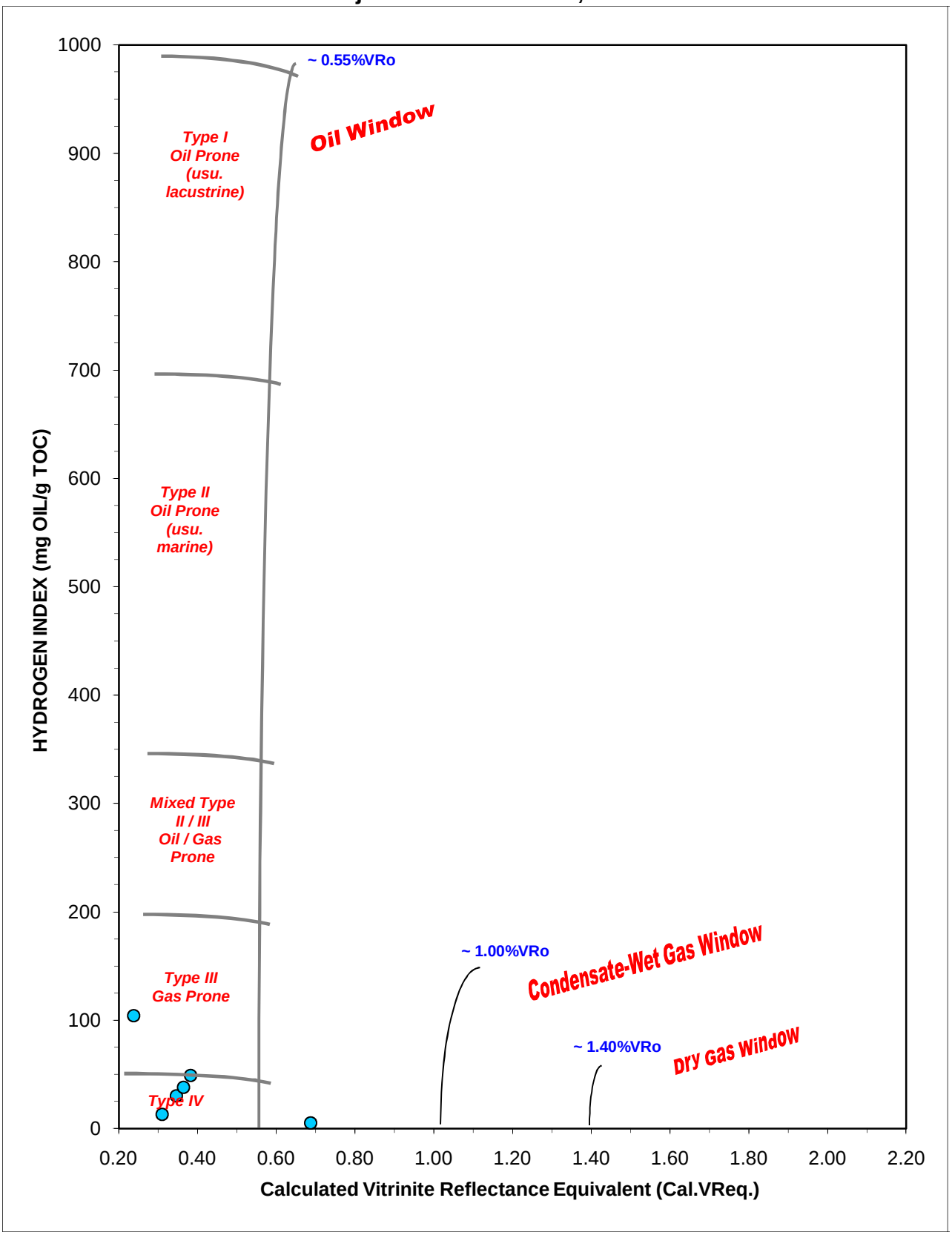

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

BELL #1 - 25

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

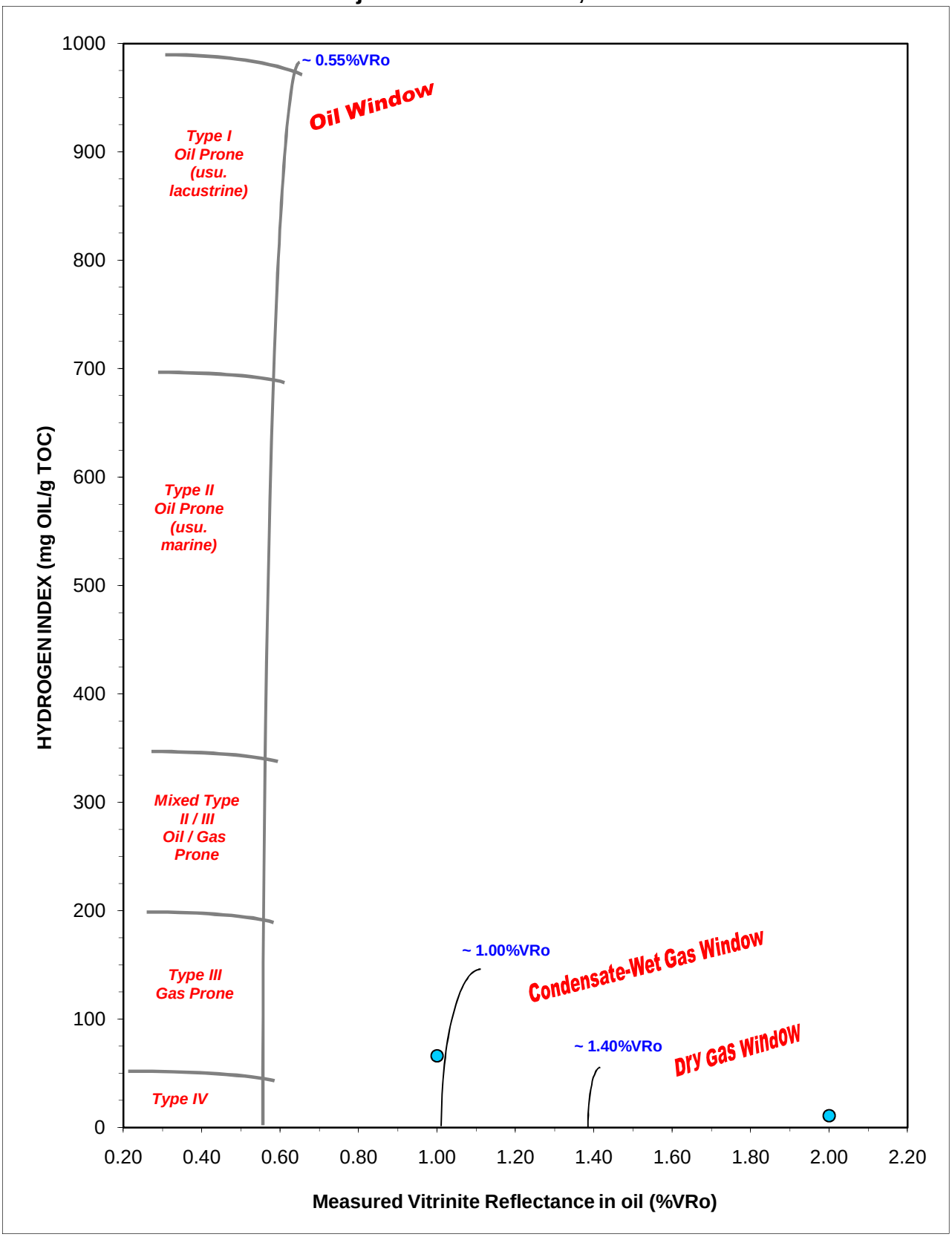

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

BELL #1 - 25

AGC Project - Arkoma Basin, Arkansas

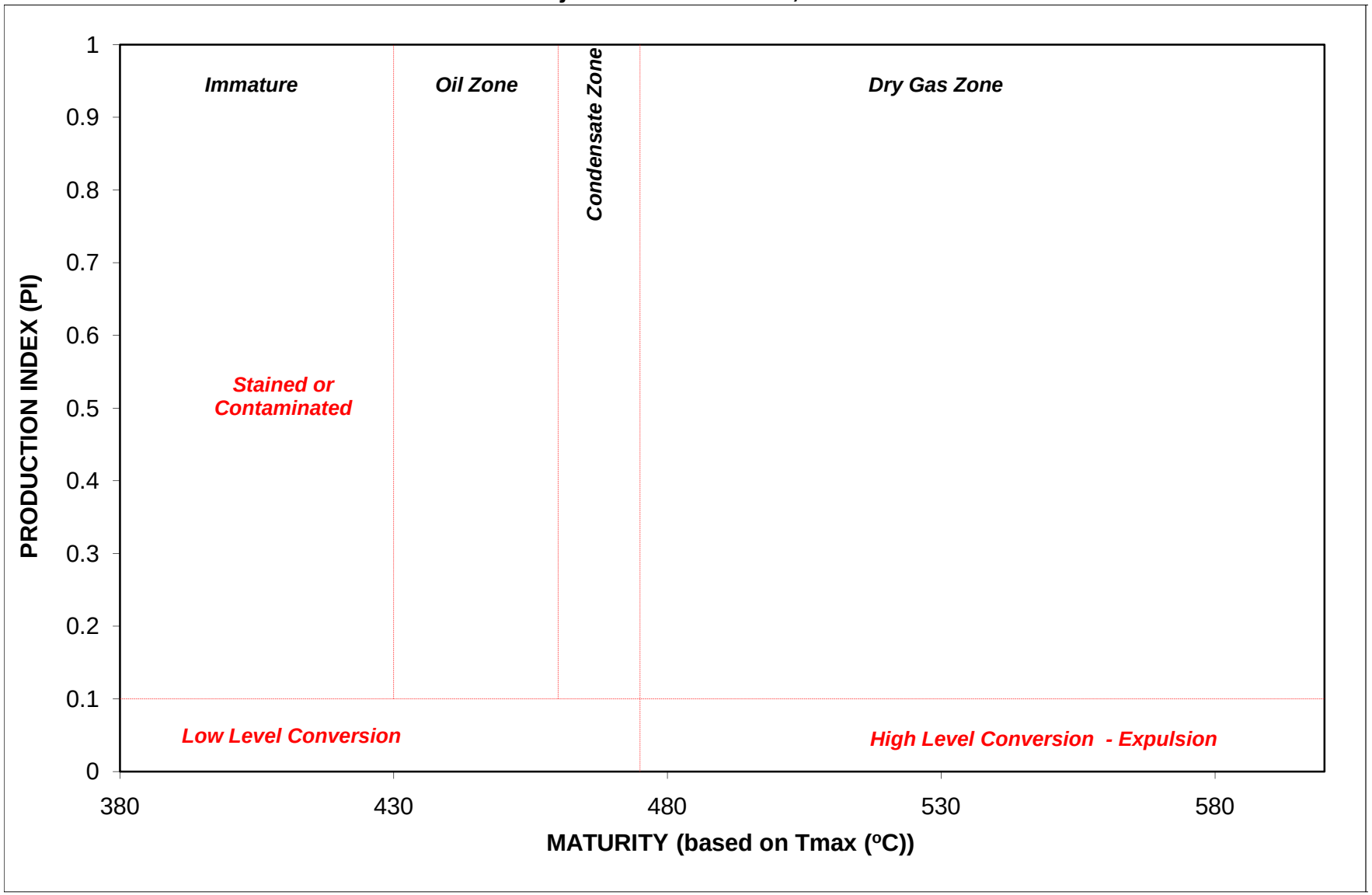

Figure 5a. Kerogen conversion and maturity (based on Tmax).

BELL #1 - 25

AGC Project - Arkoma Basin, Arkansas

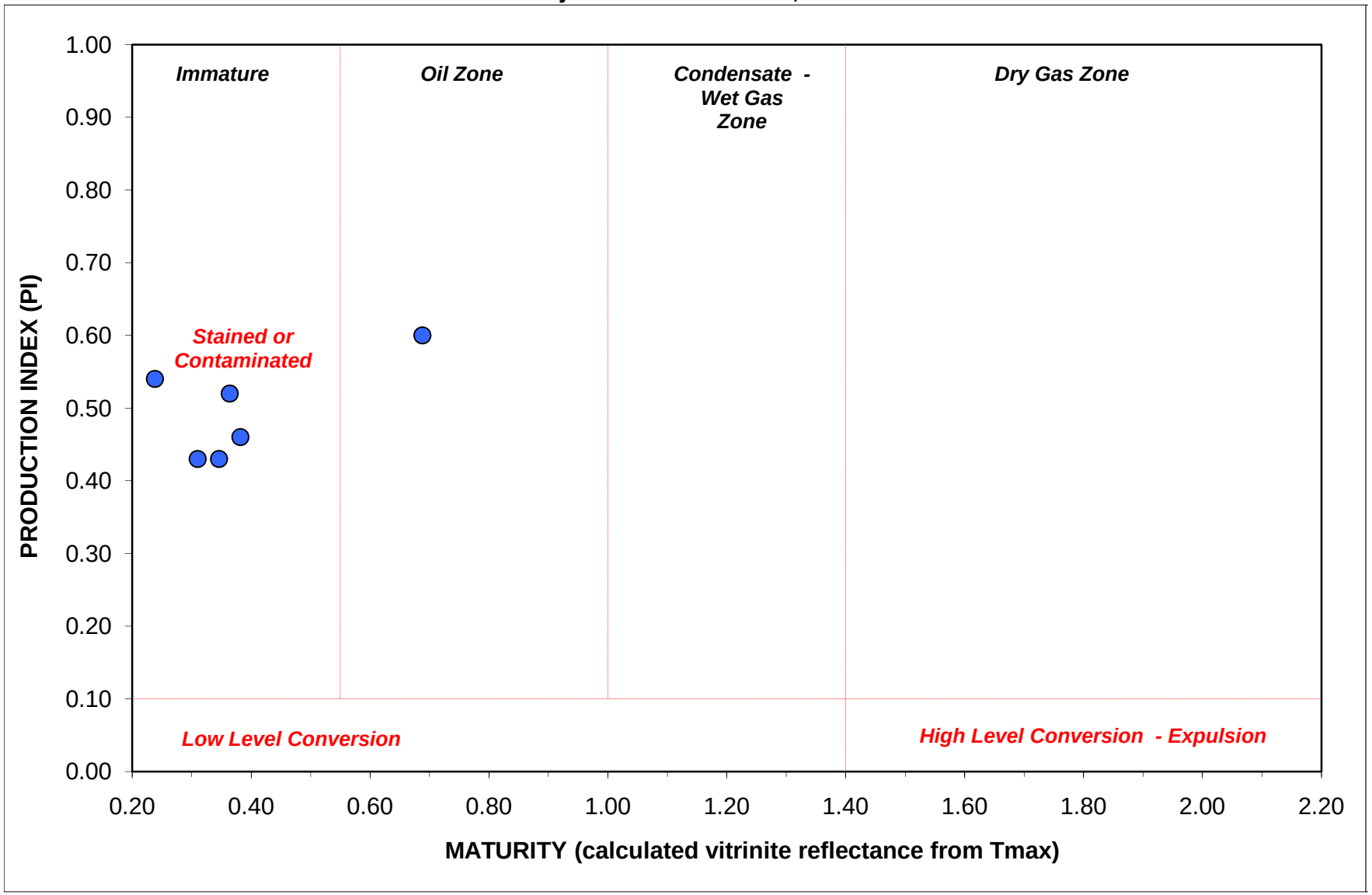

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

BELL #1 - 25

AGC Project - Arkoma Basin, Arkansas

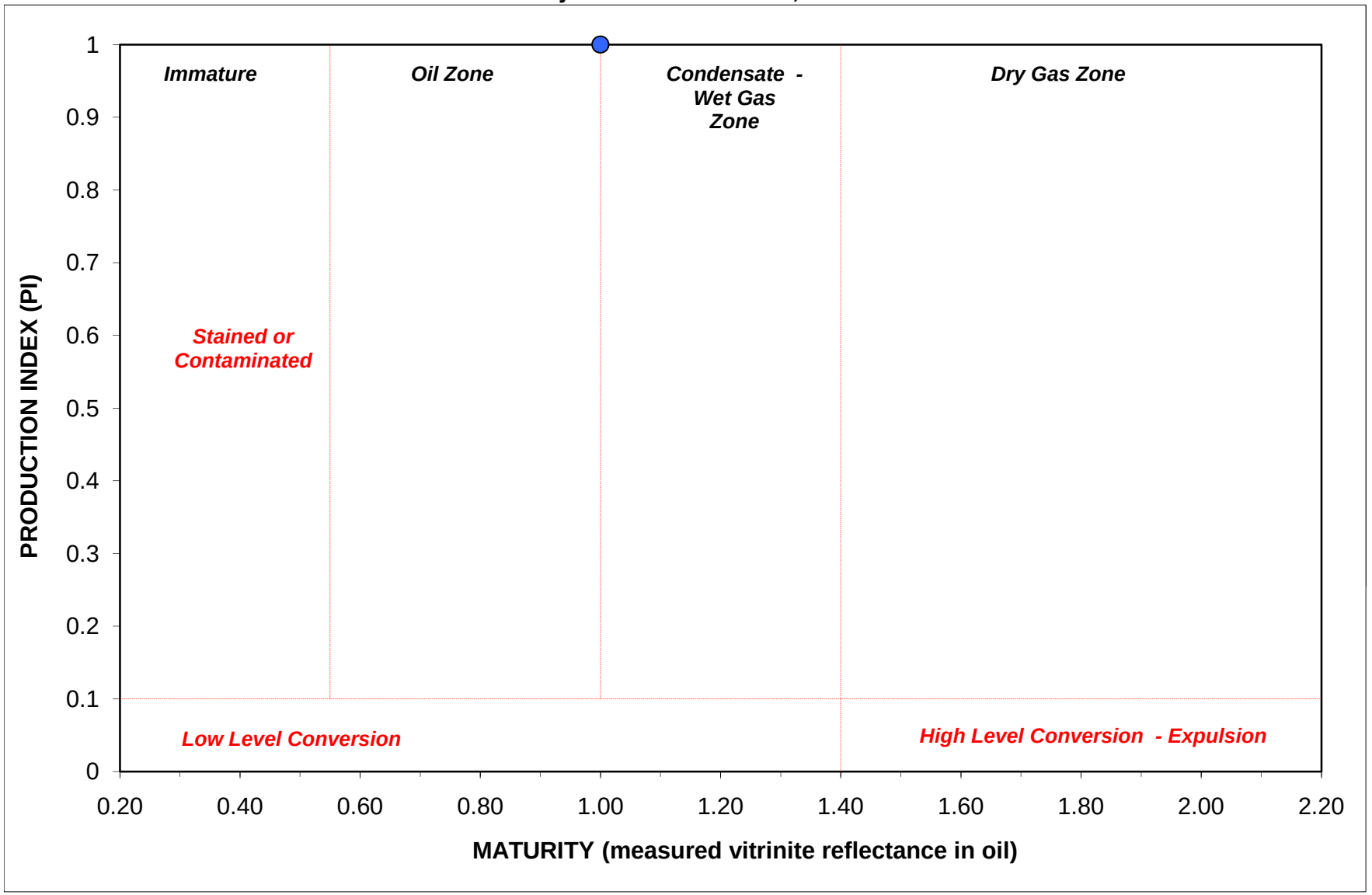

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 3. Geochemical and thermal maturity analyses for the well cutting samples from the Gordon #1

GORDON #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-4168-169525	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5190	5200	5195		Cuttings	NORM	0.55	0.37	0.17	0.13	0.21	302	*	-1.00			24	38	1	31	0.57
06-4168-169526	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5200	5210	5205		Cuttings	NORM	0.52	0.39	0.12	0.08	0.22	302	*	-1.00			15	42	0	23	0.60
06-4168-169527	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5210	5220	5215		Cuttings	NORM	0.38	0.20	0.06	0.05	0.19	322	*	-1.00			13	50	0	16	0.55
06-4168-169528	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5220	5230	5225		Cuttings	NORM	0.43	0.27	0.09	0.13	0.22	326	*	-1.00			30	51	1	21	0.41
06-4168-169529	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5230	5240	5235		Cuttings	NORM	0.50	0.34	0.09	0.05	0.23	323	*	-1.00			10	46	0	18	0.64
06-4168-169530	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5240	5250	5245		Cuttings	NORM	0.39	0.20	0.08	0.05	0.17	2	*	-1.00			13	44	0	21	0.62
06-4168-169531	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5250	5260	5255		Cuttings	NORM	0.44	0.28	0.10	0.10	0.24	302	*	-1.00			23	55	0	23	0.50
06-4168-169532	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5260	5270	5265	Fayetteville	Cuttings	NORM	0.32	0.16	0.06	0.07	0.20	332	*	-1.00			22	63	0	19	0.46
06-4168-169533	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5270	5280	5275	Fayetteville	Cuttings	NORM	0.32	0.17	0.07	0.07	0.20	302	*	-1.00			22	63	0	22	0.50
06-4168-169534	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5280	5290	5285	Fayetteville	Cuttings	NORM	1.01	0.91	0.26	0.24	0.33	302	*	-1.00			24	33	1	26	0.52
06-4168-169535	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5290	5300	5295	Fayetteville	Cuttings	NORM	0.91	0.70	0.12	0.13	0.45	373	*	-1.00			14	49	0	13	0.48
06-4168-169536	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5300	5310	5305	Fayetteville	Cuttings	NORM	1.17	0.96	0.13	0.10	0.35	327	*	-1.00			9	30	0	11	0.57
06-4168-169537	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5310	5320	5315	Fayetteville	Cuttings	NORM	3.67	4.15	0.65	0.52	0.61	361		-1.00			14	17	1	18	0.56
06-4168-169538	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5320	5330	5325		Cuttings	NORM	5.13	5.55	1.00	0.39	0.53	340	*	-1.00			8	10	1	19	0.72
06-4168-169539	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5330	5360	5345		Cuttings	NORM	1.02	0.99	0.25	0.12	0.21	302	*	-1.00			12	21	1	25	0.68
06-4168-169540	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5360	5390	5375		Cuttings	NORM	0.87	0.73	0.17	0.12	0.19	302	*	-1.00			14	22	1	20	0.59
06-4168-169541	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5390	5420	5405		Cuttings	NORM	0.88	0.77	0.20	0.05	0.18	2	*	-1.00			6	20	0	23	0.80
06-4168-169542	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5420	5450	5435		Cuttings	NORM	0.64	0.48	0.14	0.11	0.14	302	*	-1.00			17	22	1	22	0.56
06-4168-169543	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5450	5480	5465		Cuttings	NORM	0.42	0.28	0.11	0.08	0.12	302	*	-1.00			19	29	1	26	0.58
06-4168-169544	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5580	5590	5585		Cuttings	NORM	0.37	0.18	0.08	0.17	0.14	302	*	-1.00			46	38	1	22	0.32
06-4168-169545	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5590	5600	5595	Chattanooga	Cuttings	NORM	0.52	0.41	0.13	0.13	0.23	302	*	-1.00			25	44	1	25	0.50
06-4168-169546	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5600	5610	5605	Chattanooga	Cuttings	NORM	0.34	0.14	0.07	0.08	0.12	330	*	-1.00			24	35	1	21	0.47
06-4168-169547	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5610	5620	5615	Chattanooga	Cuttings	NORM	3.60	4.35	0.32	0.29	0.32	372	*	-1.00			8	9	1	9	0.52
06-4168-169548	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5620	5630	5625		Cuttings	NORM	3.40	3.96	0.22	0.18	0.35	349	*	-1.00			5	10	1	6	0.55
06-4168-169549	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5630	5640	5635		Cuttings	NORM	0.48	0.40	0.13	0.15	0.14	363	*	-1.00			31	29	1	27	0.46
06-4168-169550	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5820	5830	5825		Cuttings	NORM	0.26	0.15	0.06	0.15	0.13	361	*	-1.00			58	50	1	23	0.29
06-4168-169551	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5830	5840	5835		Cuttings	NORM	0.28	0.20	0.07	0.05	0.14	2	*	-1.00			18	50	0	25	0.58
06-4168-169552	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5840	5850	5845		Cuttings	NORM	0.29	0.21	0.08	0.05	0.16	307	*	-1.00			17	55	0	28	0.62
06-4168-169553	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	5970	6000	5985		Cuttings	NORM	0.35	0.23	0.08	0.08	0.16	302	*	-1.00			23	46	1	23	0.50
06-4168-169554	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	6000	6030	6015		Cuttings	NORM	0.29	0.20	0.08	0.12	0.14	302	*	-1.00			41	48	1	28	0.40
06-4168-169555	Arkoma	3131102680000	ARCO OIL & GAS CORP	GORDON FANNIE I	1	SEBASTIAN	AR	6030	6060	6045		Cuttings	NORM	0.36	0.27	0.11	0.25	0.35	404	*	0.11			69	97	1	31	0.31

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

GORDON #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

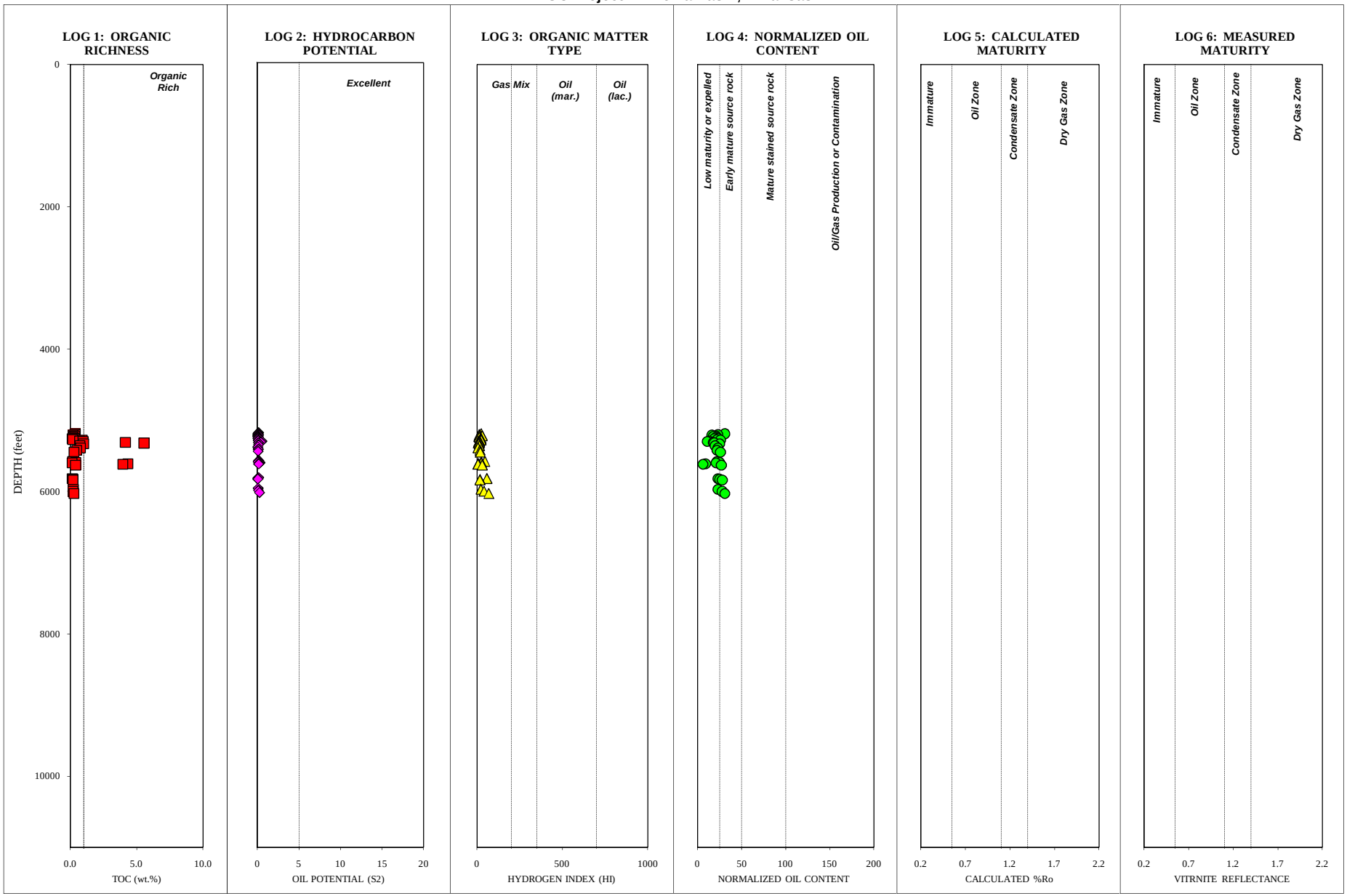

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

GORDON #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

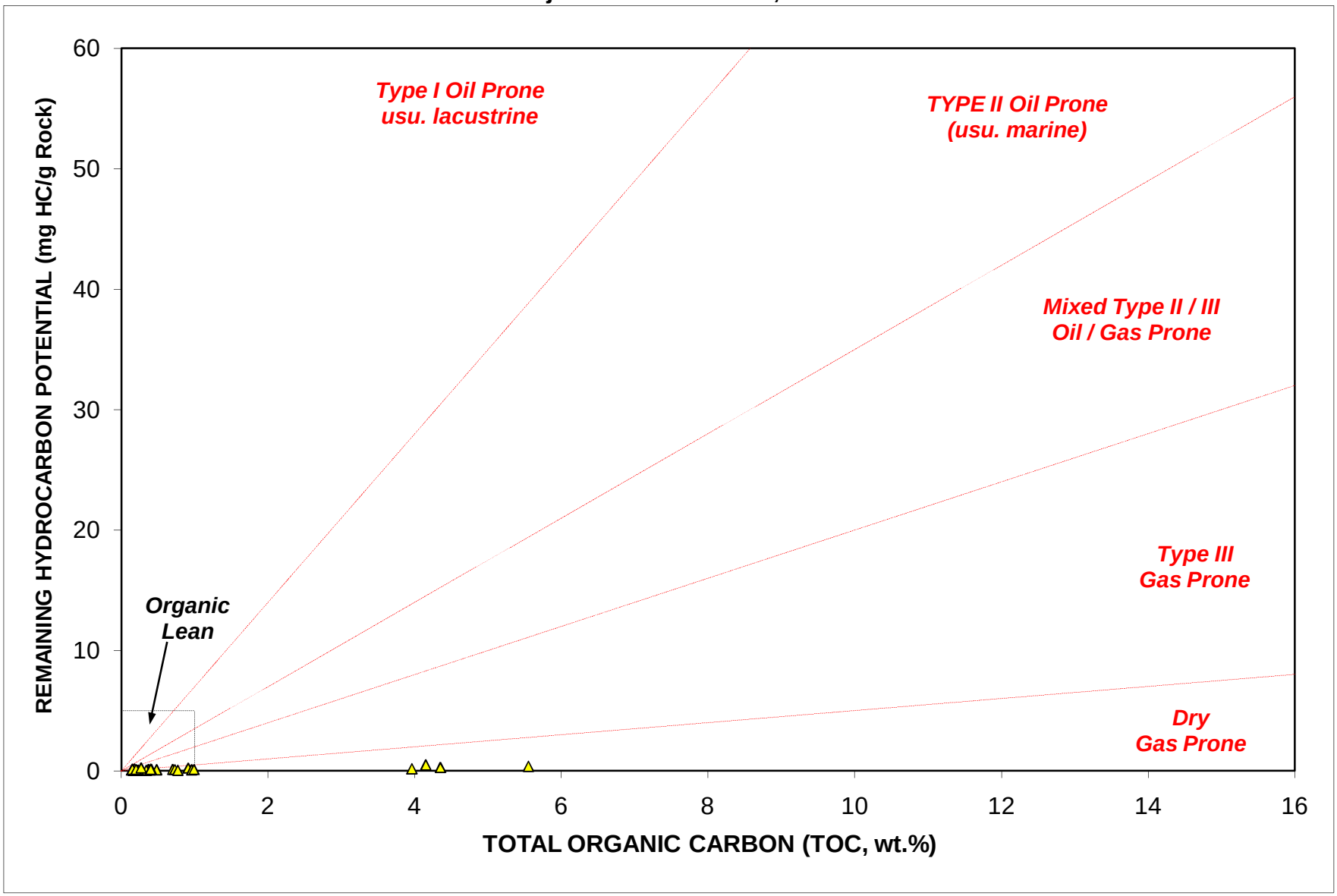

Figure 2. Kerogen Quality

Humble Geochemical Services Division

GORDON #1

KEROGEN TYPE

AGC Project - Arkoma Basin, Arkansas

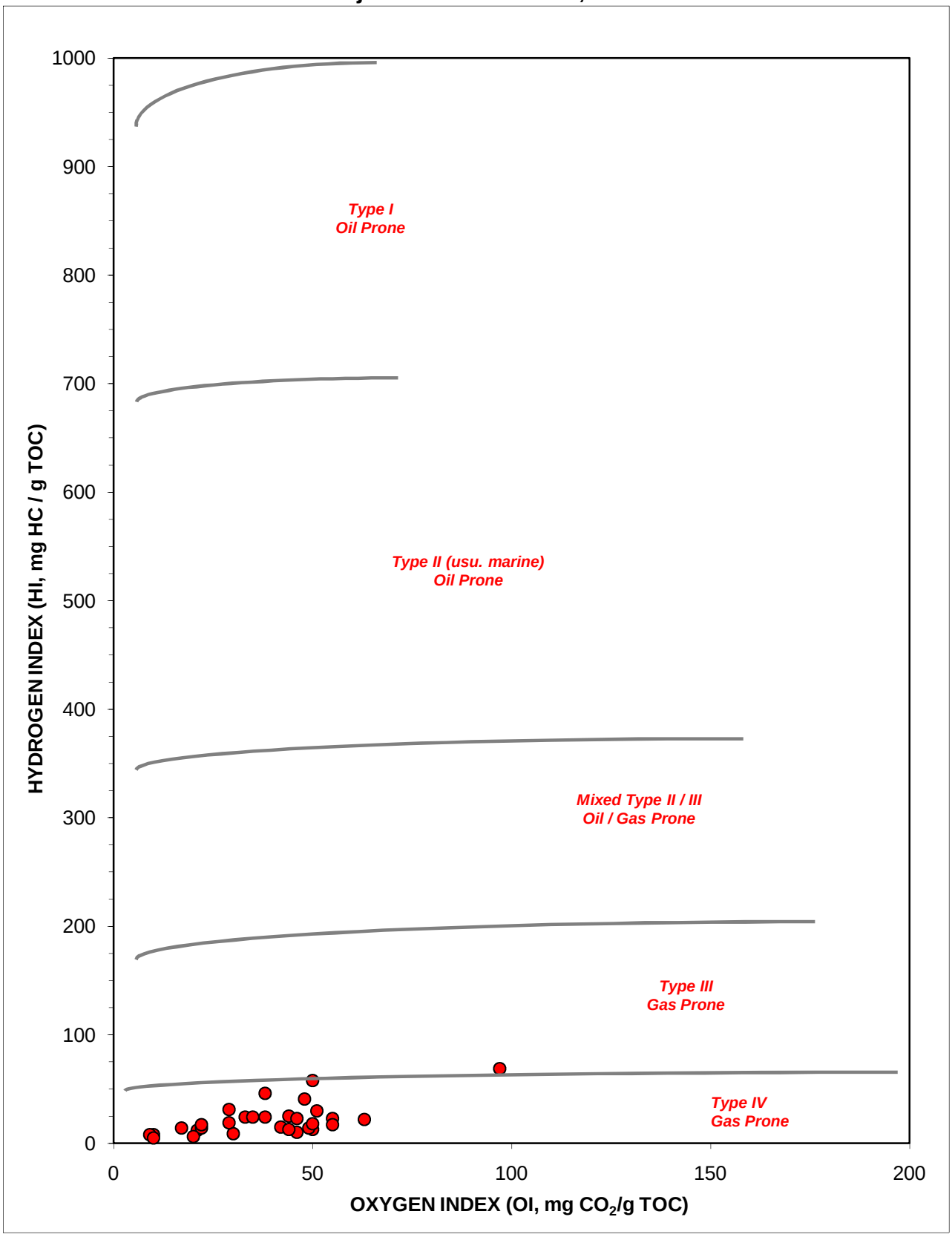

Figure 3. Kerogen type

GORDON #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

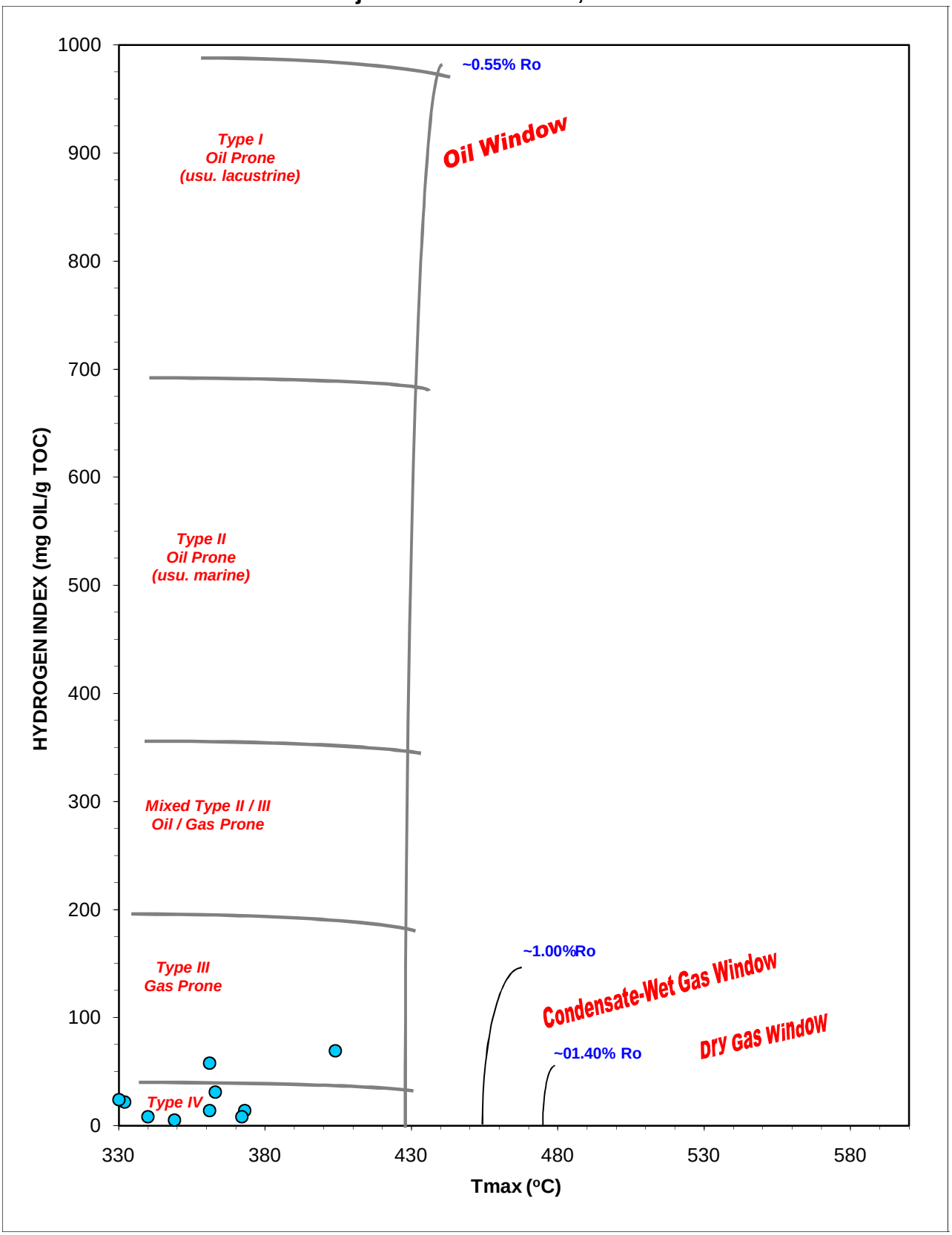

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

GORDON #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

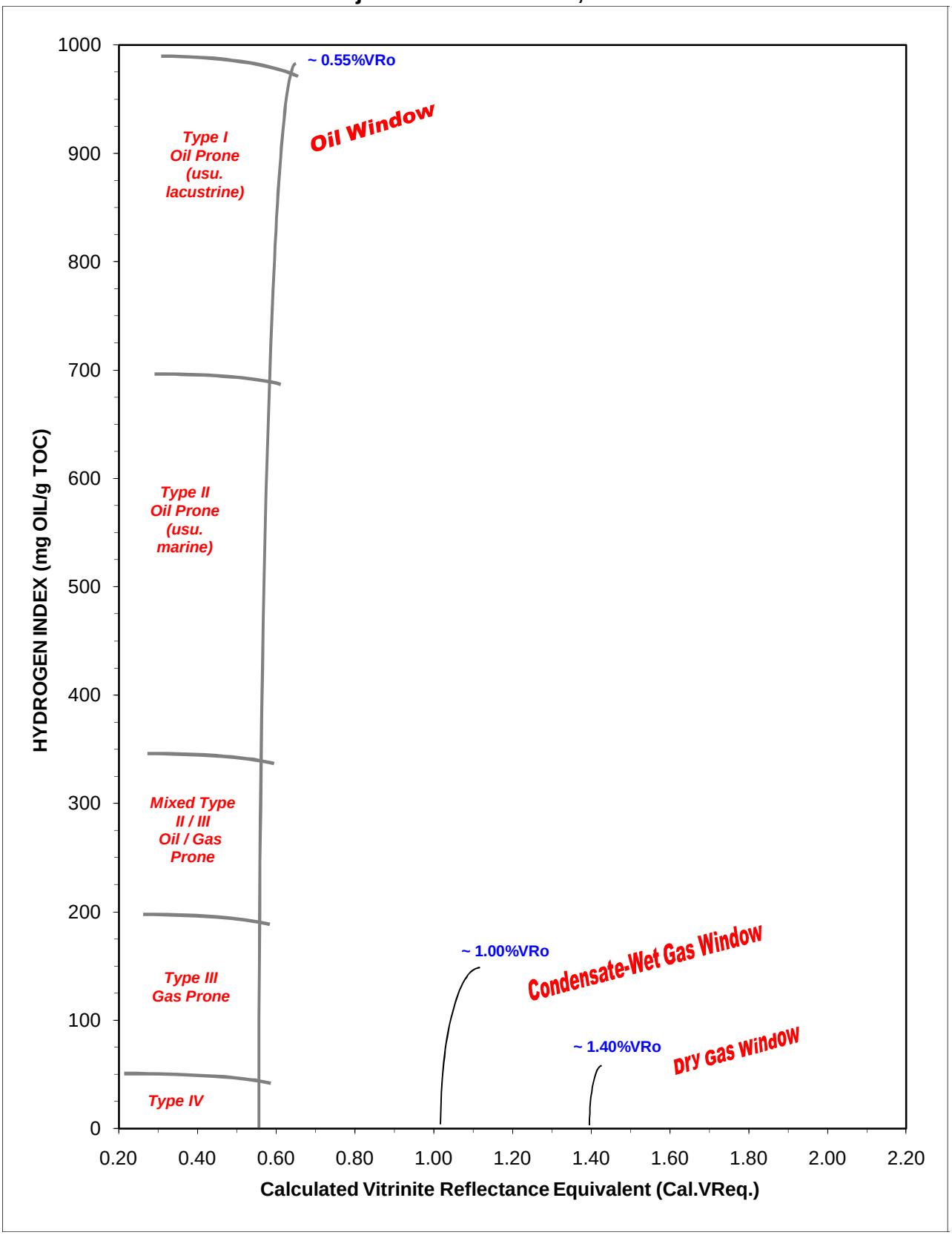

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

GORDON #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

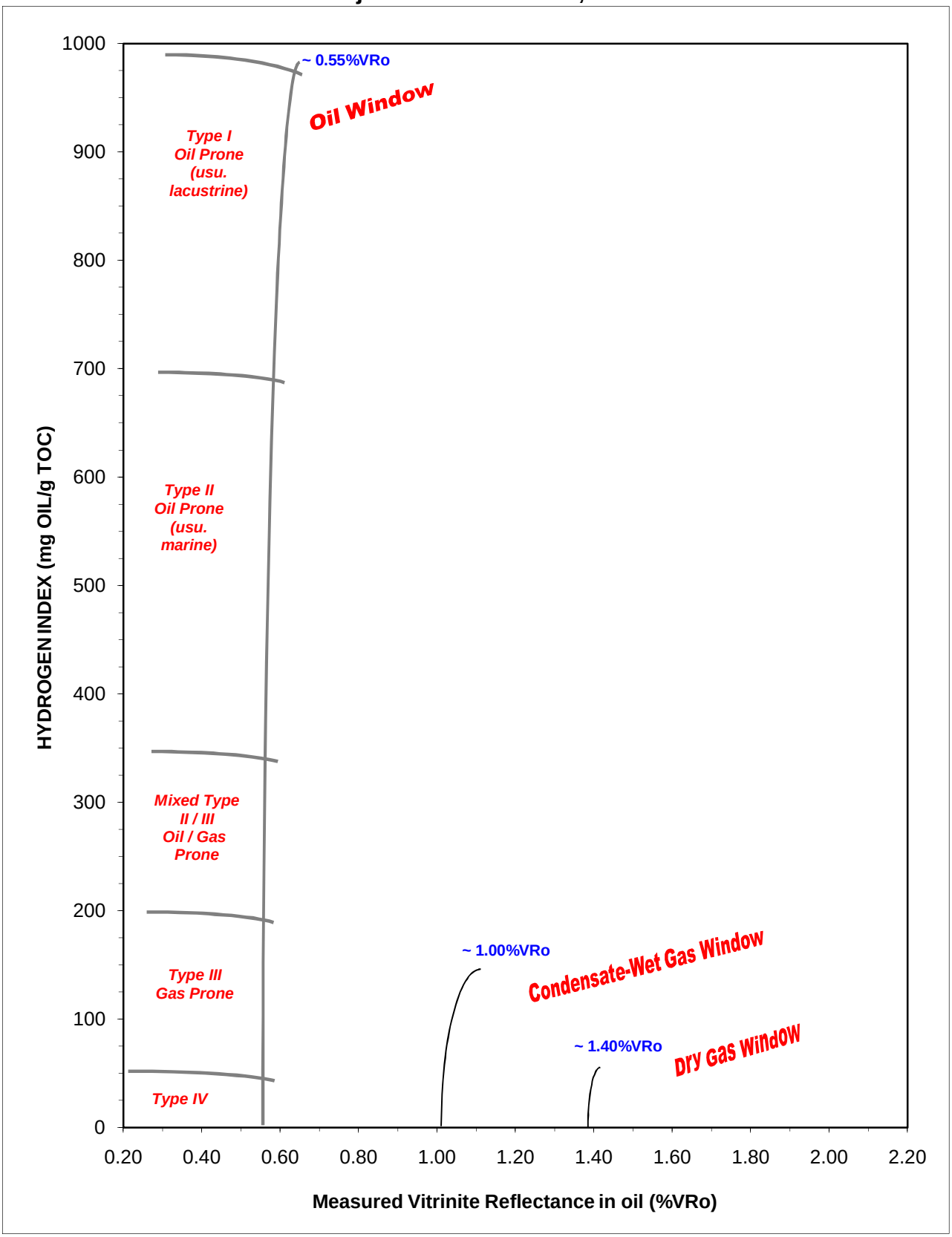

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

GORDON #1

AGC Project - Arkoma Basin, Arkansas

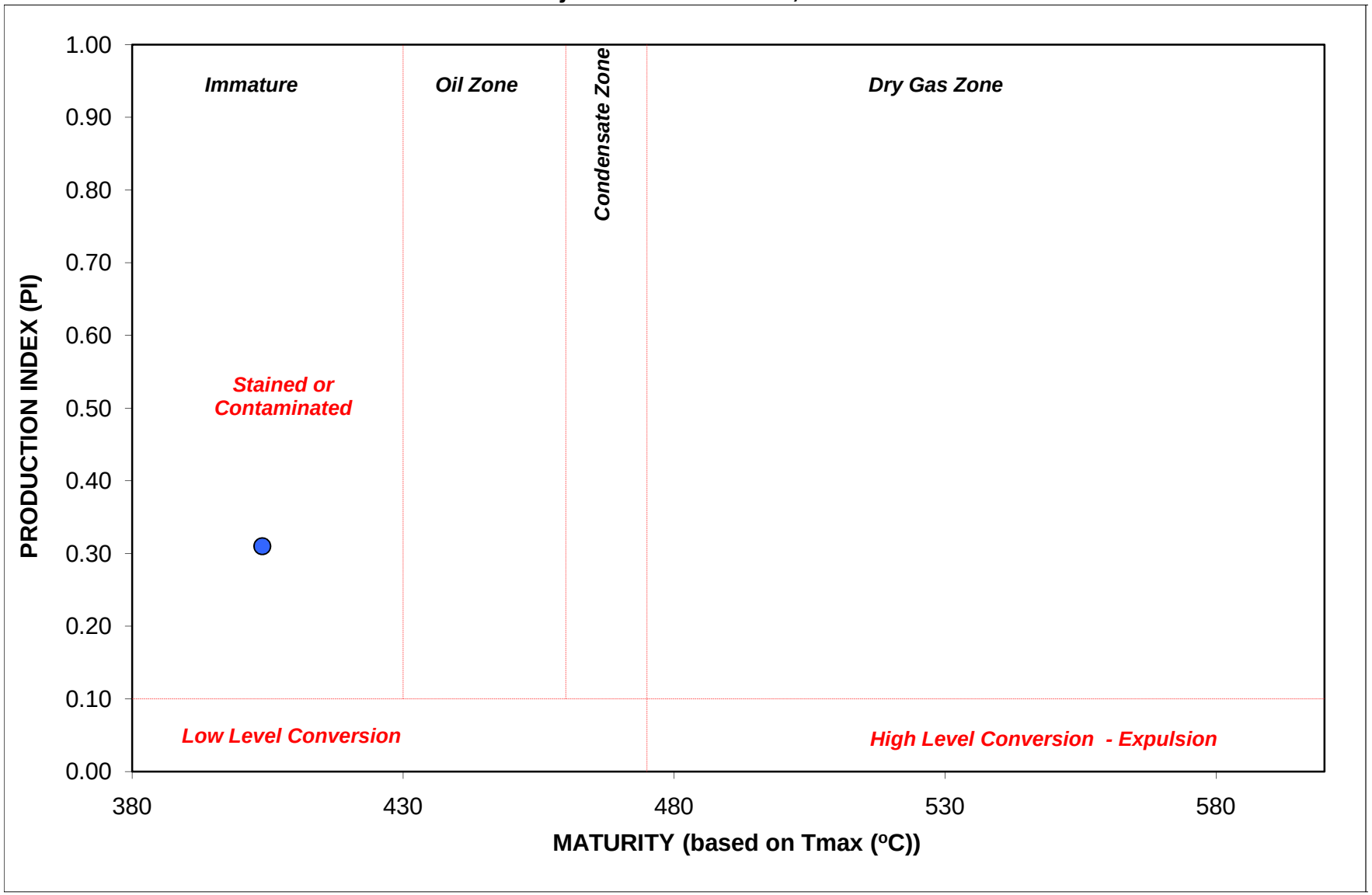

Figure 5a. Kerogen conversion and maturity (based on Tmax).

GORDON #1

AGC Project - Arkoma Basin, Arkansas

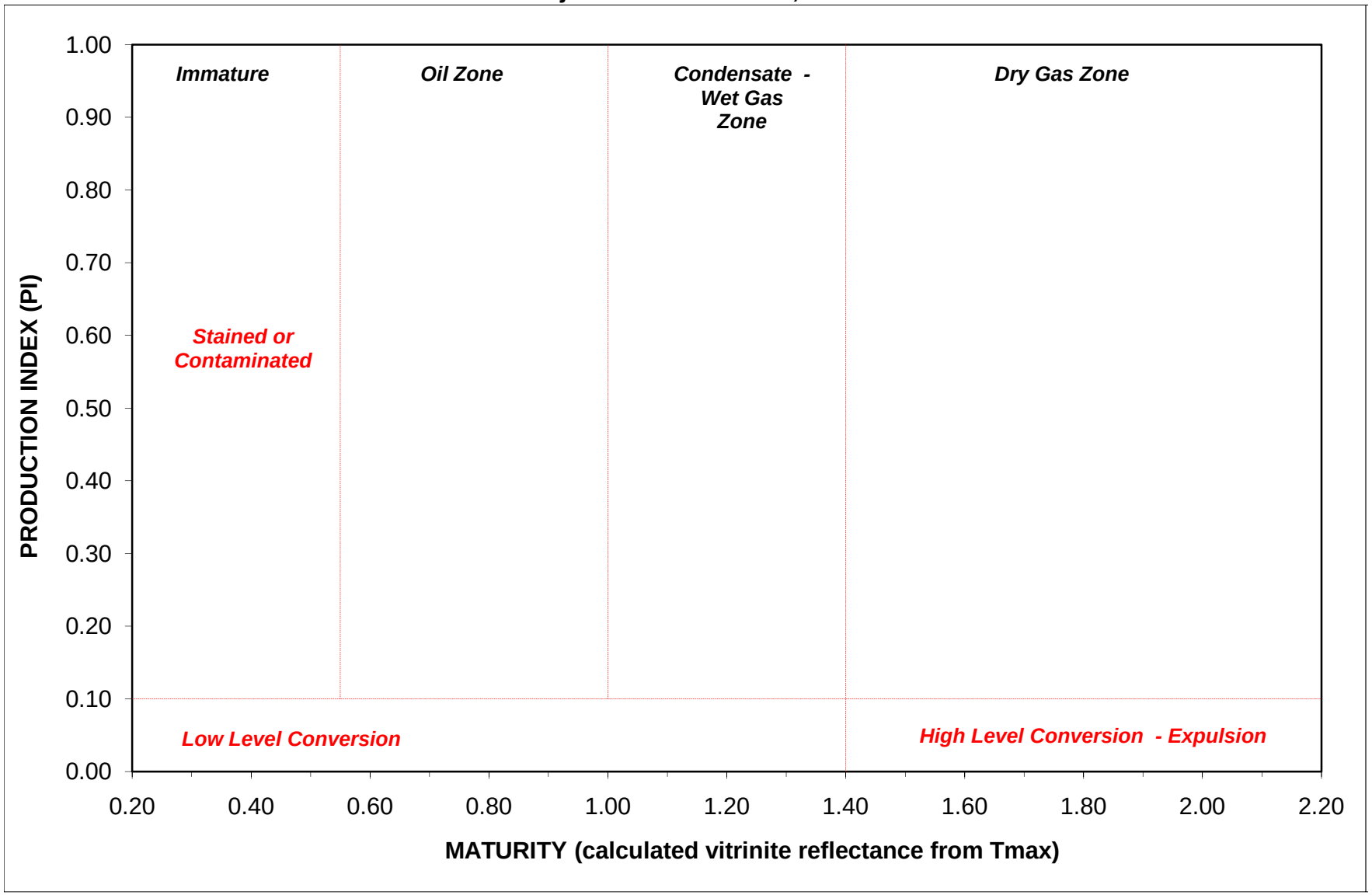

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

GORDON #1

AGC Project - Arkoma Basin, Arkansas

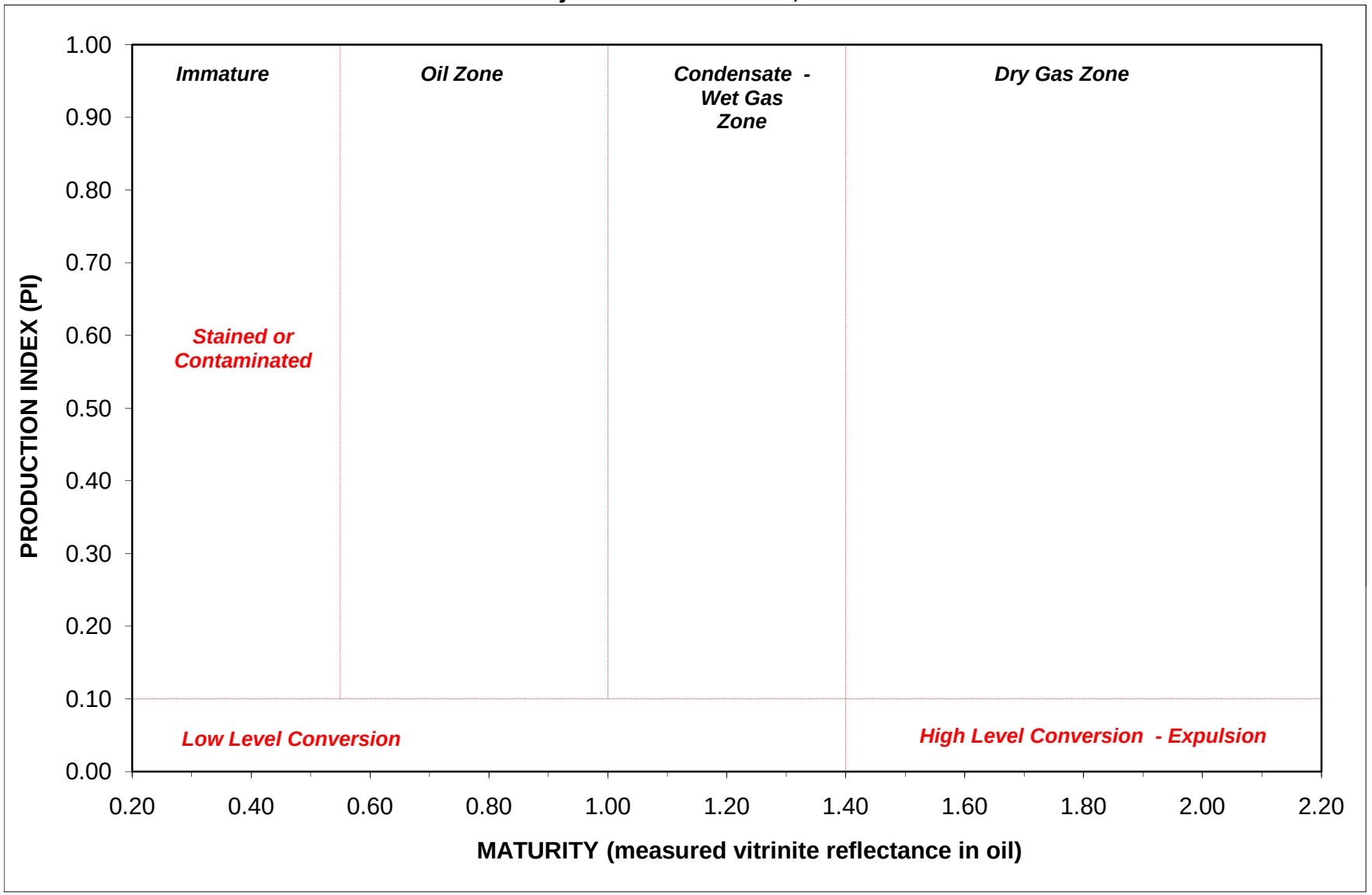

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 4. Geochemical and thermal maturity analyses for the well cutting samples from the Hales #1

HALES #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-4168-165113	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	6750	6770	6760		cuttings	NORM	1.78	1.55	1.33	1.61	0.71	416		0.33	2.53	C	90	40	2	75	0.45
06-4168-165114	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	7650	7670	7660		cuttings	NORM	2.31	2.30	3.33	3.10	1.05	406		0.15	2.67	C	134	45	3	144	0.52
06-4168-165115	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	8400	8420	8410		cuttings	NORM	1.73	1.53	2.65	2.41	0.84	399		-1.00	3.08	C	139	49	3	153	0.52
06-4168-165116	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	9700	9720	9710		cuttings	NORM	0.72	0.37	0.17	0.23	0.19	390	*	-1.00			32	26	1	24	0.43
06-4168-165117	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	10500	10510	10505		cuttings	NORM	2.30	2.17	1.76	3.49	0.72	420		0.40	3.67	C	152	31	5	77	0.34
06-4168-165118	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	11500	11520	11510		cuttings	NORM	1.26	0.88	0.32	0.53	0.36	401		0.06			42	29	1	25	0.38
06-4168-165119	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	12500	12520	12510		cuttings	NORM	2.27	1.96	0.46	0.97	0.59	404		0.11	4.04	C	43	26	2	20	0.32
06-4168-165120	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13520	13540	13530		cuttings	NORM	0.41	0.24	0.22	0.44	0.18	408	*	0.18			107	44	2	54	0.33
06-4168-165121	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13820	13850	13835		cuttings	NORM	0.74	0.58	1.22	1.30	0.39	432		0.62			176	53	3	165	0.48
06-4168-165122	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13850	13880	13865		cuttings	NORM	0.94	0.72	1.54	1.12	0.37	423		0.45			119	39	3	164	0.58
06-4168-165123	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13880	13910	13895		cuttings	NORM	1.17	0.93	2.54	2.21	0.46	424		0.47			189	39	5	217	0.53
06-4168-165124	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13910	13940	13925		cuttings	NORM	1.26	1.16	3.35	3.48	0.51	438		0.72	4.41	C	276	40	7	266	0.49
06-4168-165125	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13940	13970	13955		cuttings	NORM	1.17	0.88	2.12	1.83	0.46	433		0.63			156	39	4	181	0.54
06-4168-165126	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	13970	14000	13985		cuttings	NORM	1.00	0.78	1.63	1.51	0.44	416		0.33			151	44	3	163	0.52
06-4168-165127	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14120	14130	14125		cuttings	NORM	0.94	0.64	0.82	0.61	0.33	406		0.15			65	35	2	87	0.57
06-4168-165128	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14130	14140	14135		cuttings	NORM	1.02	0.67	1.01	0.69	0.34	396		-1.00			68	33	2	99	0.59
06-4168-165129	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14140	14150	14145		cuttings	NORM	1.14	0.90	1.31	1.13	0.38	417		0.35			99	33	3	115	0.54
06-4168-165130	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14150	14160	14155		cuttings	NORM	0.86	0.50	0.37	0.35	0.30	399	*	-1.00			41	35	1	43	0.51
06-4168-165131	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14160	14170	14165		cuttings	NORM	0.61	0.34	0.22	0.73	0.33	437		0.71			120	54	2	36	0.23
06-4168-165132	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14170	14180	14175		cuttings	NORM	0.54	0.38	0.18	0.54	0.25	437		0.71			100	46	2	33	0.25
06-4168-165133	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14180	14190	14185		cuttings	NORM	0.50	0.30	0.33	1.45	0.32	443		0.81			290	64	5	66	0.19
06-4168-165134	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14190	14200	14195		cuttings	NORM	0.80	0.52	0.53	1.54	0.39	448		0.90			192	49	4	66	0.26
06-4168-165135	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14200	14210	14205		cuttings	NORM	0.51	0.31	0.14	0.72	0.31	444		0.83			141	61	2	27	0.16
06-4168-165136	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14210	14220	14215		cuttings	NORM	0.64	0.30	0.31	0.55	0.23	441		0.78			86	36	2	48	0.36
06-4168-165137	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14220	14250	14235		cuttings	NORM	0.37	0.20	0.22	0.66	0.27	443		0.81			178	73	2	59	0.25
06-4168-165138	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14250	14280	14265		cuttings	NORM	0.47	0.27	0.36	0.51	0.26	444		0.83			109	55	2	77	0.41
06-4168-165139	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14280	14310	14295		cuttings	NORM	1.22	0.96	1.11	1.13	0.36	437		0.71			93	30	3	91	0.50
06-4168-165140	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14310	14340	14325		cuttings	NORM	1.77	1.73	2.00	1.35	0.46	423		0.45	3.91	D	76	26	3	113	0.60
06-4168-165141	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14340	13470	13905		cuttings	NORM	1.55	1.56	1.38	1.21	0.39	426		0.51			78	25	3	89	0.53
06-4168-165142	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14370	14400	14385		cuttings	NORM	1.80	1.91	1.61	1.38	0.52	430		0.58			77	29	3	89	0.54
06-4168-165143	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14400	14430	14415		cuttings	NORM	1.74	1.66	0.74	1.08	0.38	436		0.69			62	22	3	43	0.41
06-4168-165144	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14430	14460	14445		cuttings	NORM	1.52	1.36	0.84	0.94	0.45	433		0.63			62	30	2	55	0.47
06-4168-165145	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14460	14490	14475		cuttings	NORM	1.64	1.55	1.44	1.51	0.43	438		0.72			92	26	4	88	0.49
06-4168-165146	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14490	14520	14505		cuttings	NORM	1.18	0.92	0.81	0.90	0.37	433		0.63			76	31	2	69	0.47
06-4168-165147	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14520	14550	14535		cuttings	NORM	1.46	1.31	0.86	0.96	0.42	433		0.63			66	29	2	59	0.47
06-4168-165149	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14560	14570	14565		cuttings	NORM	1.29	1.12	0.91	0.72	0.39	416		0.33			56	30	2	71	0.56
06-4168-165150	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14570	14580	14575		cuttings	NORM	1.74	1.70	1.38	0.98	0.42	429		0.56			56	24	2	79	0.58
06-4168-165151	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14580	14590	14585		cuttings	NORM	1.36	1.37	1.03	1.13	0.41	430		0.58			83	30	3	76	0.48
06-4168-165152	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14590	14600	14595	Chattanooga	cuttings	NORM	1.89	2.03	0.80	0.78	0.42	434		0.65			41	22	2	42	0.51
06-4168-165153	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14600	14610	14605	Chattanooga	cuttings	NORM	2.13	2.24	0.80	0.62	0.48	421		0.42			29	23	1	38	0.56
06-4168-165154	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14610	14620	14615	Chattanooga	cuttings	NORM	3.79	4.05	1.37	1.05	0.51	422		0.44			28	13	2	36	0.57
06-4168-165155	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14620	14630	14625	Chattanooga	cuttings	NORM	4.20	4.58	1.45	1.37	0.52	422		0.44			33	12	3	35	0.51
06-4168-165156	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14630	14640	14635	Chattanooga	cuttings	NORM	4.21	4.39	1.11	0.77	0.42	408		0.18			18	10	2	26	0.59
06-4168-165157	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14640	14650	14645	Chattanooga	cuttings	NORM	5.73	6.30	4.35	2.76	0.48	419		0.38			48	8	6	76	0.61
06-4168-165158	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14650	14660	14655	Chattanooga	cuttings	NORM	5.91	6.63	4.89	2.39	0.53	411		0.24			40	9	5	83	0.67
06-4168-165159	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14660	14670	14665	Chattanooga	cuttings	NORM	5.20	5.93	5.06	5.63	0.65	421		0.42			108	12	9	97	0.47
06-4168-165160	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14670	14680	14675	Chattanooga	cuttings	NORM	4.74	4.98	2.87	1.99	0.57	421		0.42			42	12	3	61	0.59
06-4168-165161	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14680	14690	14685	Chattanooga	cuttings	NORM	4.87	3.89	1.47	1.00	0.51	391		-1.00			21	10	2	30	0.60
06-4168-165162	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14690	14700	14695		cuttings	NORM	5.95	6.15	3.11	1.58	0.54	388		-1.00	5.05	C	27	9	3	52	0.66
06-4168-165163	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14700	14710	14705		cuttings	NORM	7.29	7.89	3.46	1.95	0.74	404		0.11			27	10	3	47	0.64
06-4168-165164	Arkoma	03131102080000	ARKLA EXPL CO	HALES	1-29	SEBASTIAN	AR	14710	14720	14715		cuttings	NORM	6.93	7.07	2.50	1.51	0.65	393		-1.00			22	9	2	36	0.62

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

HALES #1
Geochemical Log

AGC Project - Arkoma Basin, Arkansas

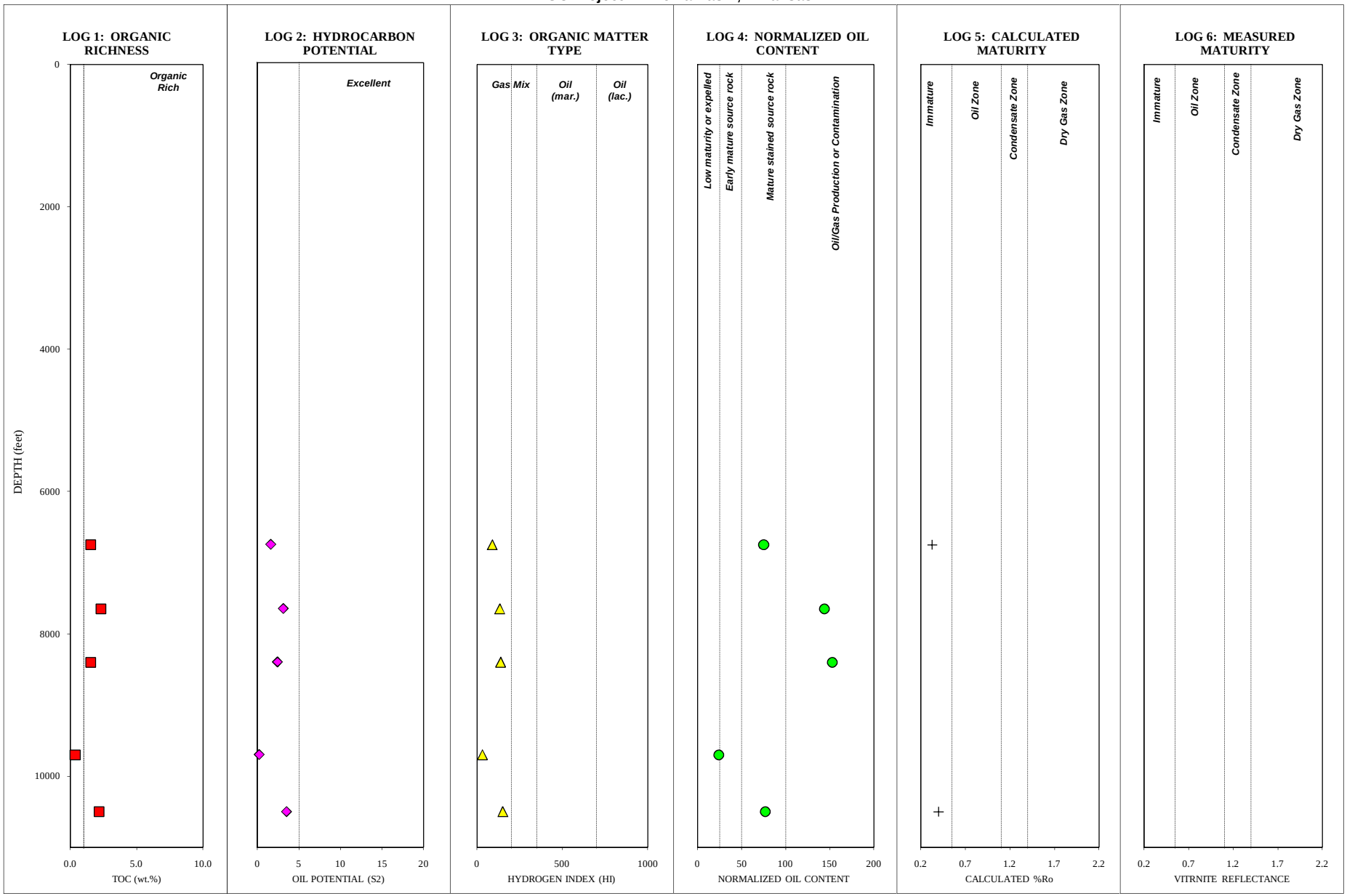

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

HALES #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

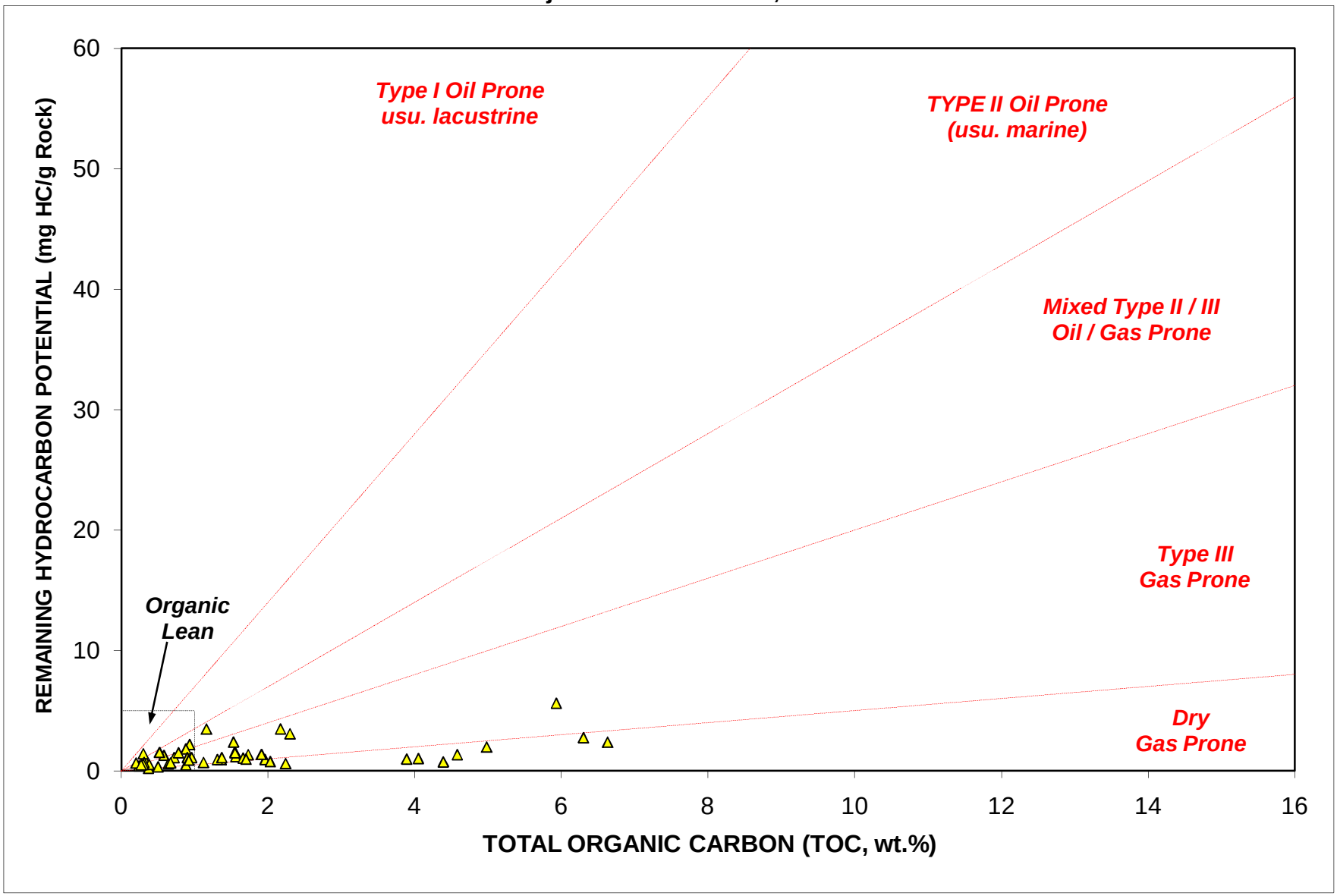

Figure 2. Kerogen Quality

Humble Geochemical Services Division

HALES #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

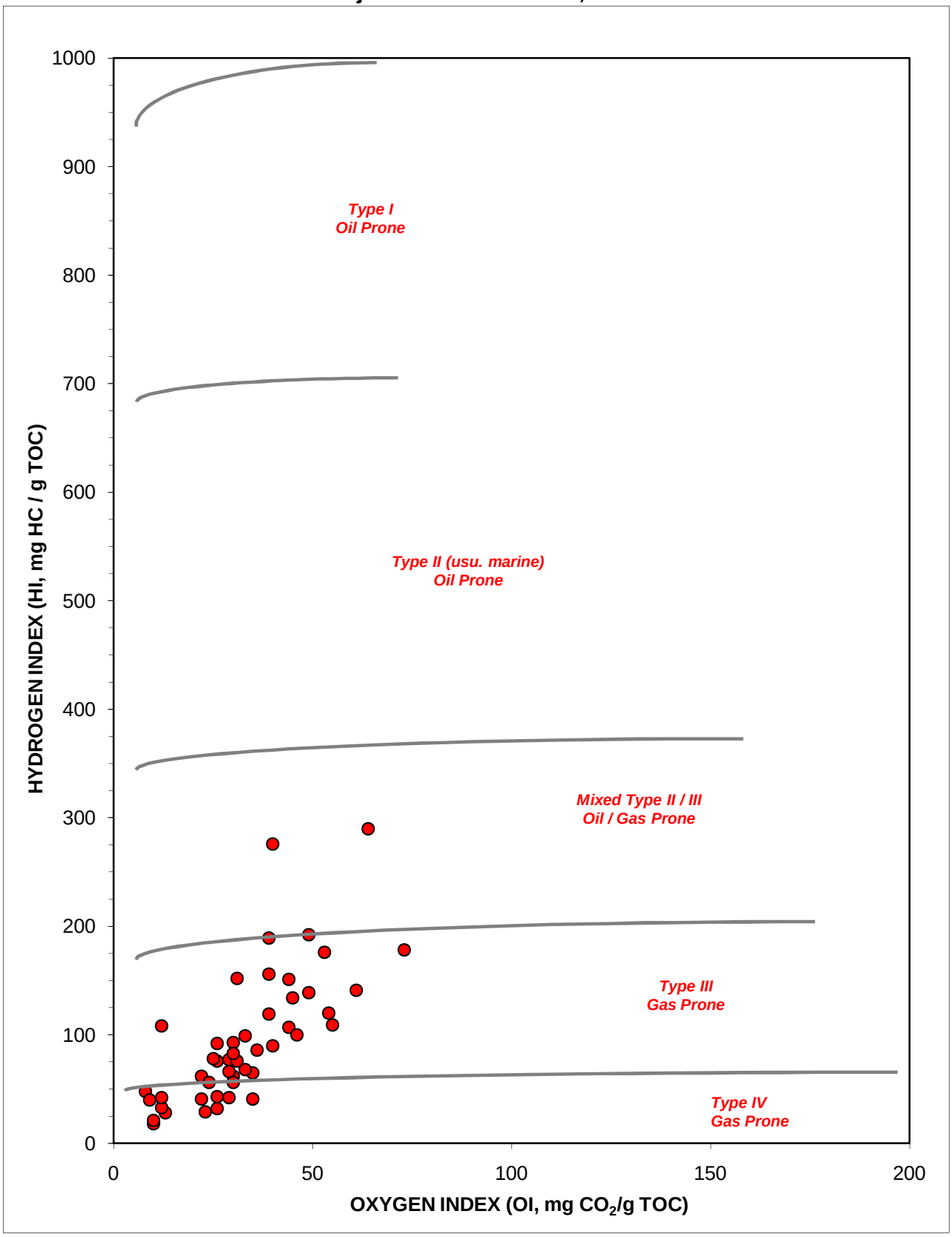

Figure 3. Kerogen type

HALES #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

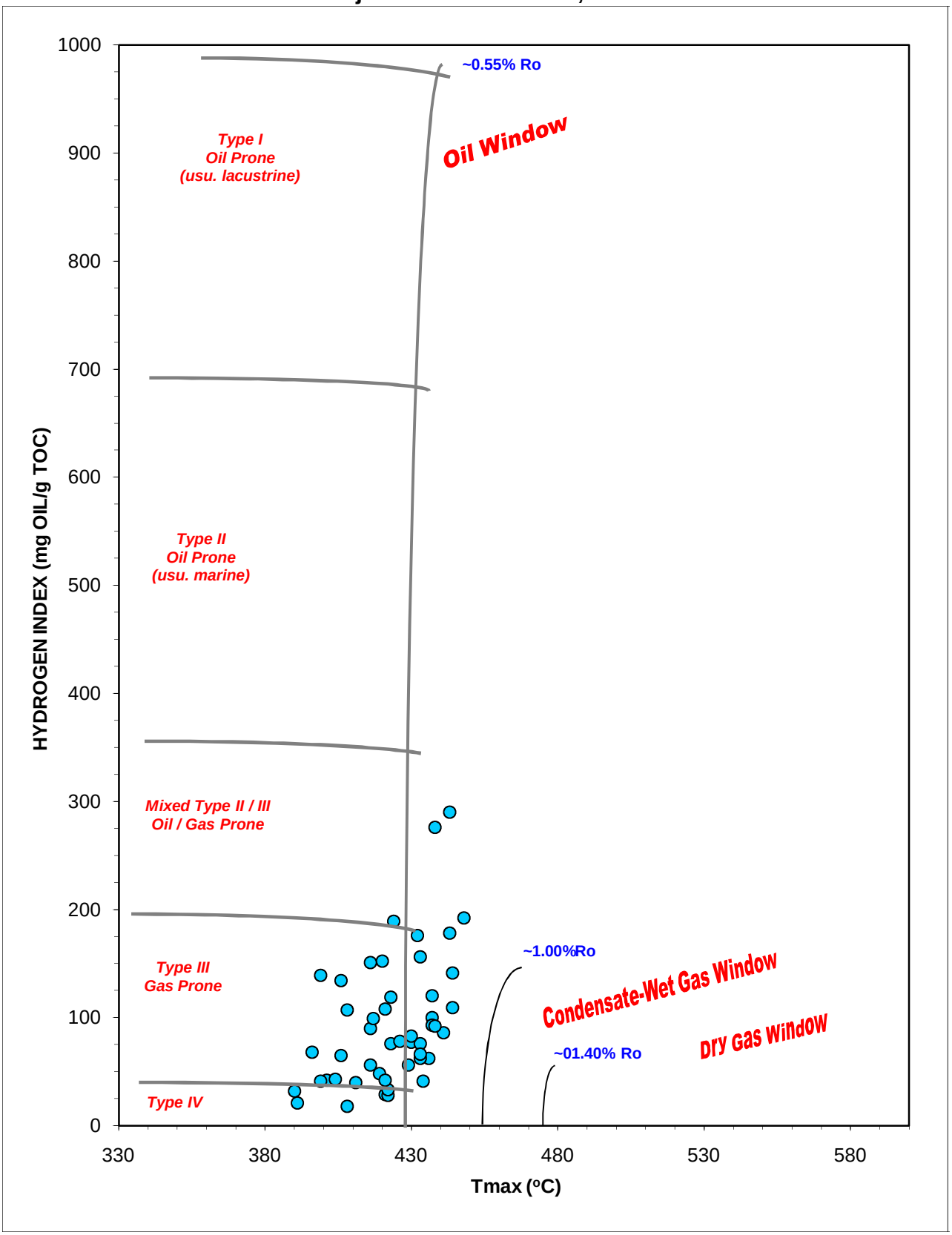

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

HALES #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

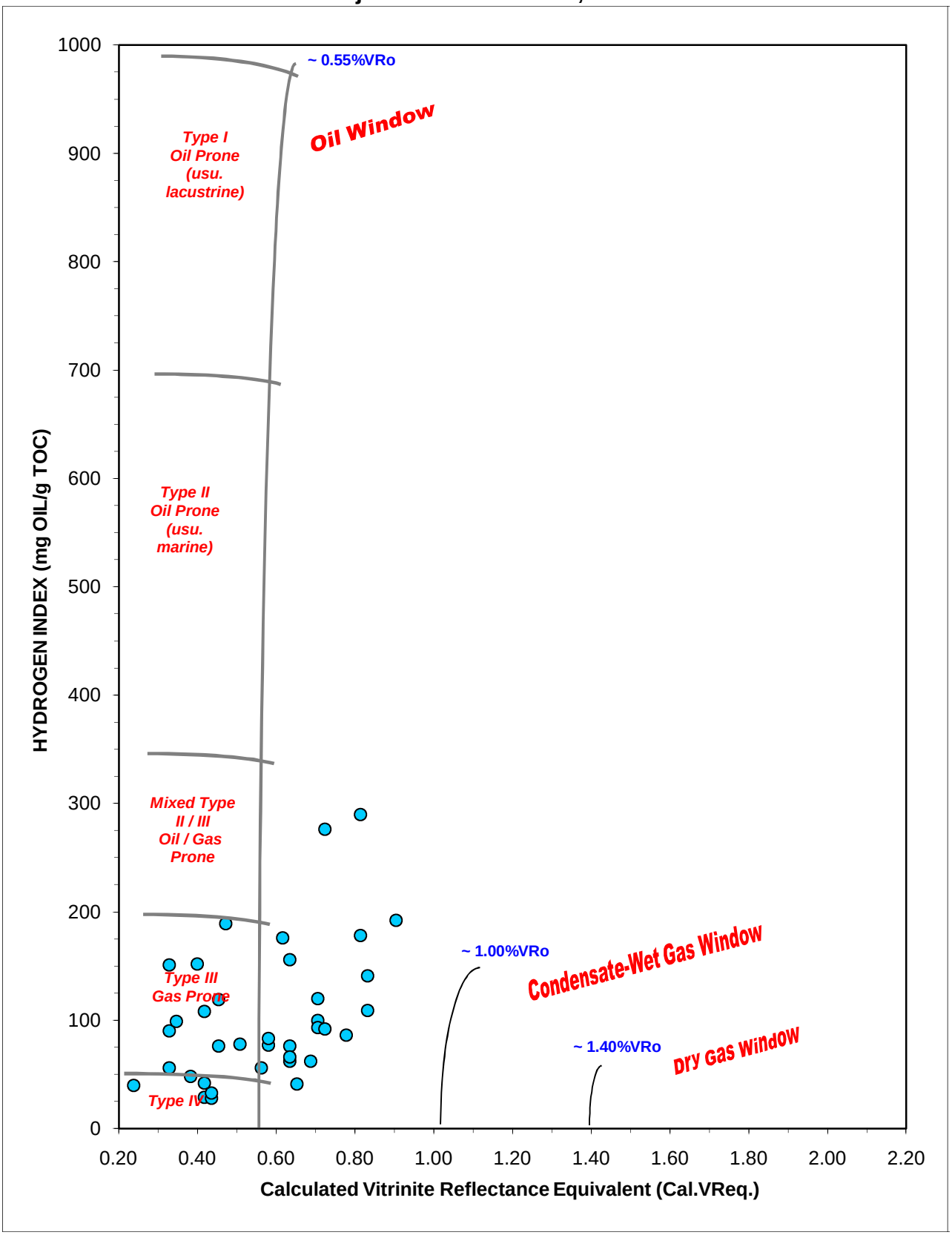

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

HALES #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

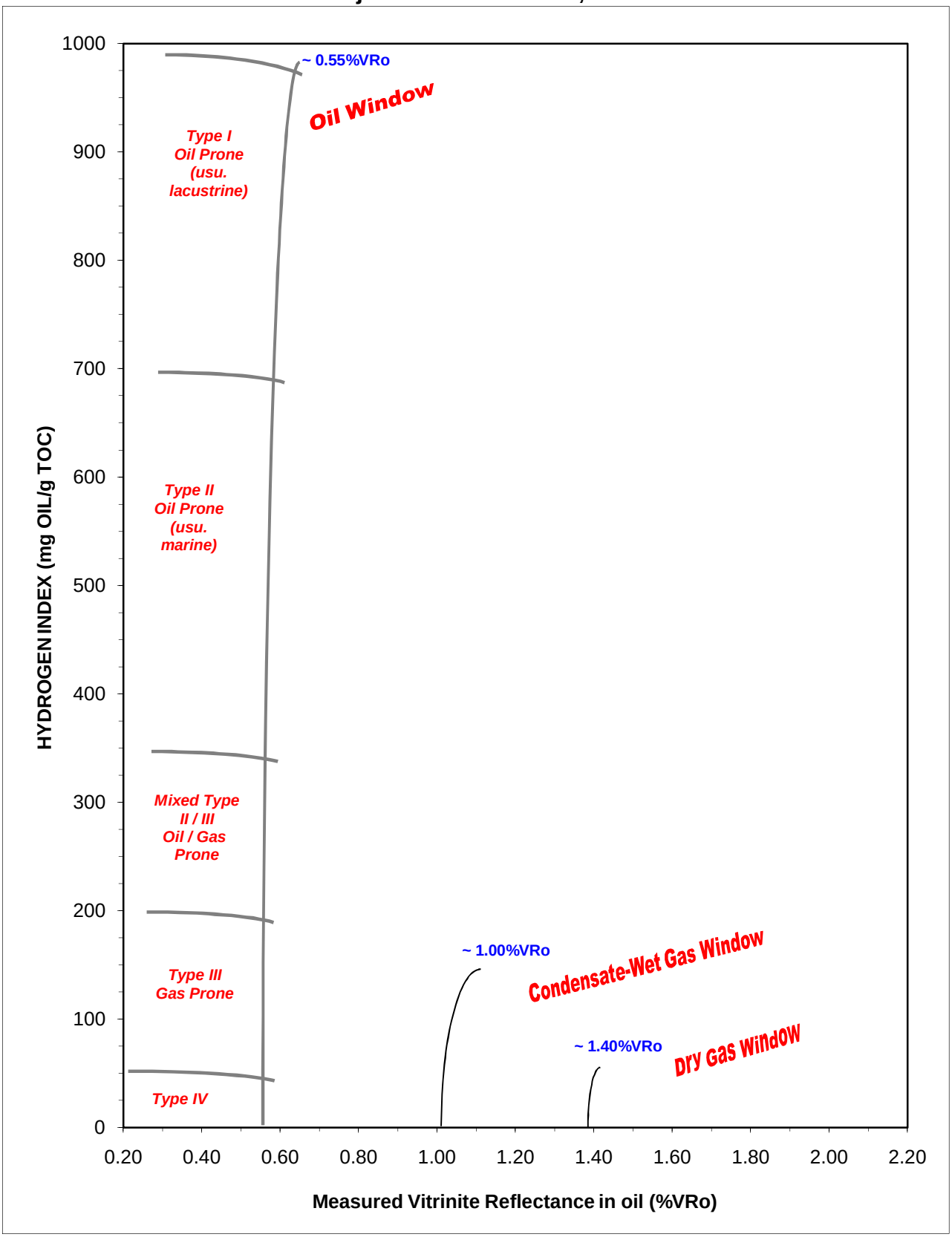

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

HALES #1

AGC Project - Arkoma Basin, Arkansas

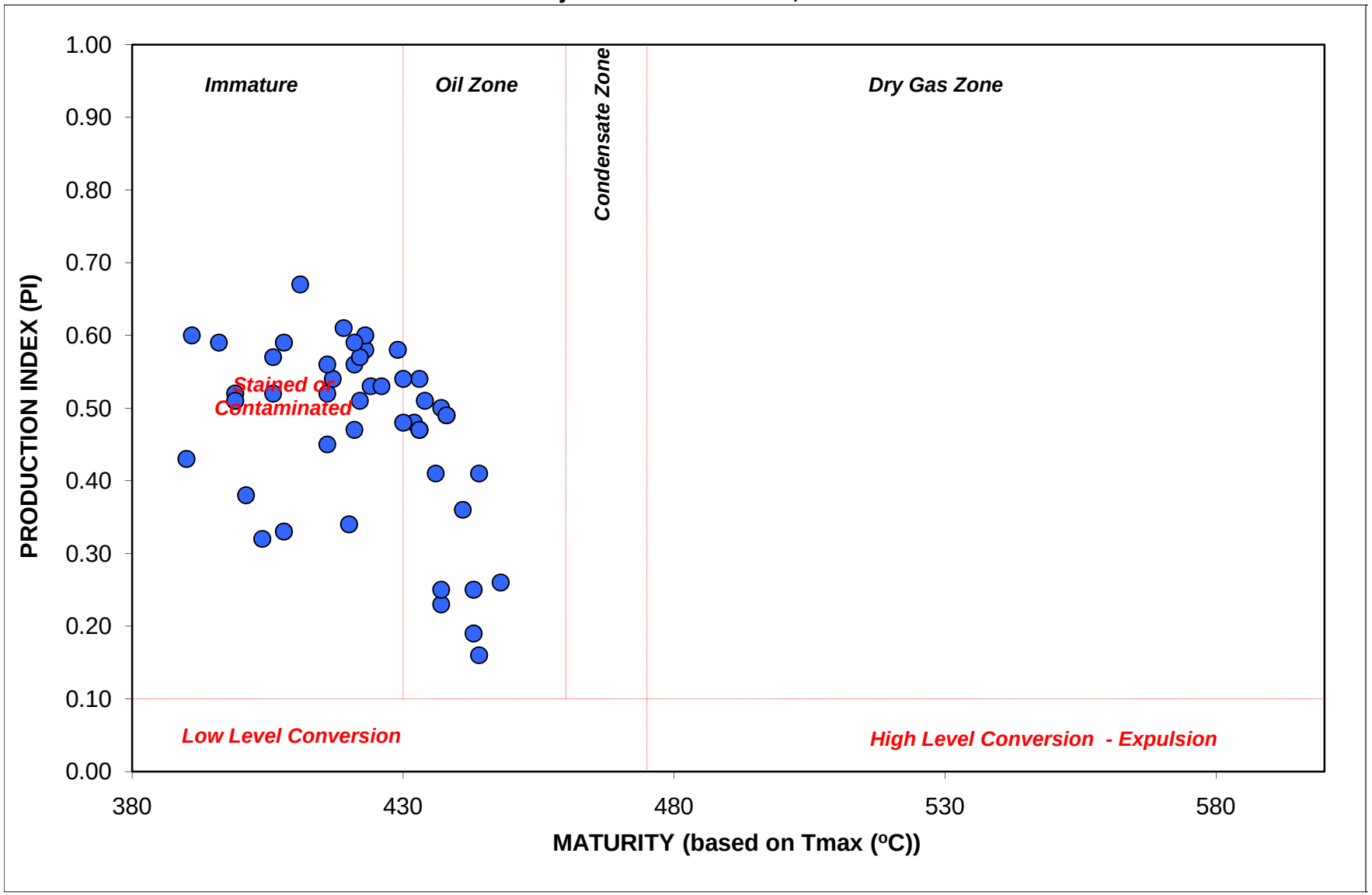

Figure 5a. Kerogen conversion and maturity (based on Tmax).

HALES #1

AGC Project - Arkoma Basin, Arkansas

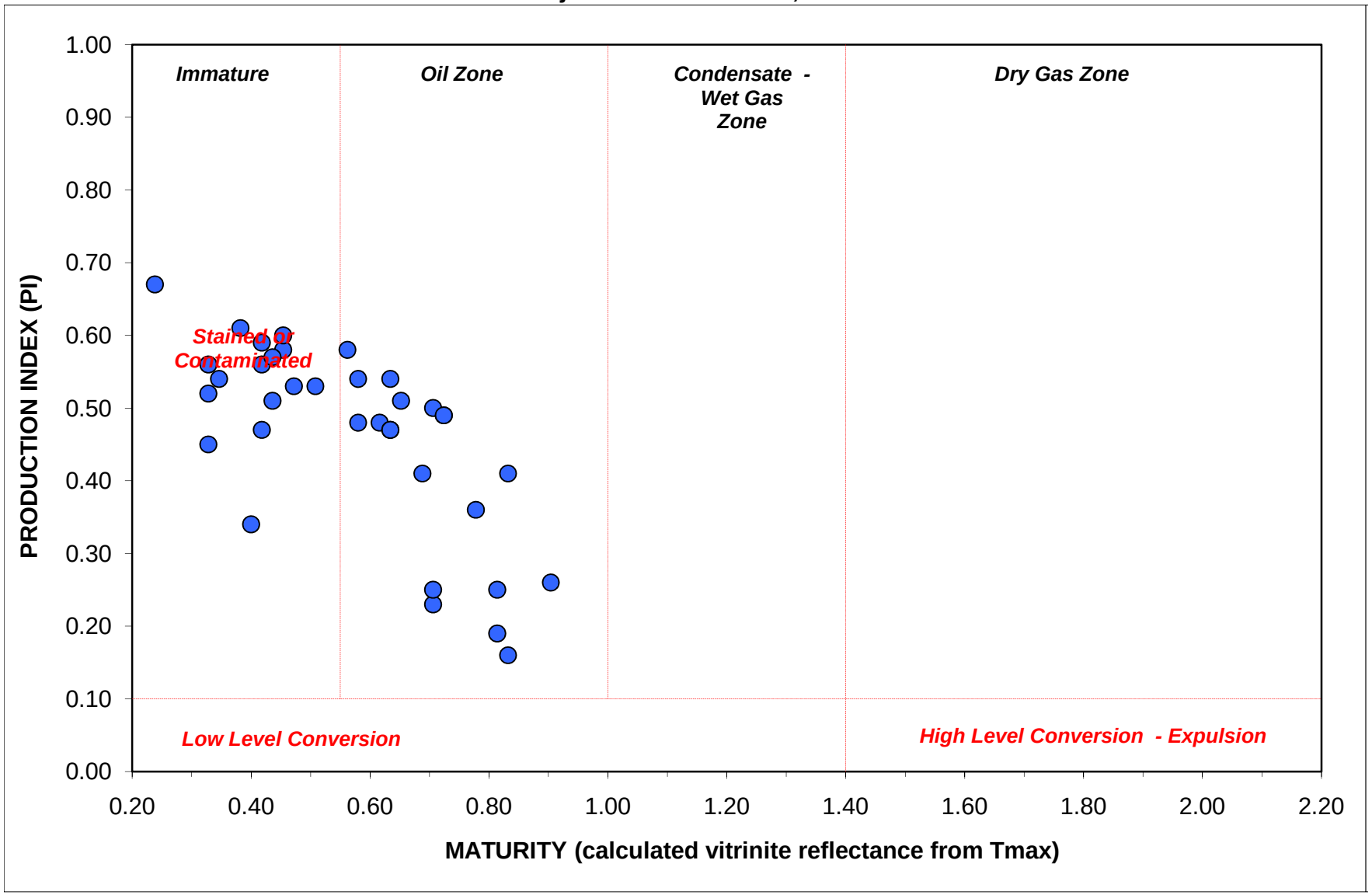

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

HALES #1

AGC Project - Arkoma Basin, Arkansas

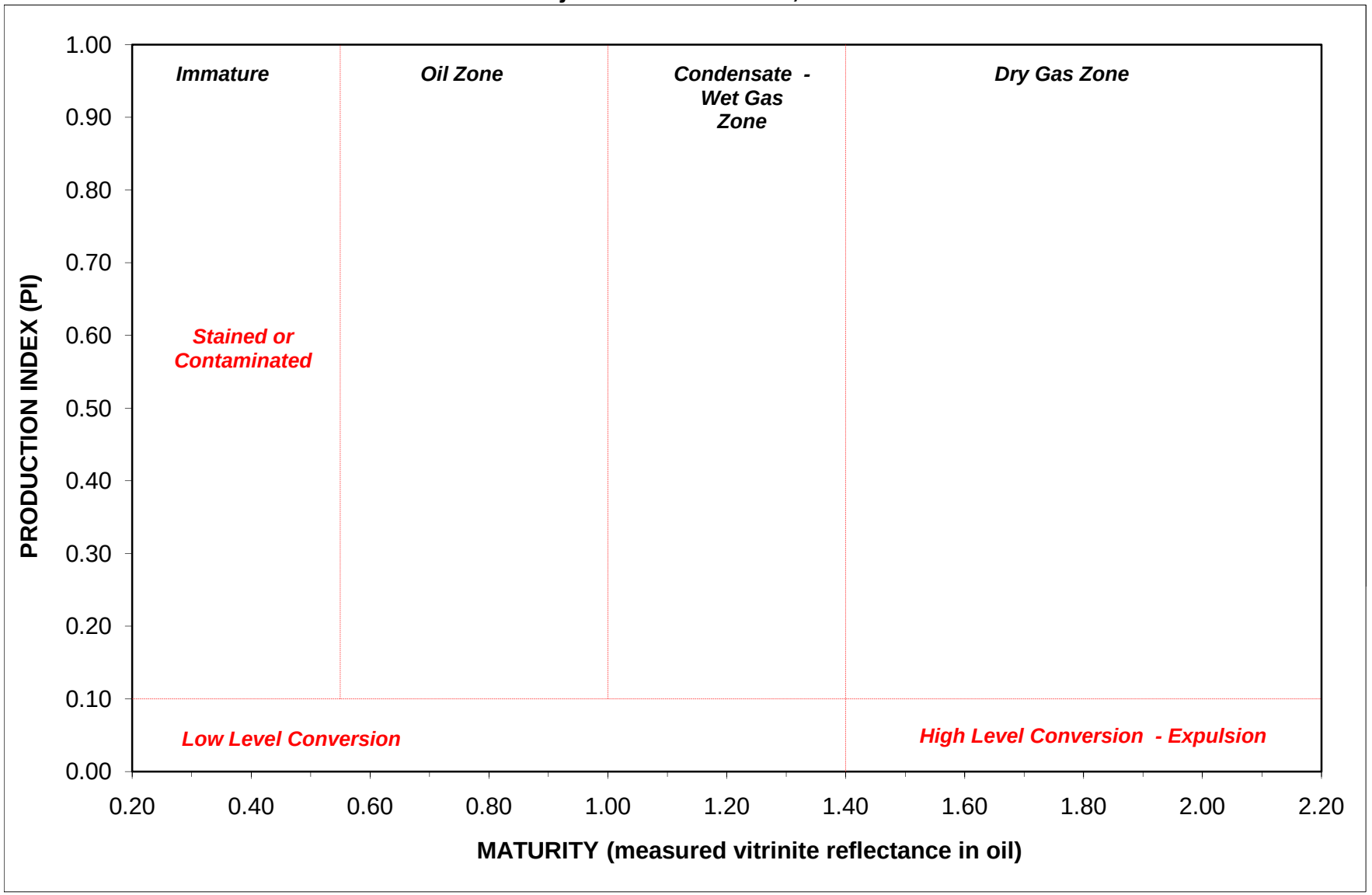

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 5. Geochemical and thermal maturity analyses for the well cutting samples from the Hatfield #1

HATFIELD #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-163627	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	6890	6920	6905		cuttings	pWR	0.89	0.72	0.32	0.19	0.45	353	*	-1.00			21	51	0	36	0.63
06-3936-163628	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7190	7200	7195		cuttings	pWR	0.96	0.74	0.29	0.29	0.53	377	*	-1.00			30	55	1	30	0.50
06-3936-163629	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7200	7210	7205		cuttings	pWR	0.84	0.66	0.25	0.22	0.43	365	*	-1.00			26	51	1	30	0.53
06-3936-163630	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7260	7270	7265		cuttings	pWR	0.83	0.67	0.28	0.23	0.55	354	*	-1.00			28	66	0	34	0.55
06-3936-163631	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7270	7280	7275		cuttings	pWR	0.78	0.63	0.32	0.27	0.48	365	*	-1.00			35	62	1	41	0.54
06-3936-163632	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7280	7290	7285		cuttings	pWR	0.88	0.69	0.26	0.26	0.50	365	*	-1.00			30	57	1	30	0.50
06-3936-163633	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7290	7300	7295	Fayetteville	cuttings	pWR	0.88	0.70	0.24	0.25	0.54	364	*	-1.00			28	61	0	27	0.49
06-3936-163634	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7300	7310	7305	Fayetteville	cuttings	pWR	1.50	1.42	0.44	0.38	0.61	359	*	-1.00			25	41	1	29	0.54
06-3936-163635	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7310	7320	7315	Fayetteville	cuttings	pWR	1.54	1.53	0.47	0.28	0.68	355	*	-1.00	2.73	E	18	44	0	31	0.63
06-3936-163636	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7320	7330	7325	Fayetteville	cuttings	pWR	1.68	1.53	0.40	0.30	0.69	353	*	-1.00			18	41	0	24	0.57
06-3936-163637	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7330	7340	7335	Fayetteville	cuttings	pWR	1.48	1.43	0.35	0.24	0.74	354	*	-1.00			16	50	0	24	0.59
06-3936-163638	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7340	7350	7345	Fayetteville	cuttings	pWR	1.83	1.79	0.50	0.31	0.72	363	*	-1.00			17	39	0	27	0.62
06-3936-163639	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7350	7360	7355	Fayetteville	cuttings	pWR	2.59	2.91	0.86	0.54	0.68	367		-1.00			21	26	1	33	0.61
06-3936-163640	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7360	7370	7365	Fayetteville	cuttings	pWR	2.54	2.83	0.70	0.47	0.77	360	*	-1.00			19	30	1	28	0.60
06-3936-163641	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7370	7380	7375	Fayetteville	cuttings	pWR	2.29	2.52	0.59	0.44	0.73	362	*	-1.00			19	32	1	26	0.57
06-3936-163642	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7380	7390	7385		cuttings	pWR	2.59	2.96	0.73	0.41	0.73	360	*	-1.00			16	28	1	28	0.64
06-3936-163643	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7390	7400	7395		cuttings	pWR	2.12	2.36	0.60	0.62	0.69	371		-1.00			29	33	1	28	0.49
06-3936-163644	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7670	7680	7675		cuttings	pWR	1.18	1.03	0.62	0.38	0.51	361	*	-1.00			32	43	1	53	0.62
06-3936-163645	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7380	7390	7385		cuttings	pWR	1.17	1.00	0.66	0.48	0.64	362	*	-1.00			41	55	1	56	0.58
06-3936-163646	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7690	7700	7695		cuttings	pWR	1.19	0.98	0.61	0.40	0.50	360	*	-1.00			34	42	1	51	0.60
06-3936-163647	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7700	7710	7705	Chattanooga	cuttings	pWR	1.26	1.00	0.62	0.45	0.53	360	*	-1.00	1.51	D	36	42	1	49	0.58
06-3936-163648	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7710	7720	7715	Chattanooga	cuttings	pWR	1.14	0.89	0.50	0.23	0.52	360	*	-1.00			20	46	0	44	0.68
06-3936-163649	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7720	7730	7725	Chattanooga	cuttings	pWR	1.15	1.01	0.64	0.41	0.52	353	*	-1.00			36	45	1	56	0.61
06-3936-163650	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7730	7740	7735	Chattanooga	cuttings	pWR	1.19	1.01	0.60	0.33	0.52	358	*	-1.00			28	44	1	50	0.65
06-3936-163651	Arkoma	03131100140000	DIAMOND SHMROCK CORP	HATFIELD	1	SEBASTIAN	AR	7740	7750	7745		cuttings	pWR	1.19	0.92	0.58	0.30	0.49	355	*	-1.00			25	41	1	49	0.66

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

HATFIELD #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

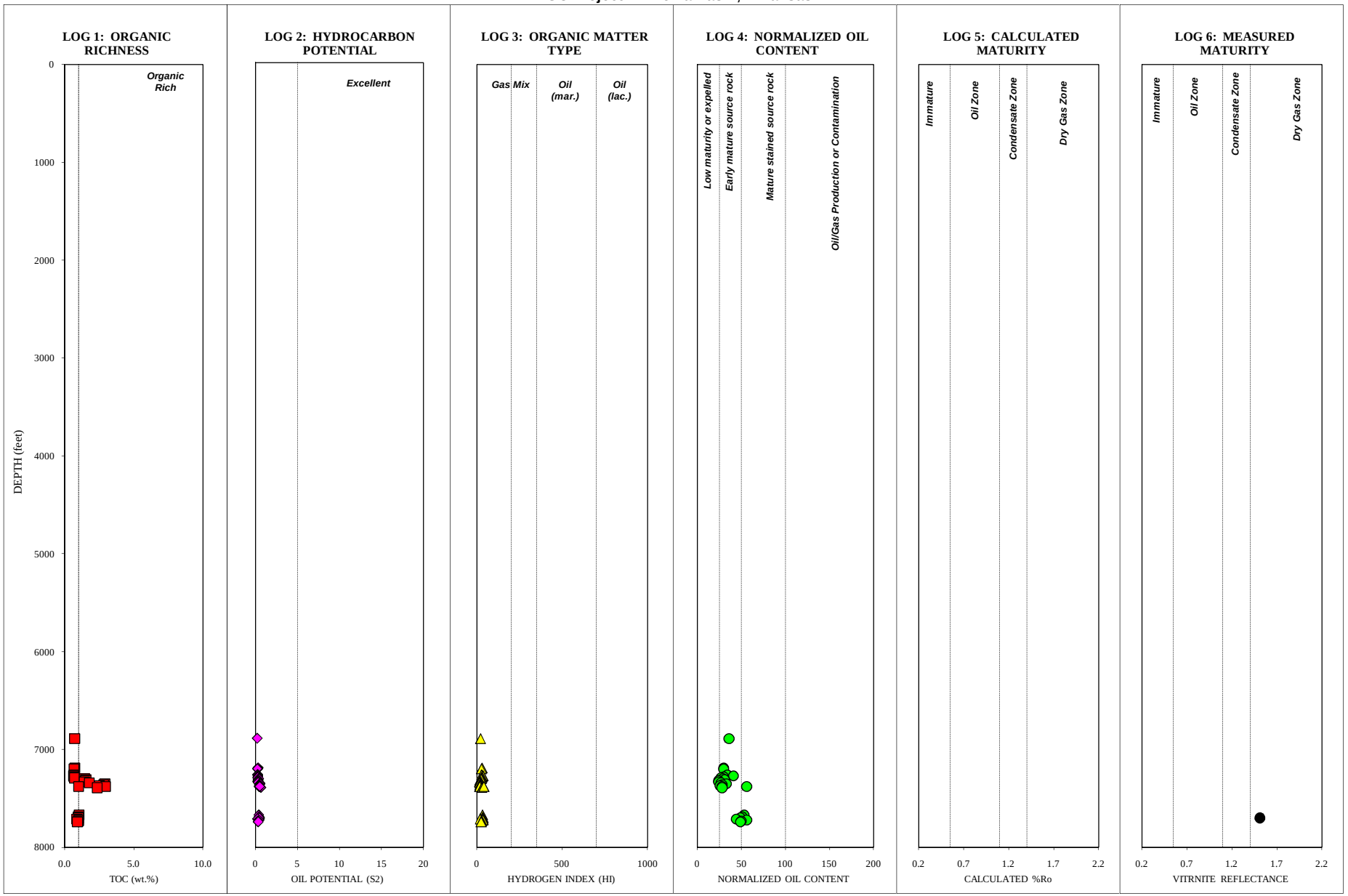

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

HATFIELD #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

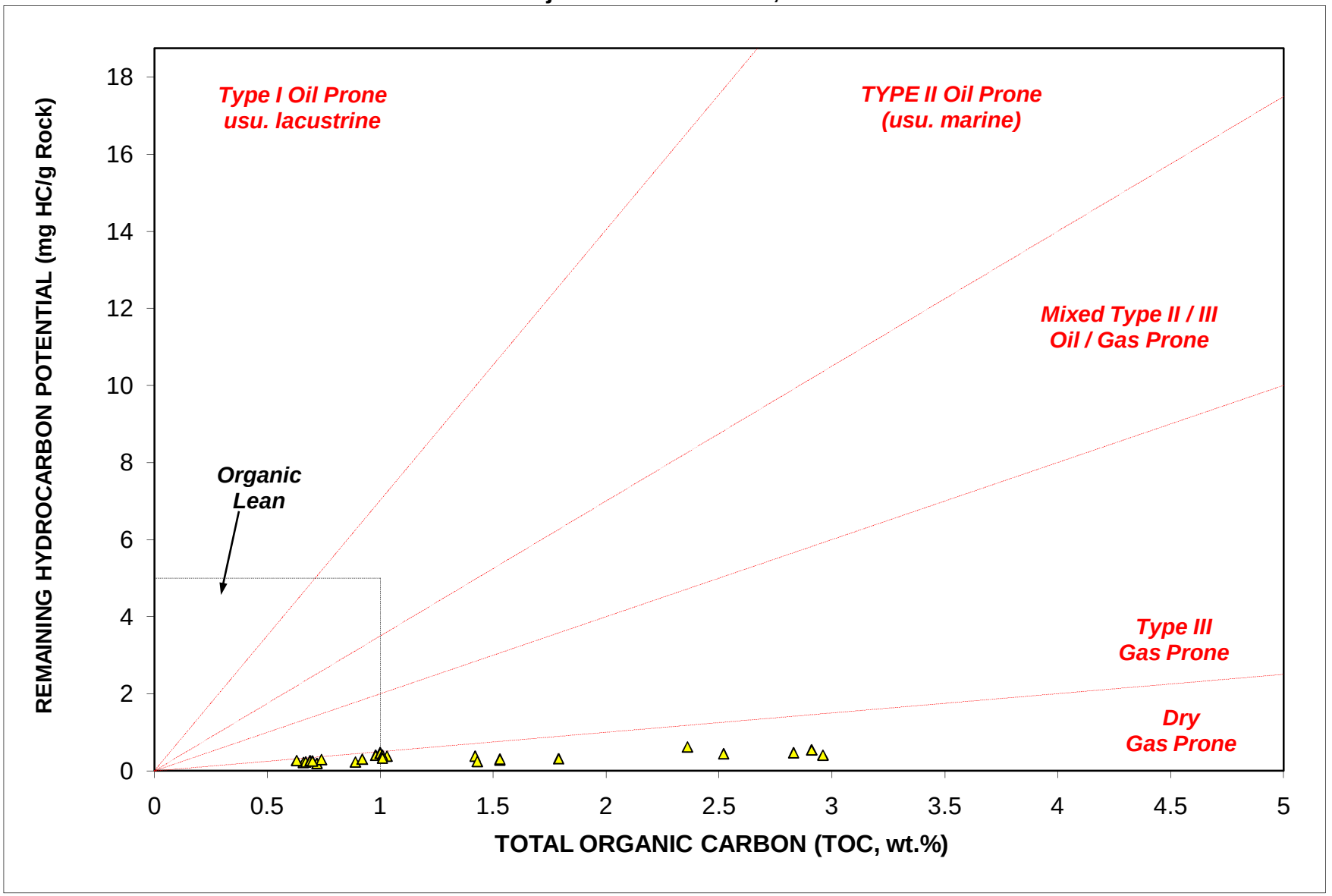

Figure 2. Kerogen Quality

Humble Geochemical Services Division

HATFIELD #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

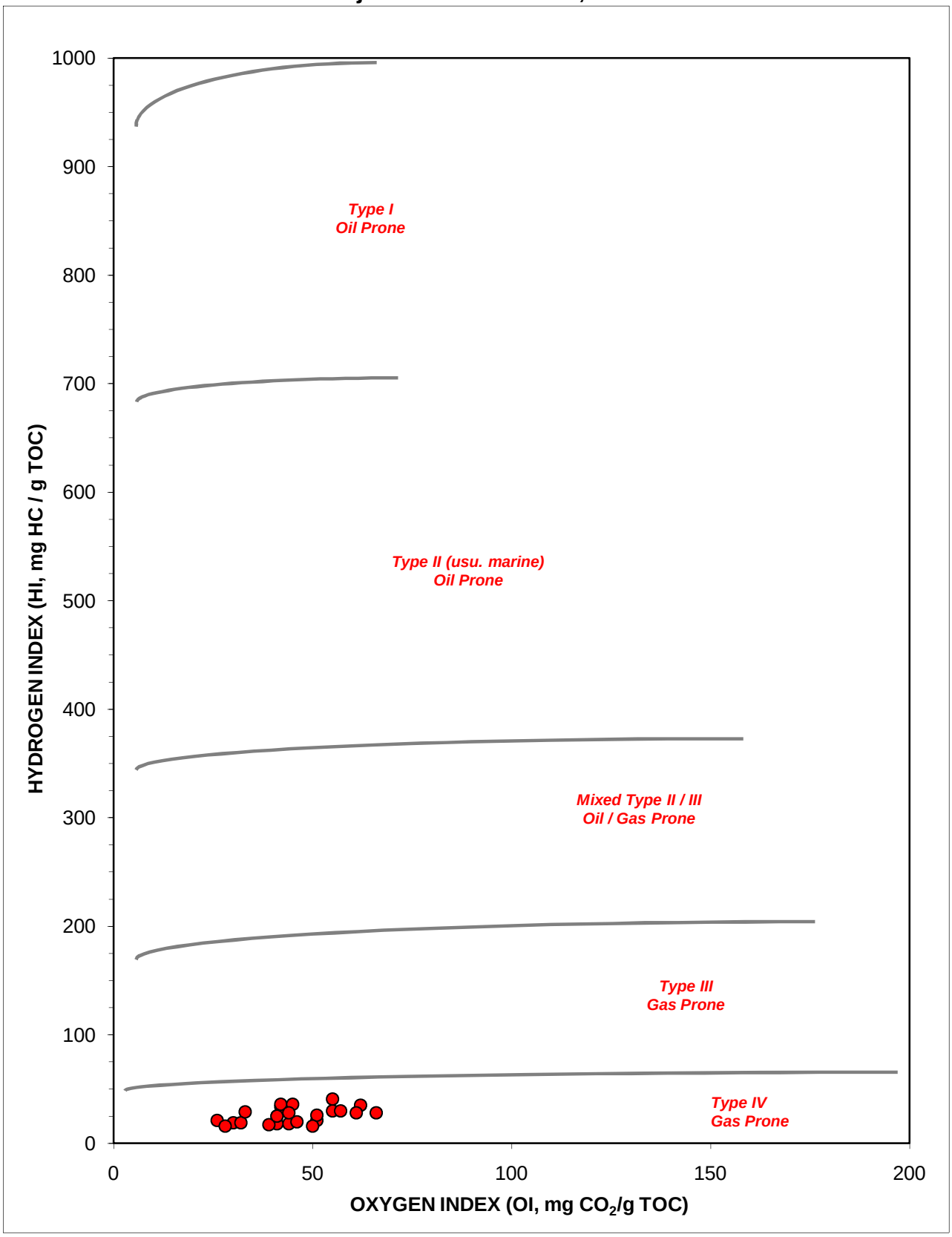

Figure 3. Kerogen type

HATFIELD #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

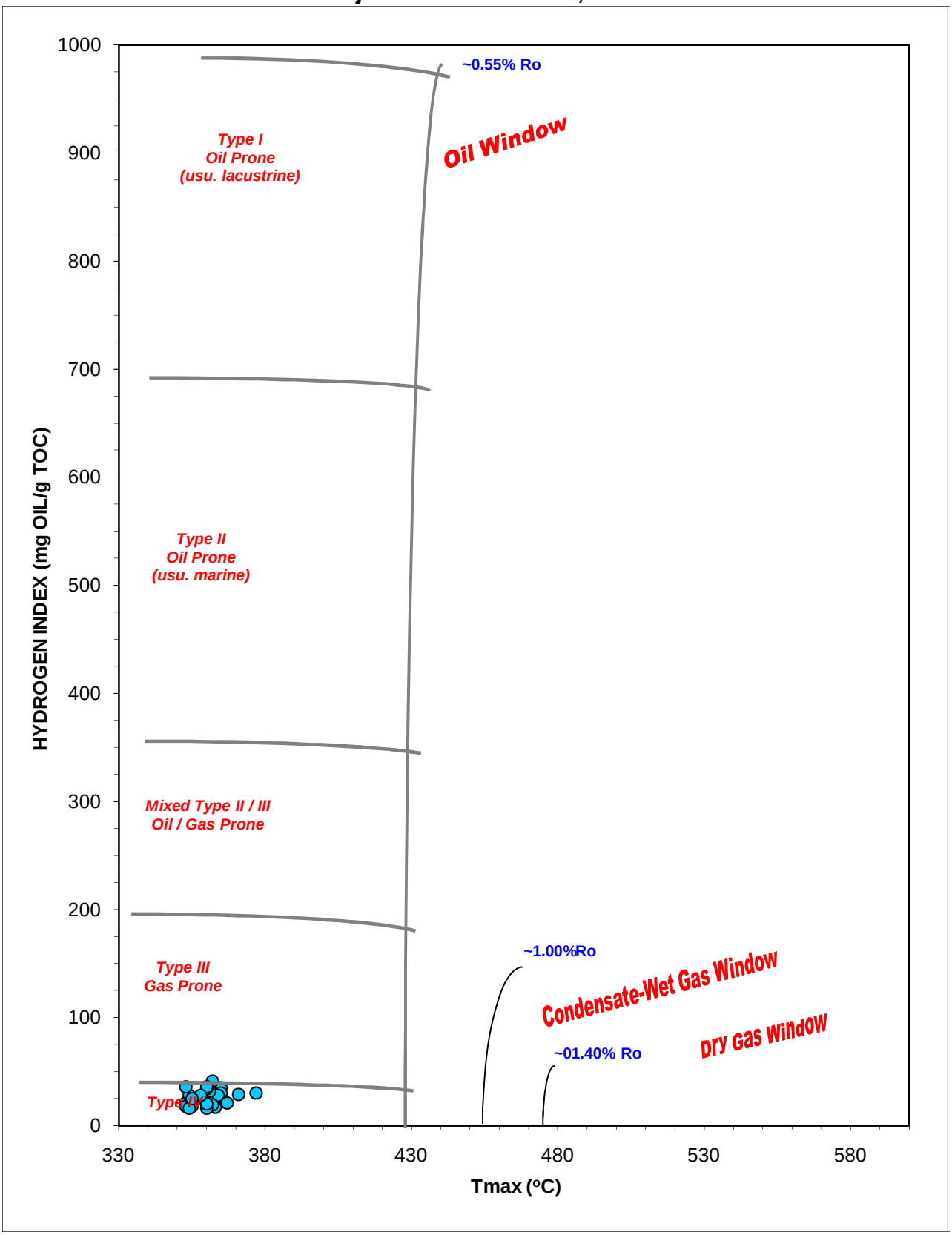

Figure 4a. Kerogen Type and Maturity (Tmax)

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HATFIELD #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

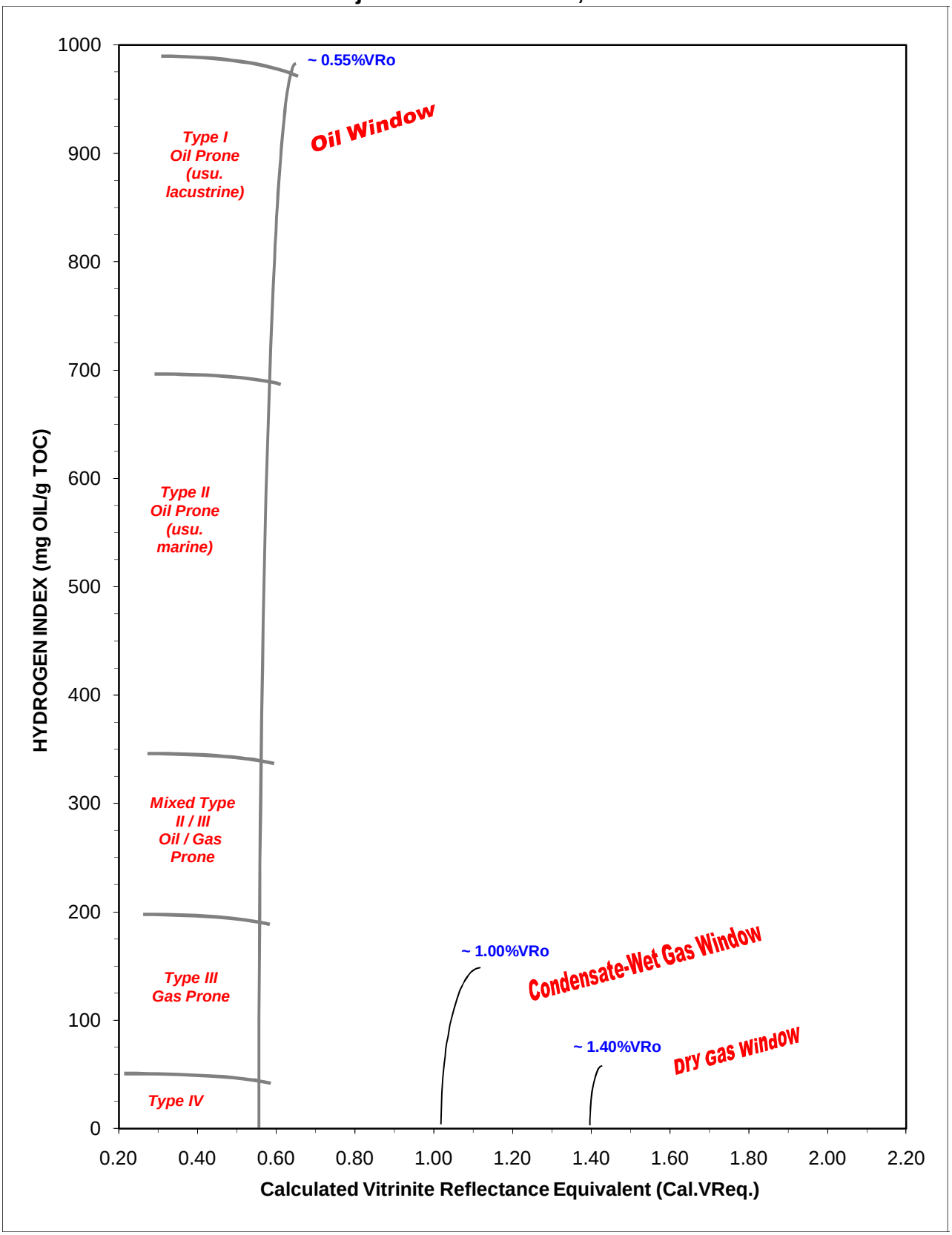

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

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HATFIELD #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

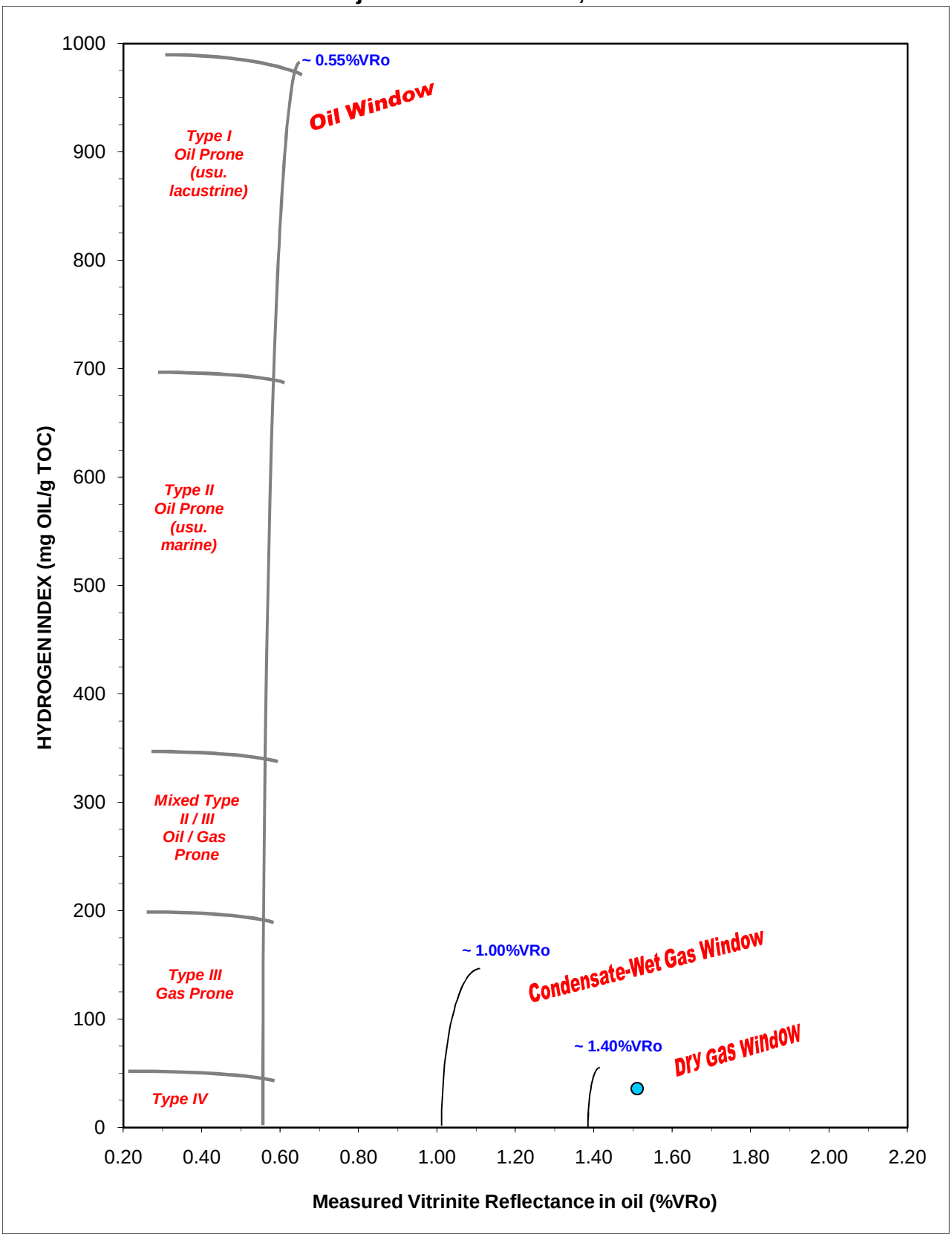

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

HATFIELD #1

AGC Project - Arkoma Basin, Arkansas

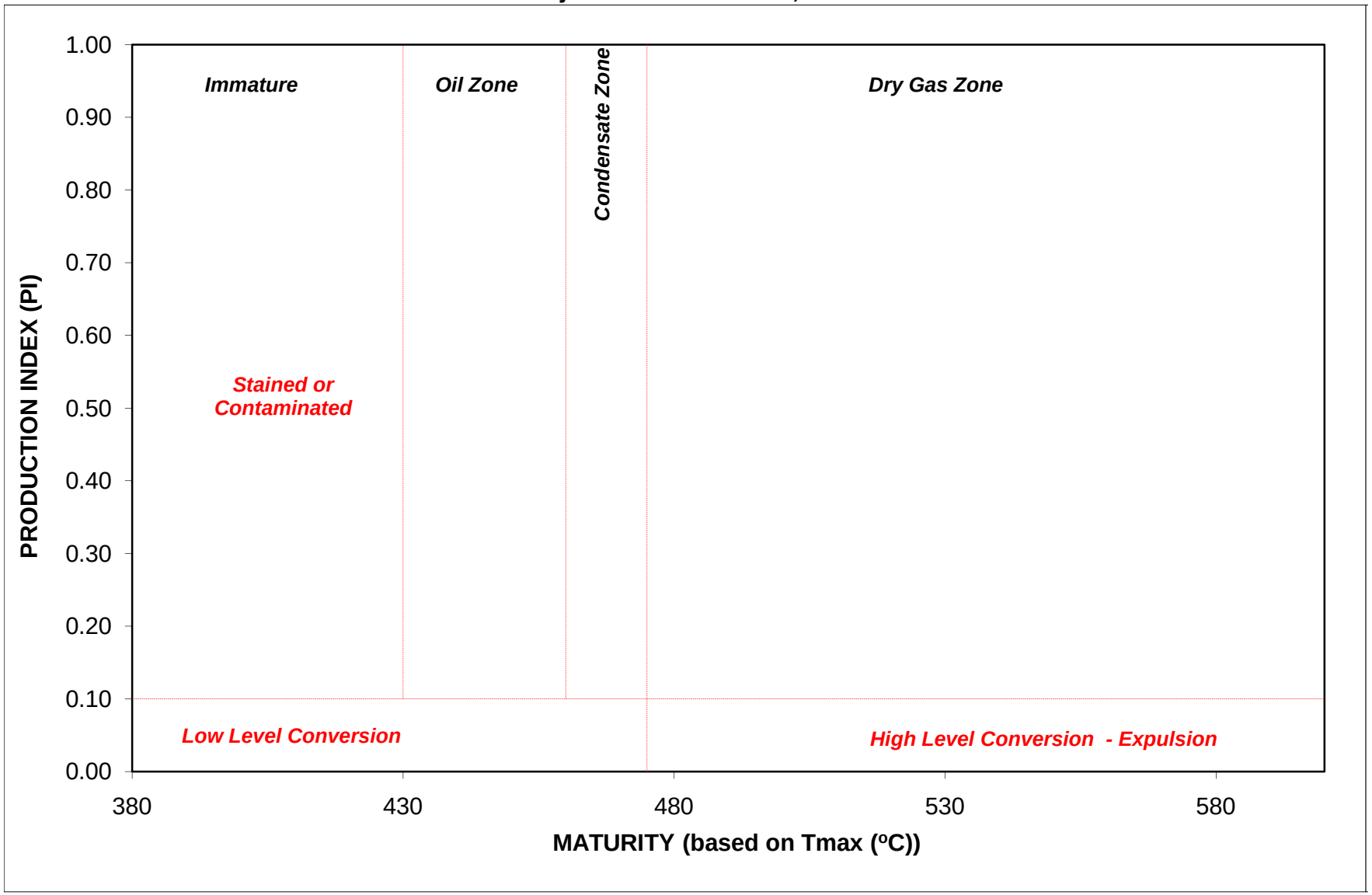

Figure 5a. Kerogen conversion and maturity (based on Tmax).

HATFIELD #1

AGC Project - Arkoma Basin, Arkansas

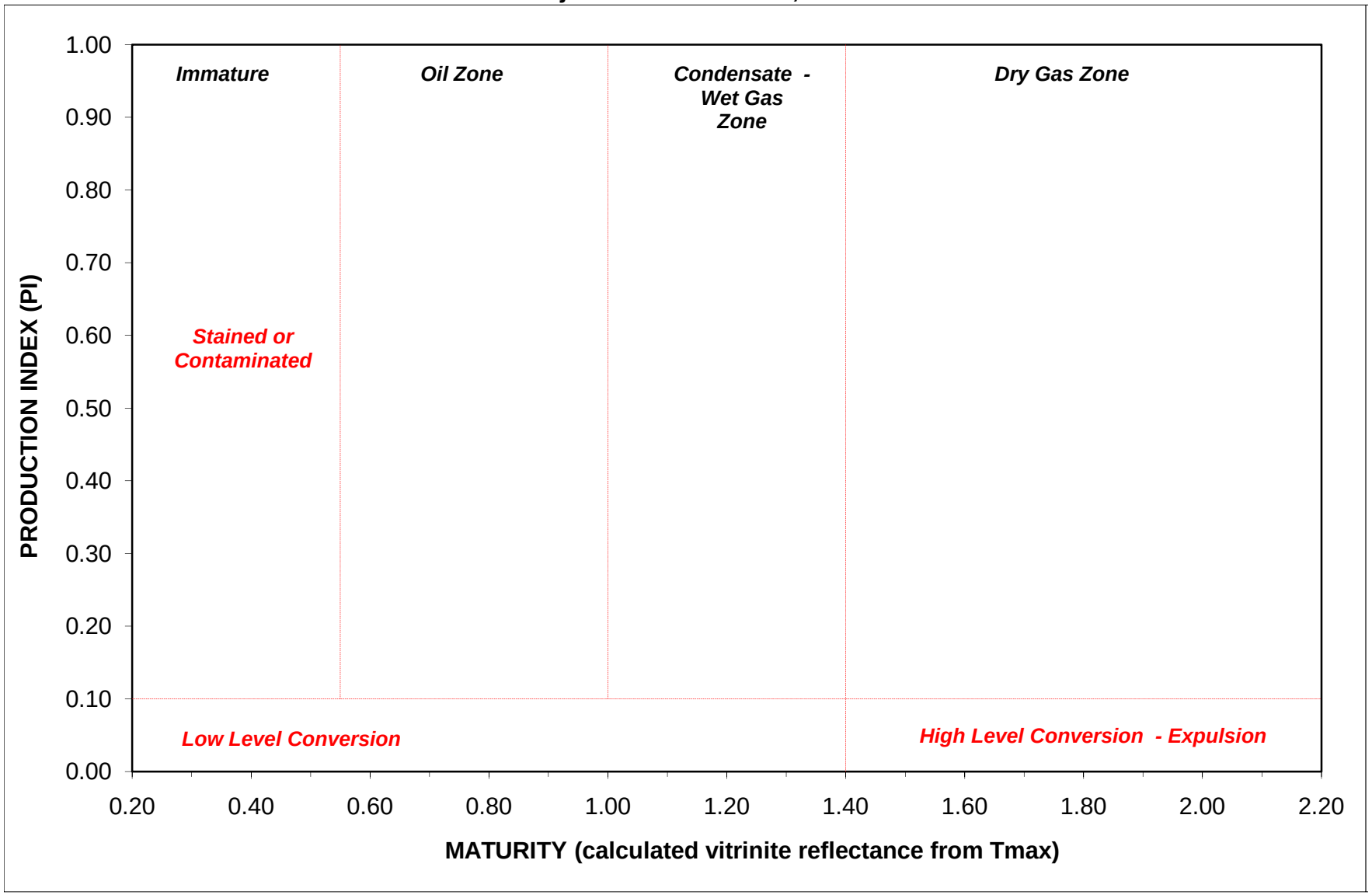

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

HATFIELD #1

AGC Project - Arkoma Basin, Arkansas

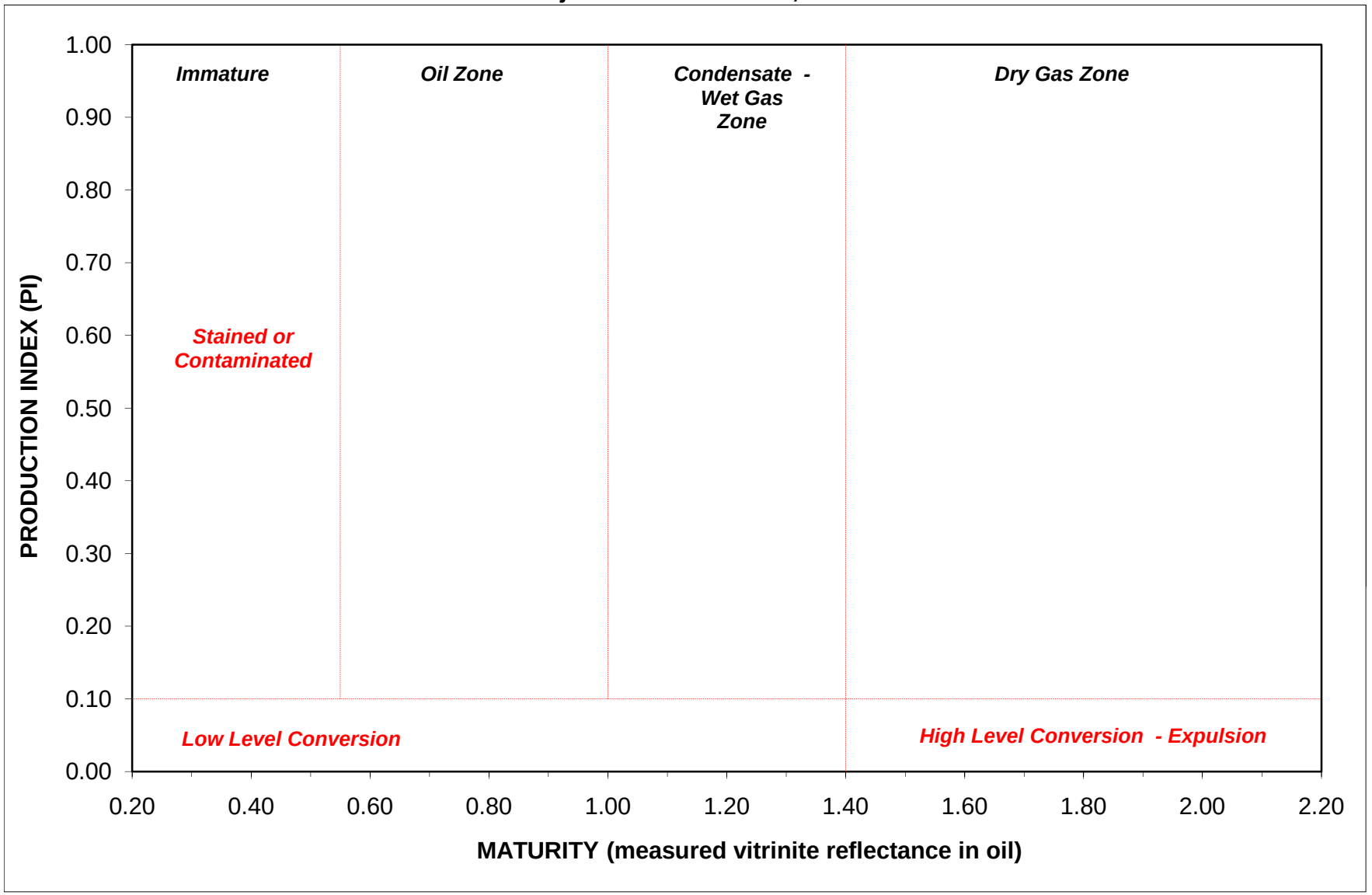

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 6. Geochemical and thermal maturity analyses for the well cutting samples from the Isom #1

ISOM #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf	HI	OI	S2/S3	S1/TOC	PI
06-3936-160983	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	6900	6920	6910		cuttings	pWR	1.22	1.03	0.27	0.98	0.74	354		-1.00	2.56	C	80	61	1	22	0.22
06-3936-160984	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	8200	8220	8210		cuttings	pWR	0.86	0.77	0.07	0.06	0.49	340	*	-1.00			7	57	0	8	0.54
06-3936-160985	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	9300	9320	9310		cuttings	pWR	0.85	0.77	0.08	0.13	0.51	384	*	-1.00			15	60	0	9	0.38
06-3936-160986	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10740	10770	10755		cuttings	pWR	2.99	2.54	0.27	0.39	0.41	389	*	-1.00	3.60	C	13	14	1	9	0.41
06-3936-160987	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10770	10800	10785		cuttings	pWR	1.15	1.05	0.14	0.19	0.31	373	*	-1.00			17	27	1	12	0.42
06-3936-160988	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10800	10830	10815		cuttings	pWR	4.29	3.06	0.33	0.57	0.69	410		0.22			13	16	1	8	0.37
06-3936-160989	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10830	10860	10845		cuttings	pWR	0.69	0.43	0.08	0.05	0.12	333	*	-1.00			7	17	0	12	0.62
06-3936-160990	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10860	10890	10875		cuttings	pWR	0.56	0.34	0.04	0.04	0.09	304	*	-1.00			7	16	0	7	0.50
06-3936-160991	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10890	10920	10905		cuttings	pWR	0.68	0.37	0.04	0.04	0.09	-1	*	-1.00			6	13	0	6	0.50
06-3936-160992	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10920	10950	10935	Fayetteville	cuttings	pWR	2.21	1.38	0.29	0.36	0.27	417	*	0.35			16	12	1	13	0.45
06-3936-160993	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10950	10980	10965	Fayetteville	cuttings	pWR	2.20	2.12	0.33	0.46	0.41	404	*	0.11			21	19	1	15	0.42
06-3936-160994	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	10980	11010	10995	Fayetteville	cuttings	pWR	2.23	1.65	0.24	0.34	0.35	400	*	-1.00			15	16	1	11	0.41
06-3936-160995	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11010	11040	11025	Fayetteville	cuttings	pWR	4.46	3.38	0.39	0.66	0.62	403		0.09			15	14	1	9	0.37
06-3936-160996	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11040	11070	11055	Fayetteville	cuttings	pWR	5.51	3.85	0.41	0.50	0.69	382		-1.00	3.55	C	9	13	1	7	0.45
06-3936-160997	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11070	11100	11085	Fayetteville	cuttings	pWR	4.73	4.10	0.58	0.64	0.66	380		-1.00			14	14	1	12	0.48
06-3936-160998	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11220	11230	11225		cuttings	pWR	3.56	3.90	0.91	0.53	0.69	365		-1.00			15	19	1	26	0.63
06-3936-160999	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11230	11240	11235		cuttings	pWR	1.28	1.34	0.20	0.20	0.69	391	*	-1.00			16	54	0	16	0.50
06-3936-161000	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11240	11250	11245		cuttings	pWR	0.68	0.55	0.11	0.13	0.30	390	*	-1.00			19	44	0	16	0.46
06-3936-161001	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11250	11260	11255		cuttings	pWR	0.80	0.68	0.10	0.10	0.33	385	*	-1.00			12	41	0	12	0.50
06-3936-161002	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11260	11270	11265		cuttings	pWR	0.97	0.73	0.11	0.10	0.26	354	*	-1.00			10	27	0	11	0.52
06-3936-161003	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11270	11280	11275		cuttings	pWR	1.66	1.76	0.20	0.31	0.43	411	*	0.24			19	26	1	12	0.39
06-3936-161004	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11280	11290	11285		cuttings	pWR	1.63	1.59	0.50	0.31	0.47	361	*	-1.00			19	29	1	31	0.62
06-3936-161005	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11290	11300	11295		cuttings	pWR	2.67	2.44	0.59	0.79	0.53	392		-1.00			30	20	1	22	0.43
06-3936-161006	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11300	11310	11305		cuttings	pWR	1.59	1.61	0.40	0.34	0.35	383	*	-1.00			21	22	1	25	0.54
06-3936-161007	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11310	11320	11315		cuttings	pWR	1.88	1.80	0.30	0.43	0.59	400	*	-1.00			23	31	1	16	0.41
06-3936-161008	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11400	11410	11405	Chattanooga	cuttings	pWR	0.60	0.40	0.07	0.08	0.25	400	*	-1.00			13	42	0	12	0.47
06-3936-161009	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11410	11420	11415	Chattanooga	cuttings	pWR	3.06	3.34	0.22	0.25	0.52	403	*	0.09			8	17	0	7	0.47
06-3936-161010	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11420	11430	11425	Chattanooga	cuttings	pWR	4.08	3.51	0.21	0.15	0.47	335	*	-1.00			4	12	0	5	0.58
06-3936-161011	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11430	11440	11435	Chattanooga	cuttings	pWR	4.75	3.90	0.21	0.15	0.47	391	*	-1.00			3	10	0	4	0.58
06-3936-161012	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11440	11450	11445	Chattanooga	cuttings	pWR	4.93	4.13	0.34	0.23	0.54	379	*	-1.00			5	11	0	7	0.60
06-3936-161013	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11450	11460	11455	Chattanooga	cuttings	pWR	4.72	4.03	0.22	0.12	0.48	377	*	-1.00			3	10	0	5	0.65
06-3936-161014	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11460	11470	11465	Chattanooga	cuttings	pWR	5.70	4.64	0.19	0.11	0.47	383	*	-1.00			2	8	0	3	0.63
06-3936-161015	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11470	11480	11475	Chattanooga	cuttings	pWR	3.91		0.16	0.05	0.38	383	*	-1.00			1	10	0	4	0.76
06-3936-161016	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11480	11490	11485	Chattanooga	cuttings	pWR	3.42		0.21	0.12	0.47	389	*	-1.00			4	14	0	6	0.64
06-3936-161017	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11490	11500	11495	Chattanooga	cuttings	pWR	1.96		0.11	0.05	0.20	6	*	-1.00			3	10	0	6	0.69
06-3936-161018	Arkoma	03083000100000	MOBIL OIL CORP	ISOM C E	1	LOGAN	AR	11500	11510	11505		cuttings	pWR	0.47		0.06	0.02	0.15	6	*	-1.00			4	32	0	13	0.75

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

ISOM #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

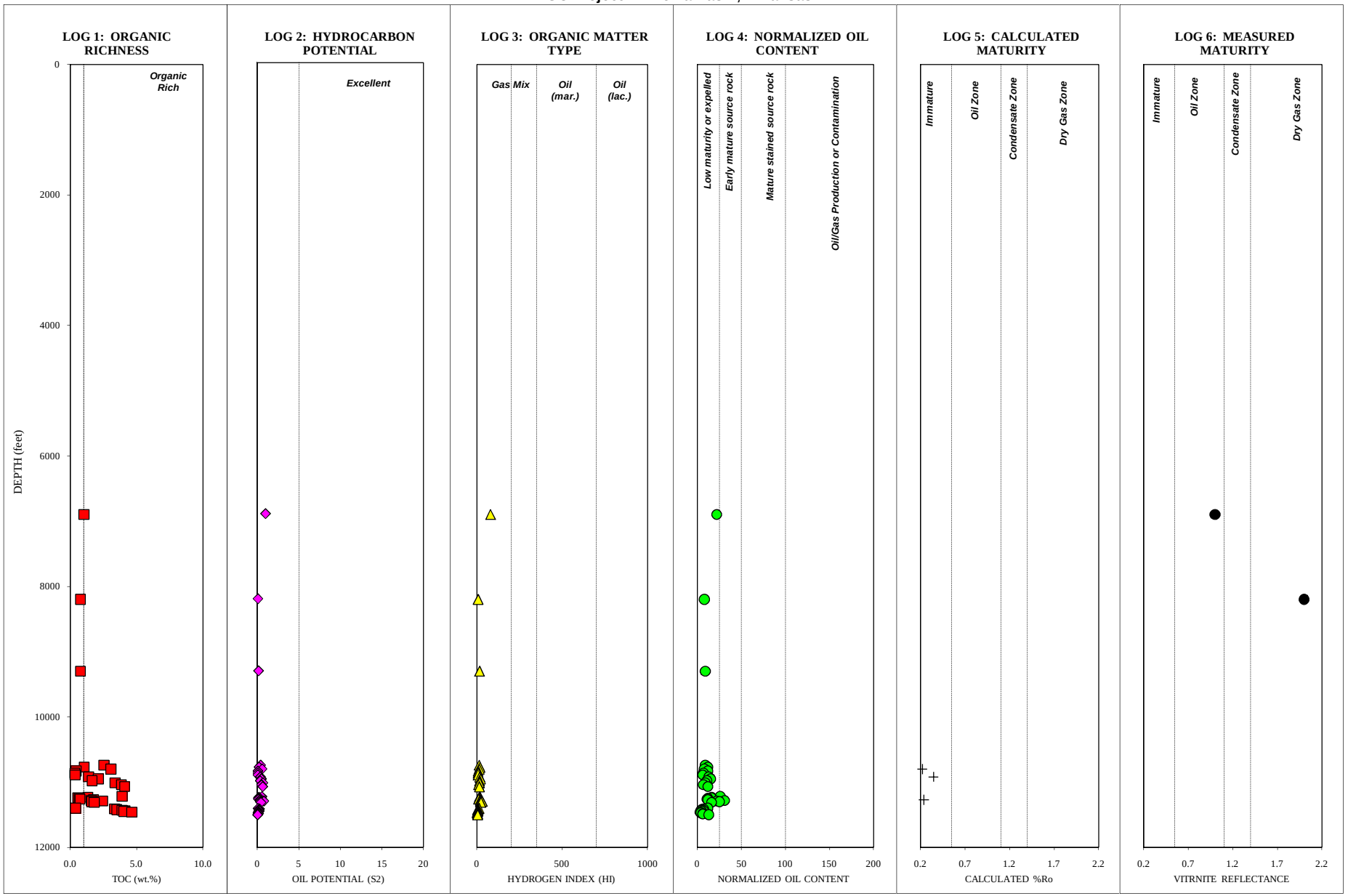

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

ISOM #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

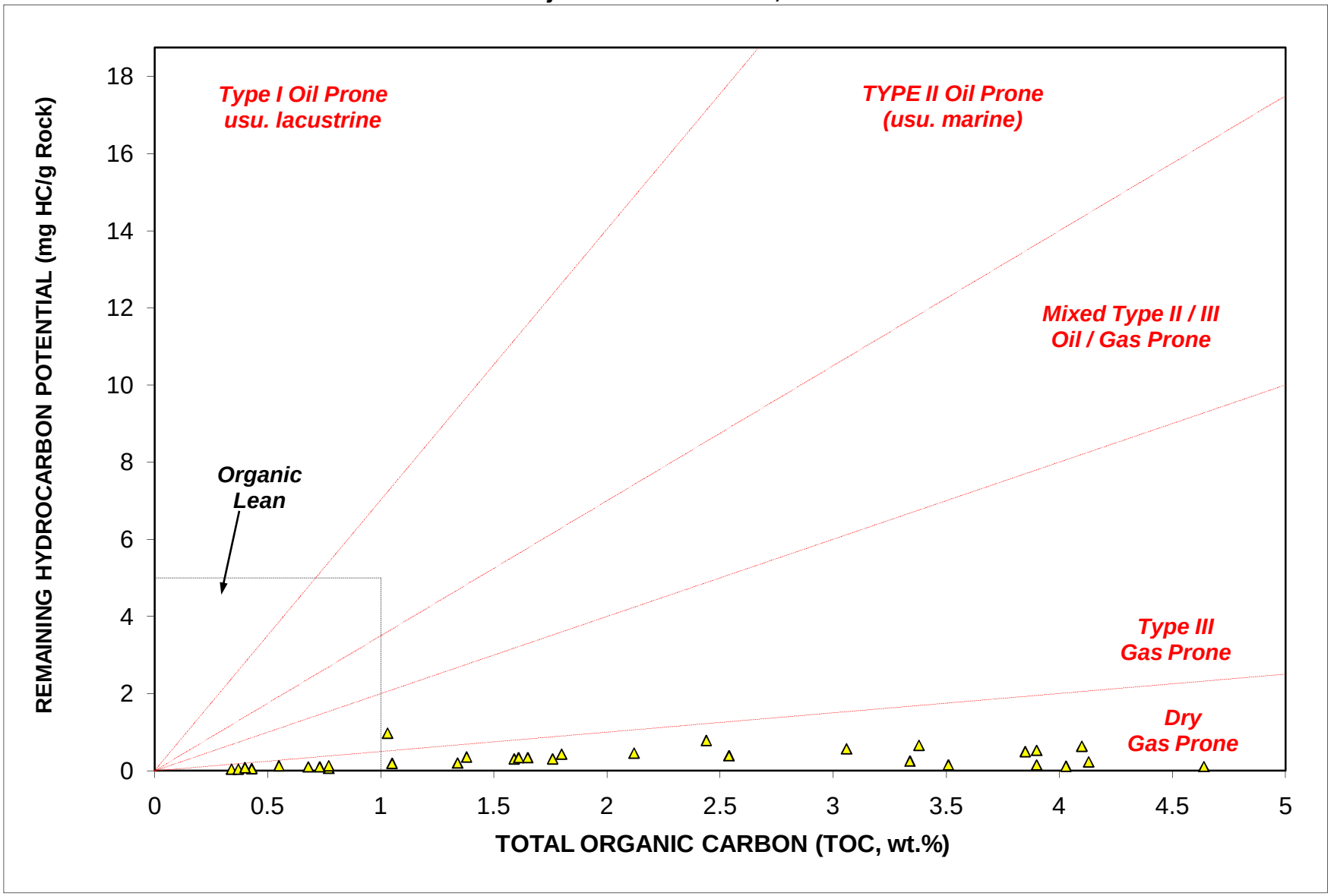

Figure 2. Kerogen Quality

Humble Geochemical Services Division

ISOM #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

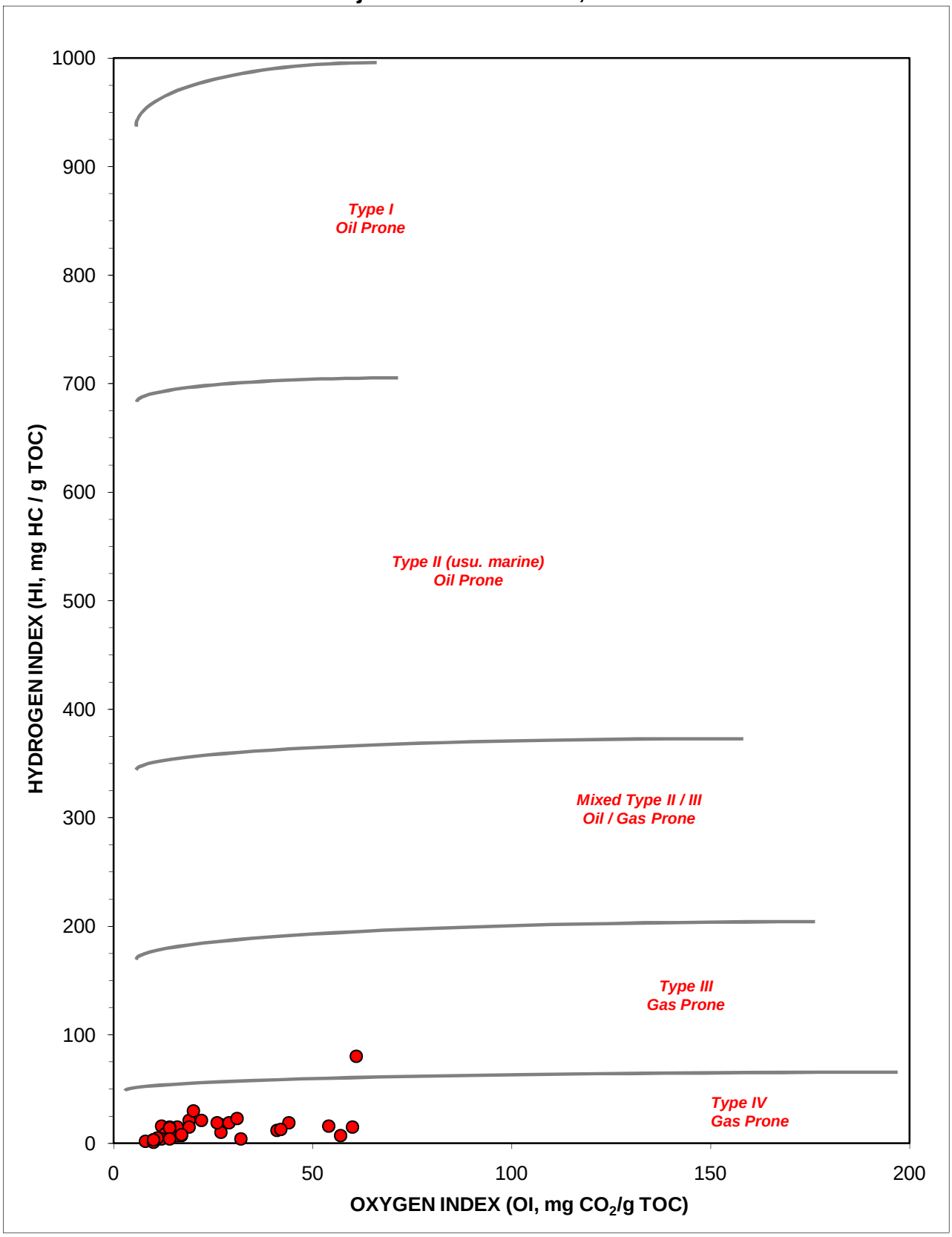

Figure 3. Kerogen type

ISOM #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

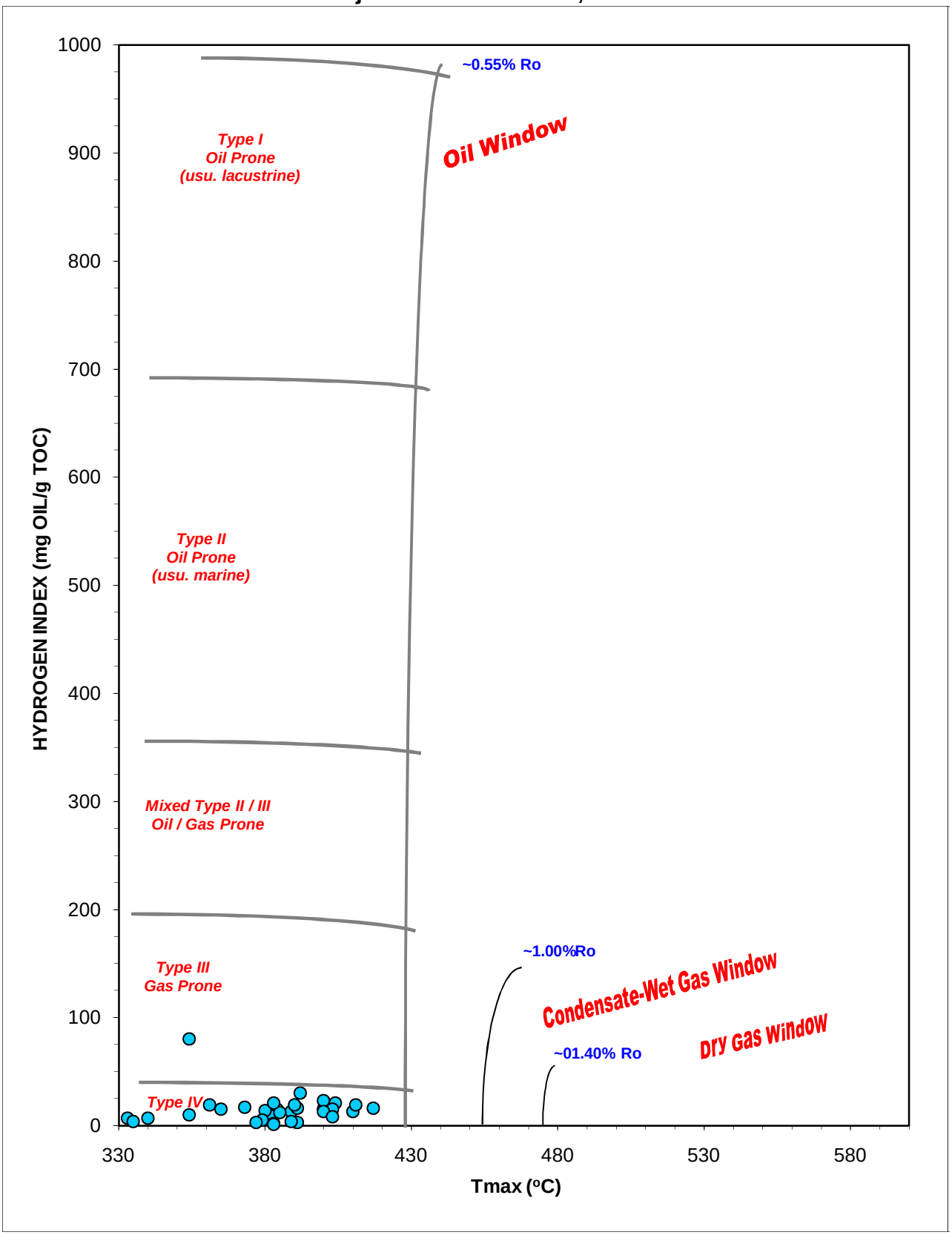

Figure 4a. Kerogen Type and Maturity (Tmax)

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ISOM #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

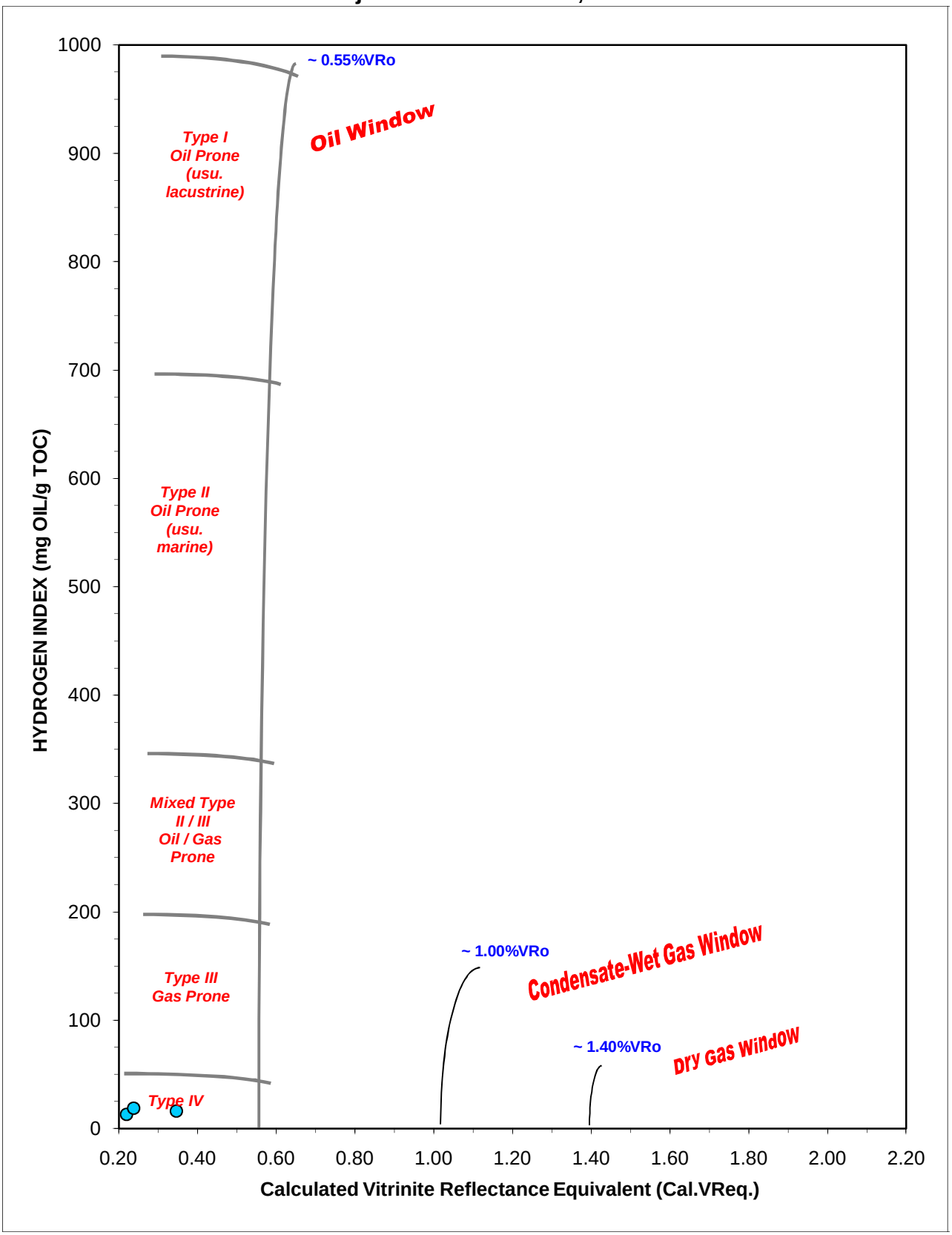

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

ISOM #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

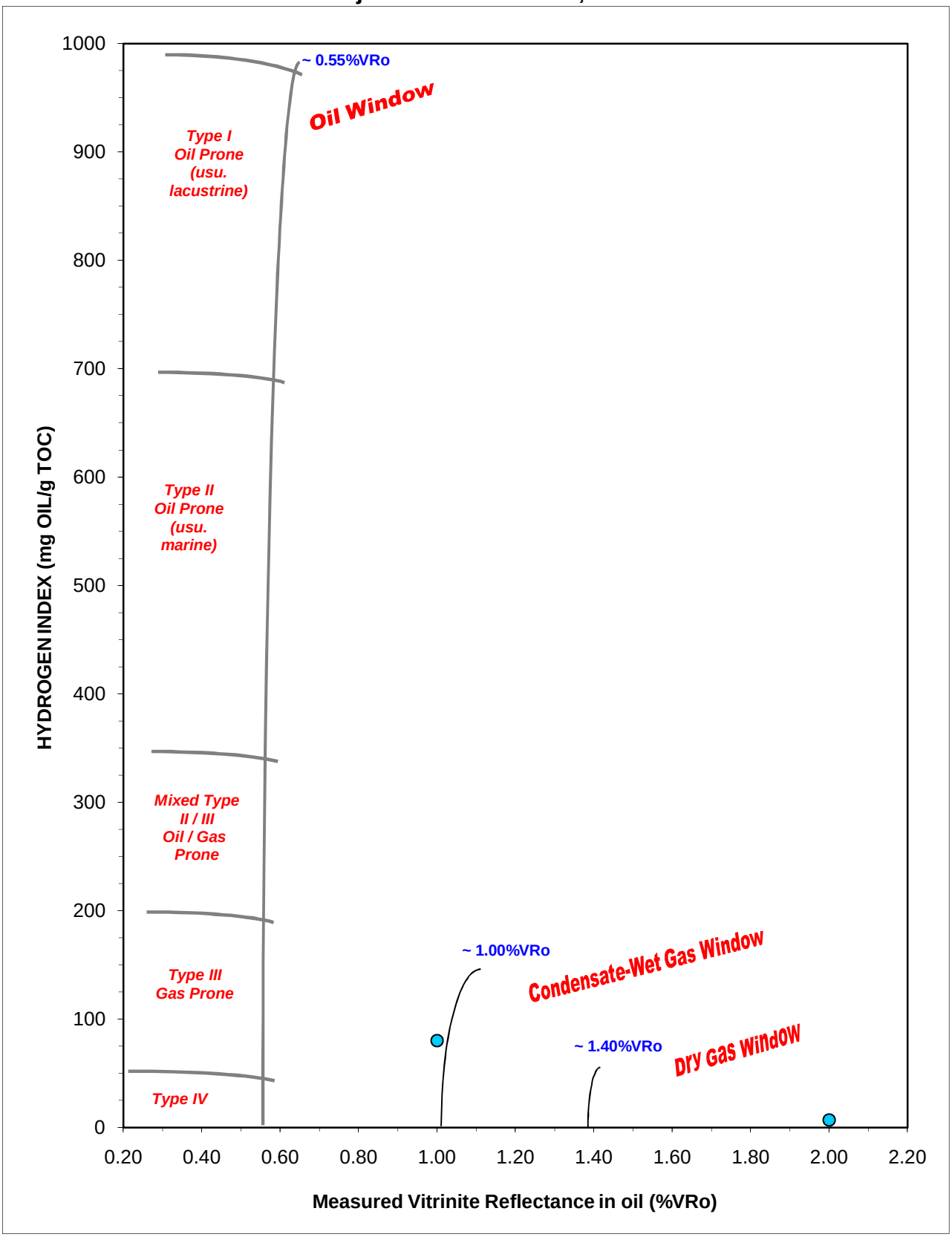

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

ISOM #1

AGC Project - Arkoma Basin, Arkansas

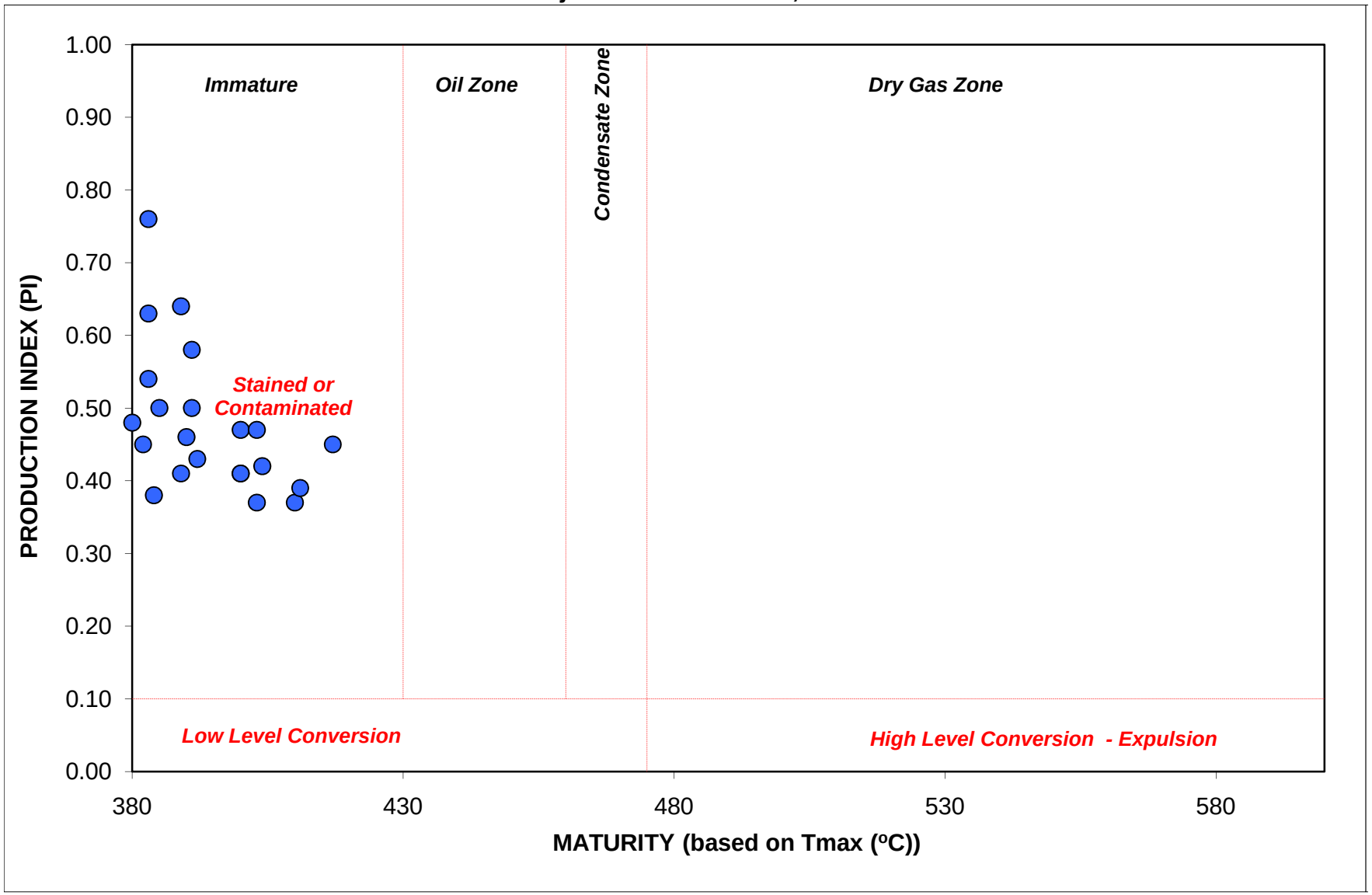

Figure 5a. Kerogen conversion and maturity (based on Tmax).

ISOM #1

AGC Project - Arkoma Basin, Arkansas

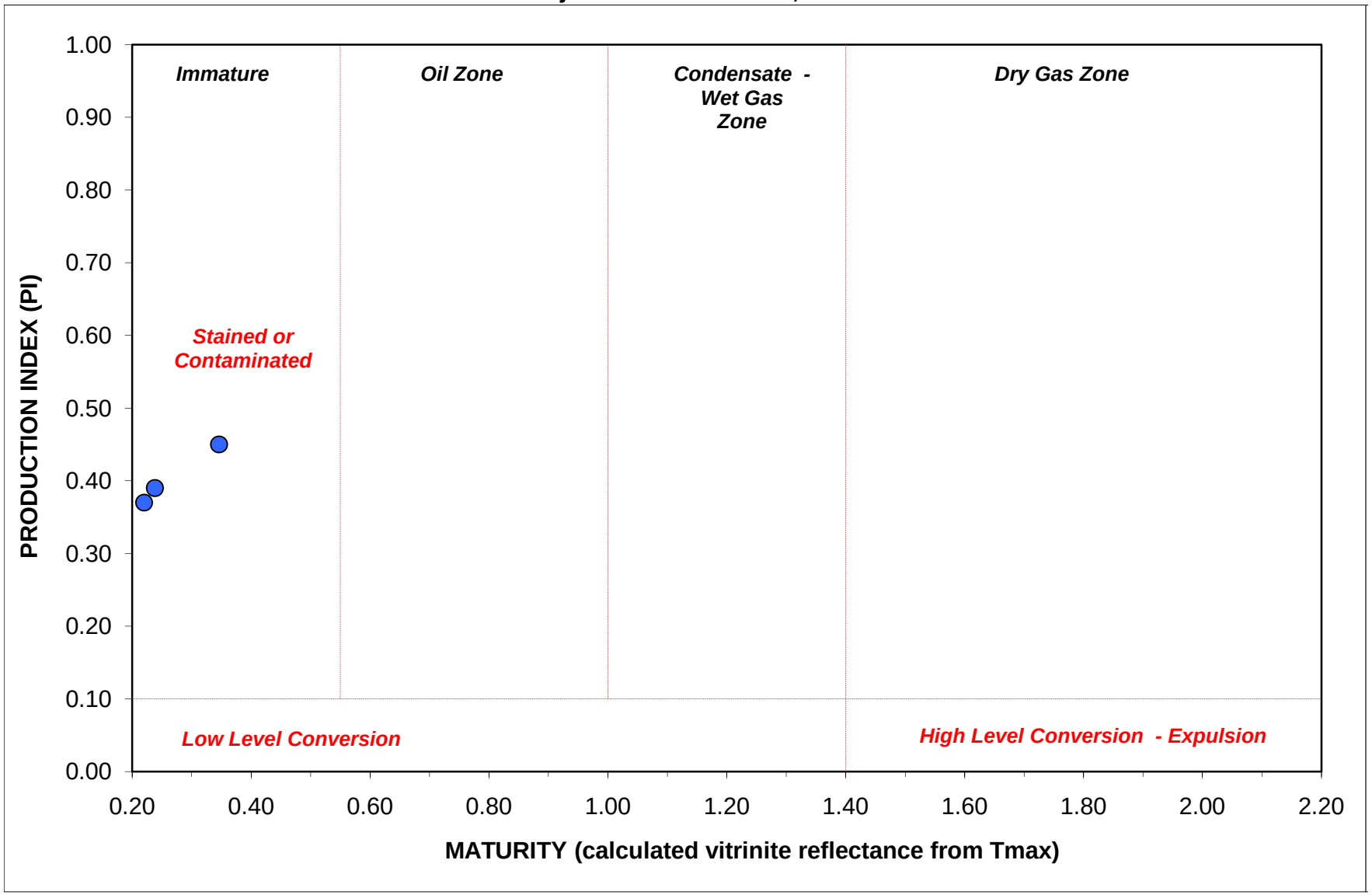

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

ISOM #1

AGC Project - Arkoma Basin, Arkansas

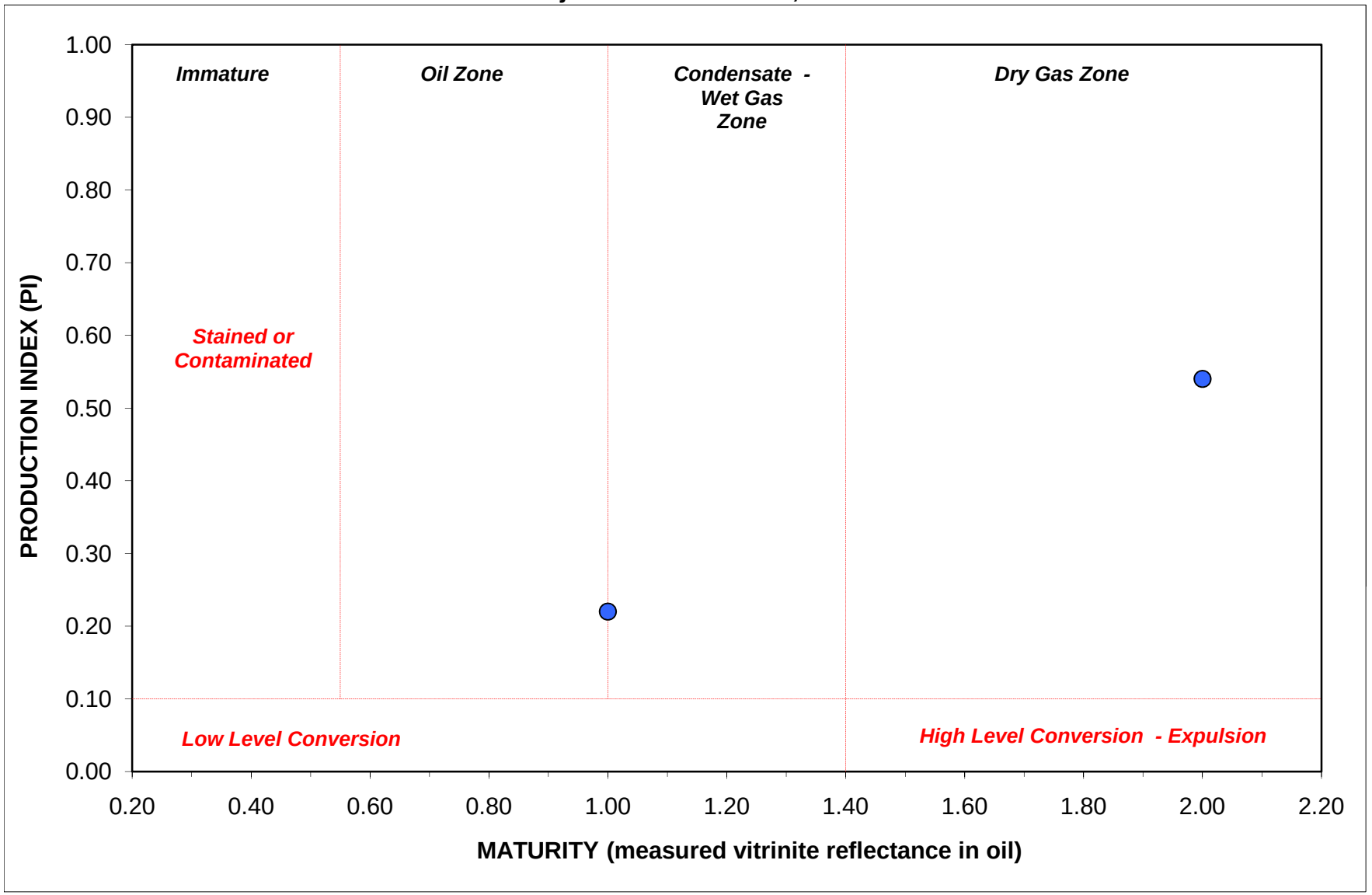

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 7. Geochemical and thermal maturity analyses for the well cutting samples from the Johnson-Bedford #1

JOHNSON-BEDFORD #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-163578	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	7300	7320	7310		cuttings	pWR	1.33	0.92	0.13	0.17	0.65	354	*	-1.00	2.54	C	13	49	0	10	0.43
06-3936-163579	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	9000	9020	9010		cuttings	pWR	1.44	1.01	0.27	0.49	0.72	386	*	-1.00	2.99	D	34	50	1	19	0.36
06-3936-163580	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	10450	10470	10460		cuttings	pWR	0.56	0.28	0.18	0.08	0.34	326	*	-1.00			14	61	0	32	0.69
06-3936-163581	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	12090	12120	12105		cuttings	pWR	4.78	4.33	0.66	0.72	0.60	387		-1.00			15	13	1	14	0.48
06-3936-163582	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	10680	10710	10695		cuttings	pWR	0.61	0.19	0.09	0.11	0.26	358	*	-1.00			18	43	0	15	0.45
06-3936-163583	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	10710	10740	10725		cuttings	pWR	0.65	0.33	0.14	0.14	0.50	379	*	-1.00			22	77	0	22	0.50
06-3936-163584	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	10740	10750	10745		cuttings	pWR	0.77	0.38	0.20	0.28	0.59	368	*	-1.00			36	77	0	26	0.42
06-3936-163585	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11130	11140	11135		cuttings	pWR	0.64	0.17	0.09	0.04	0.15	353	*	-1.00			6	23	0	14	0.69
06-3936-163586	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11140	11150	11145		cuttings	pWR	0.57	0.20	0.09	0.04	0.15	-1	*	-1.00			7	26	0	16	0.69
06-3936-163587	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11150	11160	11155		cuttings	pWR	0.87	0.66	0.20	0.14	0.21	313	*	-1.00			16	24	1	23	0.59
06-3936-163588	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11160	11170	11165		cuttings	pWR	1.49	1.10	0.24	0.26	0.23	383	*	-1.00			17	15	1	16	0.48
06-3936-163589	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11170	11180	11175		cuttings	pWR	2.22	2.08	0.50	0.25	0.33	377	*	-1.00			11	15	1	23	0.67
06-3936-163590	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11180	11190	11185		cuttings	pWR	1.73	1.40	0.31	0.24	0.34	368	*	-1.00			14	20	1	18	0.56
06-3936-163591	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11190	11200	11195		cuttings	pWR	1.14	0.69	0.24	0.16	0.22	358	*	-1.00			14	19	1	21	0.60
06-3936-163592	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11200	11210	11205		cuttings	pWR	1.16	0.89	0.25	0.30	0.35	383	*	-1.00			26	30	1	22	0.45
06-3936-163593	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11210	11220	11215		cuttings	pWR	1.24	0.77	0.29	0.29	0.26	386	*	-1.00			23	21	1	23	0.50
06-3936-163594	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11220	11230	11225		cuttings	pWR	1.08	0.84	0.30	0.33	0.32	384	*	-1.00			31	30	1	28	0.48
06-3936-163595	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11230	11240	11235		cuttings	pWR	1.18	0.84	0.31	0.30	0.28	387	*	-1.00			25	24	1	26	0.51
06-3936-163596	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11240	11250	11245		cuttings	pWR	1.14	0.84	0.31	0.24	0.32	387	*	-1.00			21	28	1	27	0.56
06-3936-163597	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11250	11260	11255		cuttings	pWR	1.11	0.83	0.31	0.23	0.29	376	*	-1.00			21	26	1	28	0.57
06-3936-163598	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11260	11270	11265		cuttings	pWR	2.01	1.90	0.43	0.57	0.43	393		-1.00			28	21	1	21	0.43
06-3936-163599	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11270	11280	11275		cuttings	pWR	1.95	1.70	0.46	0.54	0.41	393		-1.00			28	21	1	24	0.46
06-3936-163600	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11280	11290	11285		cuttings	pWR	1.15	0.80	0.34	0.28	0.26	387	*	-1.00			24	23	1	30	0.55
06-3936-163601	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11290	11320	11305		cuttings	pWR	3.45	1.31	0.61	0.66	0.36	378		-1.00			19	10	2	18	0.48
06-3936-163602	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11320	11350	11335		cuttings	pWR	3.28	0.83	0.43	0.42	0.34	382	*	-1.00			13	10	1	13	0.51
06-3936-163603	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11350	11380	11365		cuttings	pWR	3.82	0.94	0.51	0.46	0.40	379	*	-1.00			12	10	1	13	0.53
06-3936-163604	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11380	11420	11400		cuttings	pWR	2.59	1.57	0.77	0.84	0.38	401		0.06			32	15	2	30	0.48
06-3936-163605	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11420	11430	11425		cuttings	pWR	2.53	1.47	0.75	0.78	0.44	401		0.06			31	17	2	30	0.49
06-3936-163606	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11430	11440	11435		cuttings	pWR	2.44	1.50	0.69	0.74	0.45	395		-1.00			30	18	2	28	0.48
06-3936-163607	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11440	11450	11445	Chattanooga	cuttings	pWR	2.32	1.48	0.65	0.61	0.41	389		-1.00			26	18	1	28	0.52
06-3936-163608	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11450	11460	11455	Chattanooga	cuttings	pWR	2.84	1.41	0.55	0.58	0.41	379		-1.00			20	14	1	19	0.49
06-3936-163609	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11460	11470	11465	Chattanooga	cuttings	pWR	2.31	1.51	0.71	0.85	0.41	404		0.11			37	18	2	31	0.46
06-3936-163610	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11470	11480	11475	Chattanooga	cuttings	pWR	2.48	1.45	0.64	0.69	0.45	395		-1.00			28	18	2	26	0.48
06-3936-163611	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11480	11490	11485	Chattanooga	cuttings	pWR	2.53	1.52	0.62	0.81	0.44	434		0.65			32	17	2	25	0.43
06-3936-163616	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11530	11540	11535	Chattanooga	cuttings	pWR	5.85	5.82	0.87	0.83	0.78	384		-1.00			14	13	1	15	0.51
06-3936-163617	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11540	11550	11545	Chattanooga	cuttings	pWR	5.78	6.00	0.61	0.43	0.86	370	*	-1.00			7	15	1	11	0.59
06-3936-163618	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11550	11560	11555	Chattanooga	cuttings	pWR	5.94	6.31	0.64	0.34	0.77	358	*	-1.00			6	13	0	11	0.65
06-3936-163619	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11560	11570	11565	Chattanooga	cuttings	pWR	6.25	6.64	0.46	0.30	0.89	367	*	-1.00			5	14	0	7	0.61
06-3936-163620	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11570	11580	11575	Chattanooga	cuttings	pWR	5.93	6.36	0.44	0.24	0.78	366	*	-1.00			4	13	0	7	0.65
06-3936-163621	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11580	11590	11585	Chattanooga	cuttings	pWR	6.00	6.29	0.40	0.27	0.77	356	*	-1.00			5	13	0	7	0.60
06-3936-163622	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11590	11600	11595		cuttings	pWR	6.15	5.84	0.34	0.32	0.78	383	*	-1.00			5	13	0	6	0.52
06-3936-163623	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11800	11810	11805		cuttings	pWR	4.71	3.67	0.42	0.45	0.58	388	*	-1.00	3.71	C	10	12	1	9	0.48
06-3936-163624	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11810	11820	11815		cuttings	pWR	5.93	5.72	0.83	0.62	0.82	373		-1.00			10	14	1	14	0.57
06-3936-163625	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11820	11830	11825		cuttings	pWR	6.17	5.98	0.73	0.74	0.96	379		-1.00			12	16	1	12	0.50
06-3936-163626	Arkoma	03131100100000	DIAMOND SHMROCK CORP	JOHNSON-BEDFORD	1	SEBASTIAN	AR	11830	11840	11835		cuttings	pWR	5.44	5.03	0.84	0.81	0.76	387		-1.00	2.96	C	15	14	1	15	0.51

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

JOHNSON-BEDFORD #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

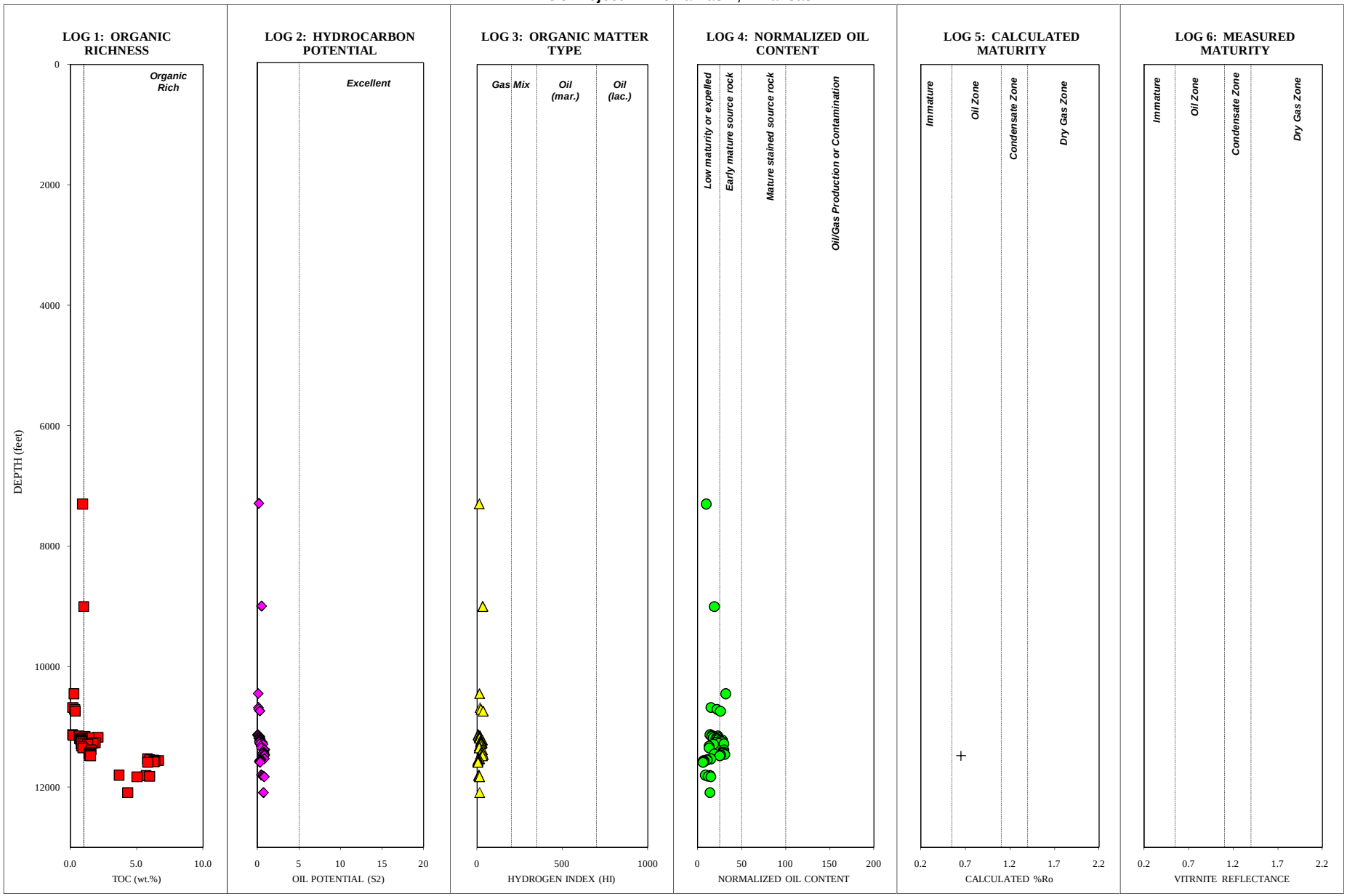

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

JOHNSON-BEDFORD #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

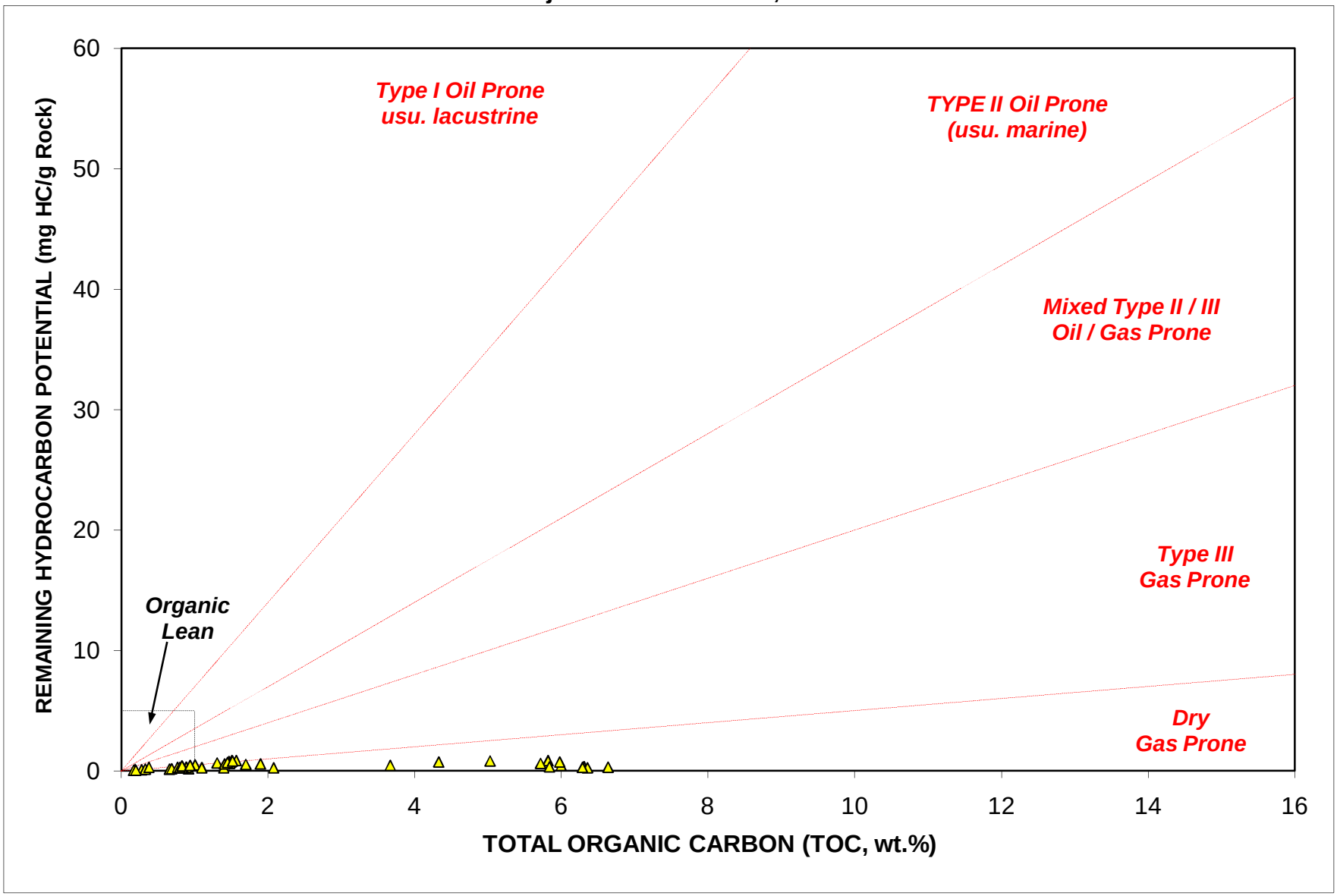

Figure 2. Kerogen Quality

JOHNSON-BEDFORD #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

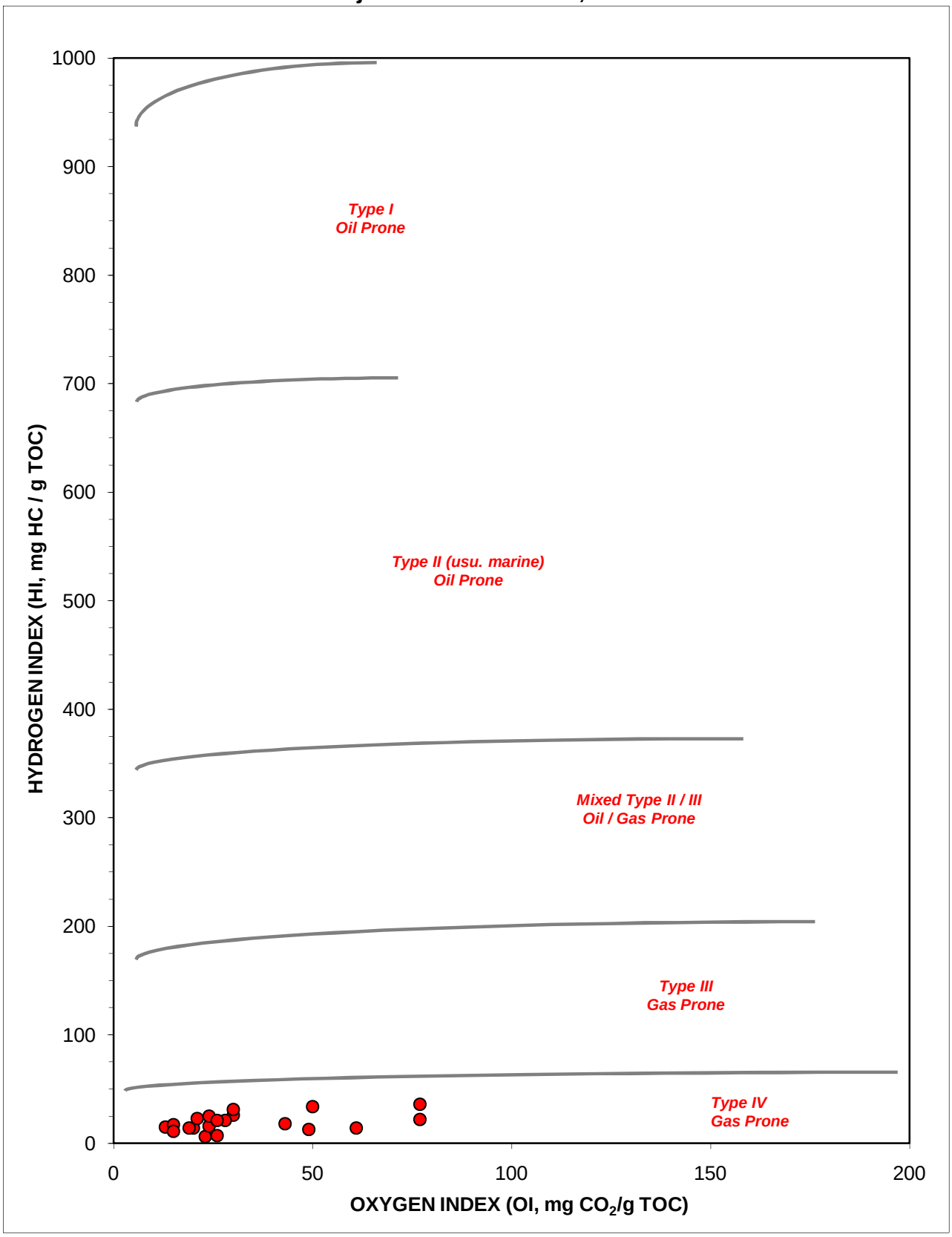

Figure 3. Kerogen type

JOHNSON-BEDFORD #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

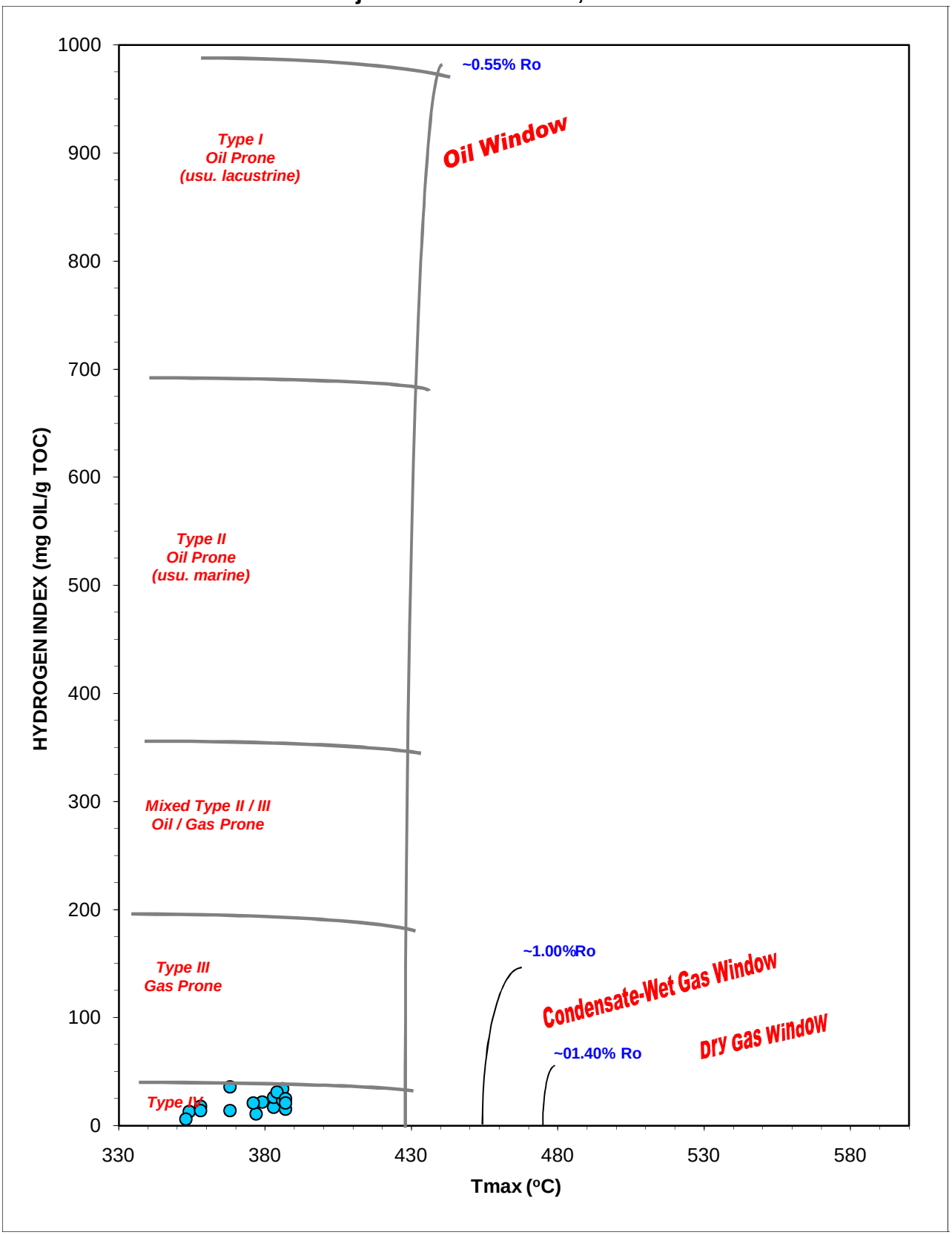

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

JOHNSON-BEDFORD #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

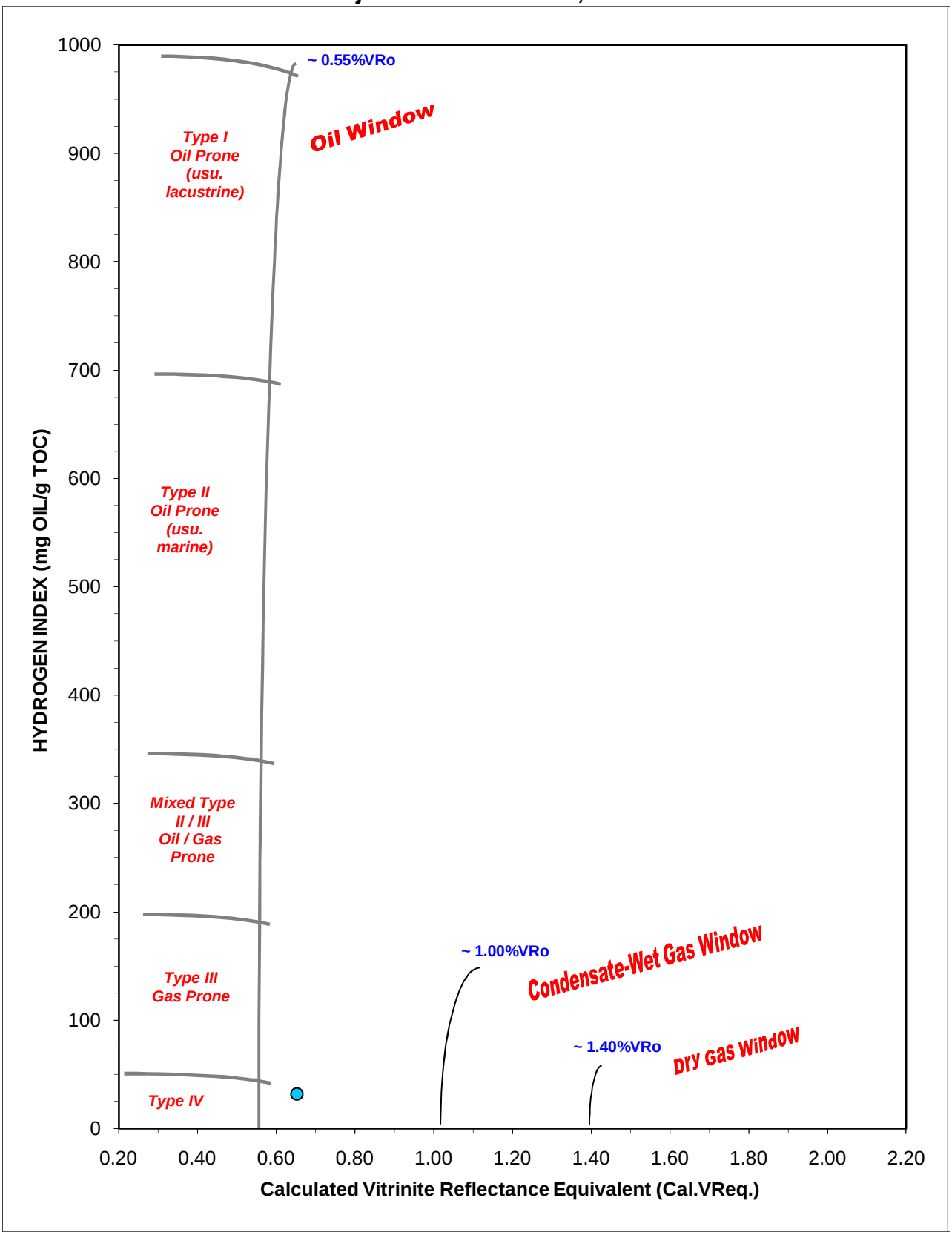

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

JOHNSON-BEDFORD #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

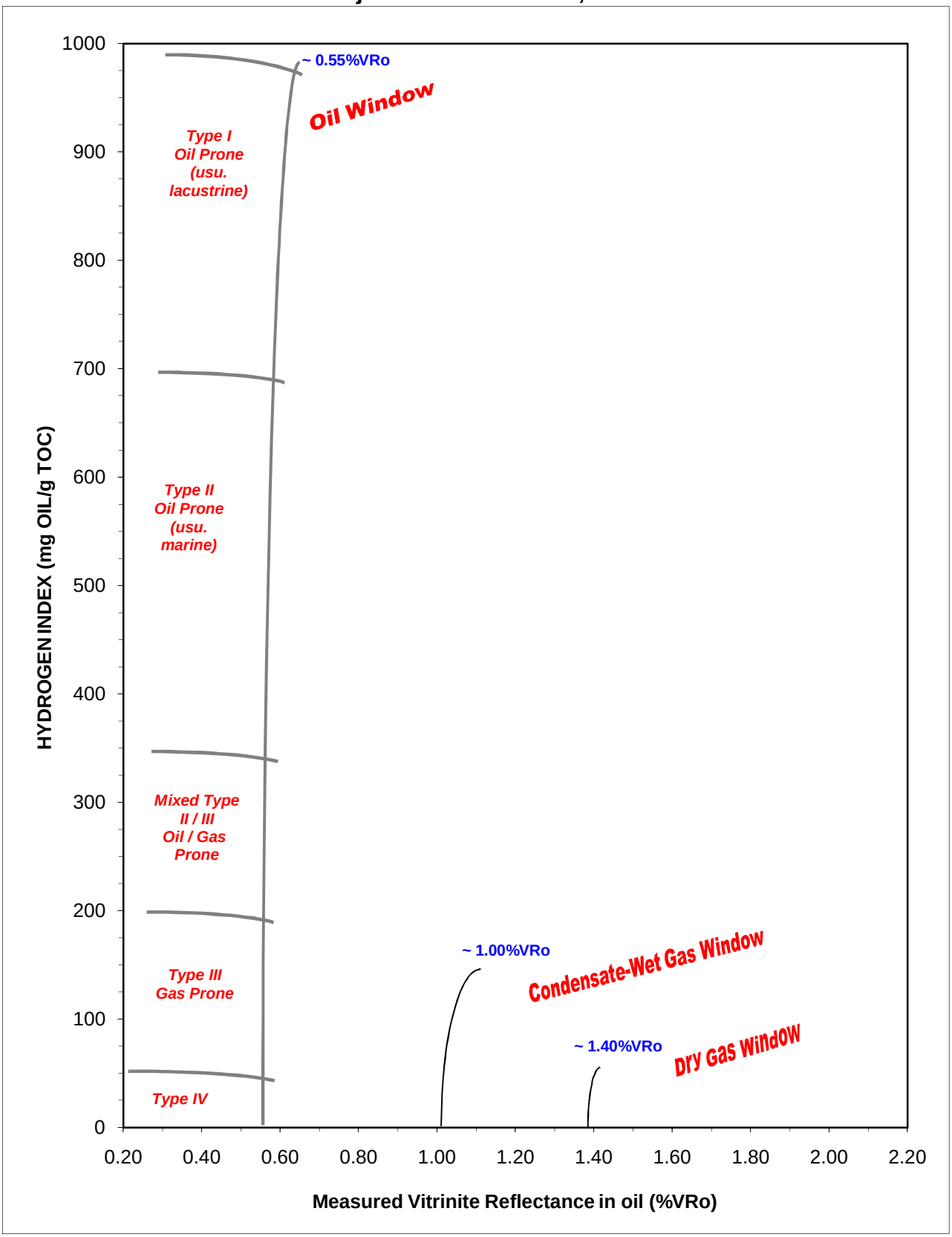

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

JOHNSON-BEDFORD #1

AGC Project - Arkoma Basin, Arkansas

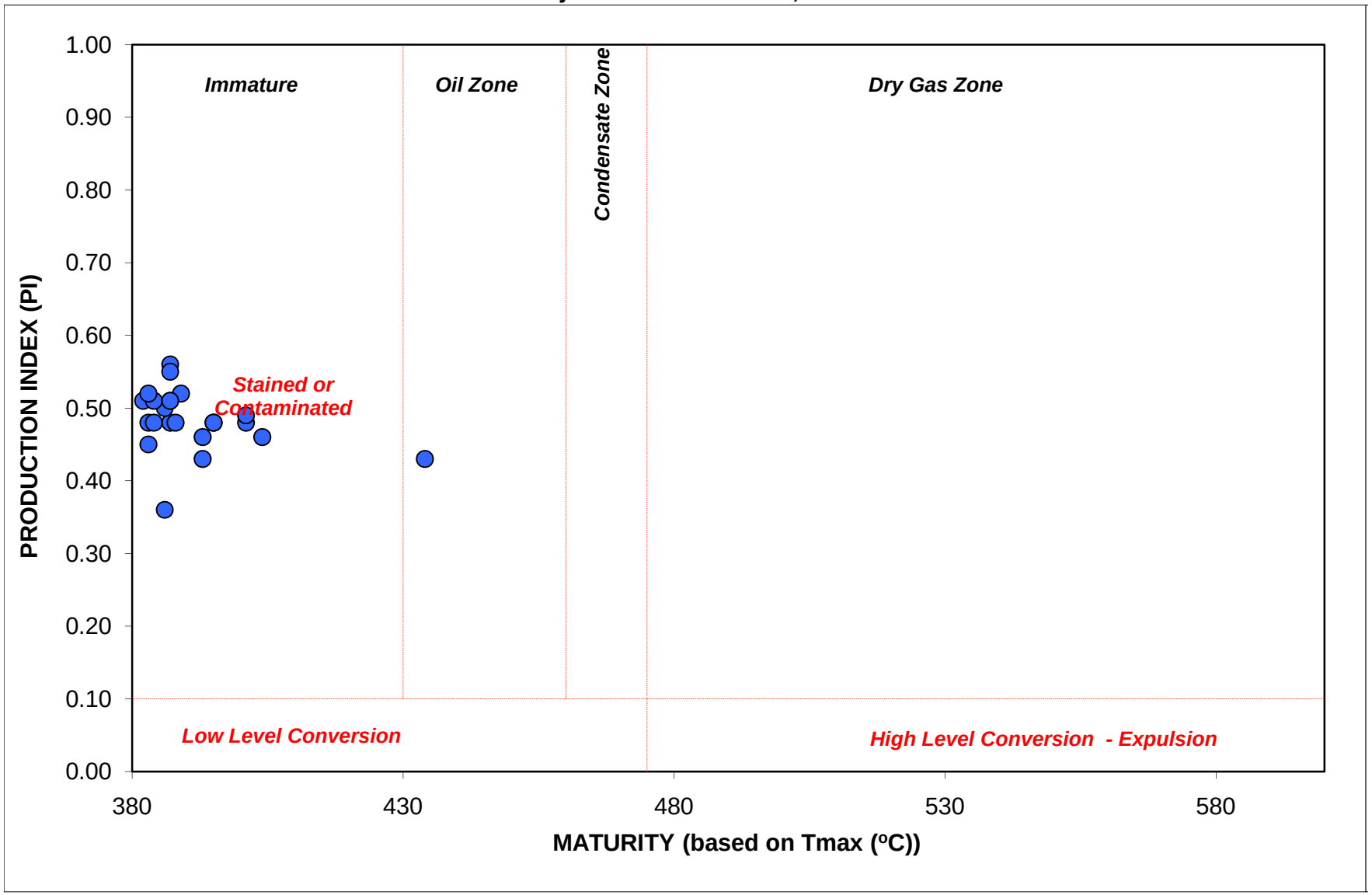

Figure 5a. Kerogen conversion and maturity (based on Tmax).

JOHNSON-BEDFORD #1

AGC Project - Arkoma Basin, Arkansas

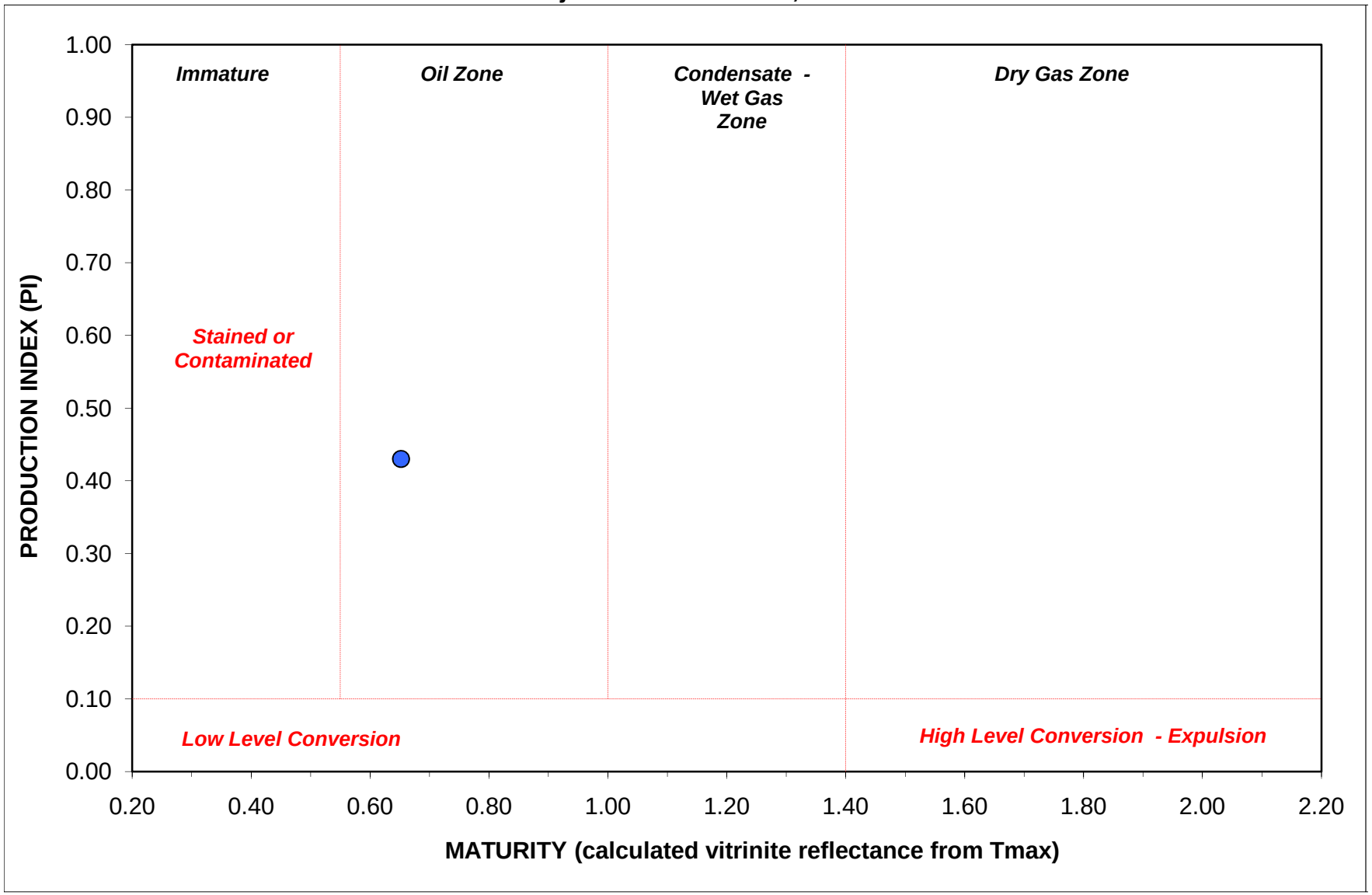

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

JOHNSON-BEDFORD #1

AGC Project - Arkoma Basin, Arkansas

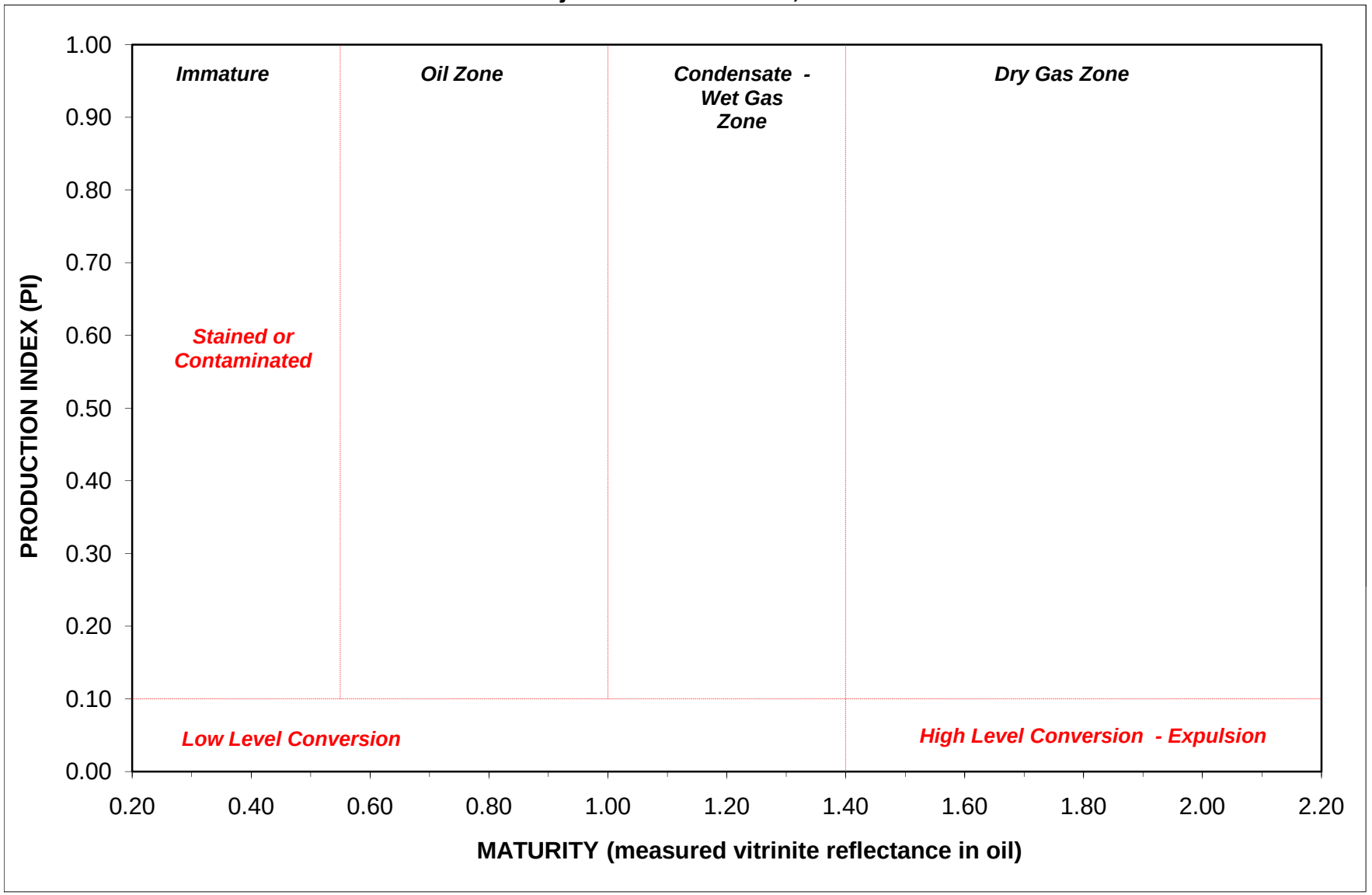

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 8. Geochemical and thermal maturity analyses for the well cutting samples from the Larco #1

LARCO #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-4168-169558	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5650	5680	5665		Cuttings	NORM	0.81	0.55	0.11	0.11	0.19	366	*	-1.00			14	23	1	14	0.50
06-4168-169559	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5680	5710	5695		Cuttings	NORM	0.83	0.59	0.10	0.11	0.18	308	*	-1.00			13	22	1	12	0.48
06-4168-169560	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5710	5740	5725		Cuttings	NORM	0.97	0.70	0.13	0.14	0.25	322	*	-1.00			14	26	1	13	0.48
06-4168-169561	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5740	5770	5755		Cuttings	NORM	0.92	0.68	0.09	0.09	0.33	302	*	-1.00			10	36	0	10	0.50
06-4168-169562	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5770	5800	5785		Cuttings	NORM	1.08	0.86	0.11	0.18	0.28	337	*	-1.00			17	26	1	10	0.38
06-4168-169563	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5840	5850	5845		Cuttings	NORM	1.04	0.86	0.10	0.14	0.27	302	*	-1.00			13	26	1	10	0.42
06-4168-169564	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5850	5860	5855		Cuttings	NORM	1.02	0.75	0.12	0.13	0.31	2	*	-1.00			13	30	0	12	0.48
06-4168-169566	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	5870	5880	5875		Cuttings	NORM	1.06	0.83	0.11	0.14	0.34	302	*	-1.00			13	32	0	10	0.44
06-4168-169567	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6550	6560	6555		Cuttings	NORM	1.46	1.33	0.16	0.14	0.20	306	*	-1.00			10	14	1	11	0.53
06-4168-169568	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6560	6570	6565		Cuttings	NORM	0.89	0.67	0.15	0.17	0.28	417	*	0.35			19	31	1	17	0.47
06-4168-169569	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6570	6580	6575		Cuttings	NORM	1.69	0.55	0.11	0.11	0.24	302	*	-1.00			7	14	0	7	0.50
06-4168-169570	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6580	6590	6585		Cuttings	NORM	0.81	0.52	0.11	0.09	0.32	302	*	-1.00			11	40	0	14	0.55
06-4168-169571	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6590	6600	6595		Cuttings	NORM	1.00	0.87	0.09	0.11	0.68	302	*	-1.00			11	68	0	9	0.45
06-4168-169572	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6600	6610	6605		Cuttings	NORM	0.79	0.55	0.09	0.12	0.22	346	*	-1.00			15	28	1	11	0.43
06-4168-169573	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6610	6620	6615		Cuttings	NORM	1.36	1.14	0.14	0.18	0.42	302	*	-1.00			13	31	0	10	0.44
06-4168-169574	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6620	6630	6625	Fayetteville	Cuttings	NORM	1.73	0.51	0.09	0.08	0.21	335	*	-1.00			5	12	0	5	0.53
06-4168-169575	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6630	6640	6635	Fayetteville	Cuttings	NORM	0.78	0.56	0.10	0.12	0.33	421	*	0.42			15	42	0	13	0.45
06-4168-169576	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6640	6650	6645	Fayetteville	Cuttings	NORM	0.77	0.56	0.10	0.13	0.24	354	*	-1.00			17	31	1	13	0.43
06-4168-169577	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6650	6660	6655	Fayetteville	Cuttings	NORM	0.78	0.59	0.11	0.19	0.25	350	*	-1.00			24	32	1	14	0.37
06-4168-169578	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6660	6670	6665	Fayetteville	Cuttings	NORM	0.77	0.49	0.08	0.10	0.16	303	*	-1.00			13	21	1	10	0.44
06-4168-169579	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6670	6680	6675	Fayetteville	Cuttings	NORM	0.90	0.48	0.09	0.23	0.22	368	*	-1.00			26	24	1	10	0.28
06-4168-169580	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6680	6690	6685		Cuttings	NORM	2.07	0.46	0.07	0.07	0.18	3	*	-1.00			3	9	0	3	0.50
06-4168-169581	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6690	6700	6695		Cuttings	NORM	1.41	0.58	0.11	0.12	0.19	326	*	-1.00			9	13	1	8	0.48
06-4168-169582	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6700	6730	6715		Cuttings	NORM	0.95	0.54	0.12	0.18	0.33	303	*	-1.00			19	35	1	13	0.40
06-4168-169583	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6760	6760	6760		Cuttings	NORM	1.04	0.34	0.09	0.08	0.14	326	*	-1.00			8	13	1	9	0.53
06-4168-169584	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6760	6790	6775		Cuttings	NORM	1.61	0.38	0.10	0.08	0.14	303	*	-1.00			5	9	1	6	0.56
06-4168-169585	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6790	6820	6805		Cuttings	NORM	2.00	0.40	0.10	0.07	0.17	425	*	0.49			4	9	0	5	0.59
06-4168-169586	Arkoma	3131102740000	TXO PROD CORP	LARCO	1	SEBASTIAN	AR	6820	6840	6830		Cuttings	NORM	0.87	0.71	0.22	0.15	0.24	341	*	-1.00			17	28	1	25	0.59

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

LARCO #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

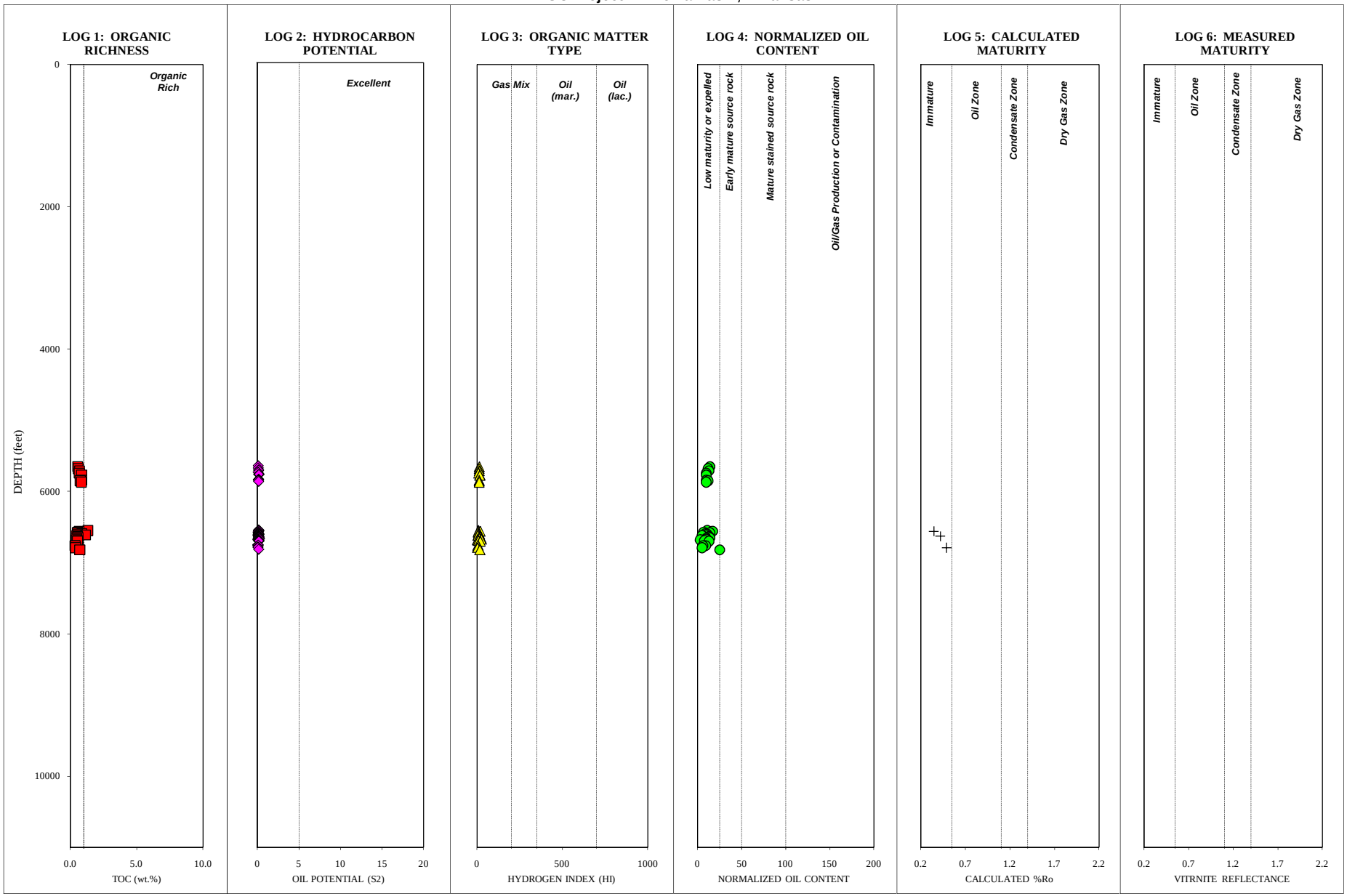

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

LARCO #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

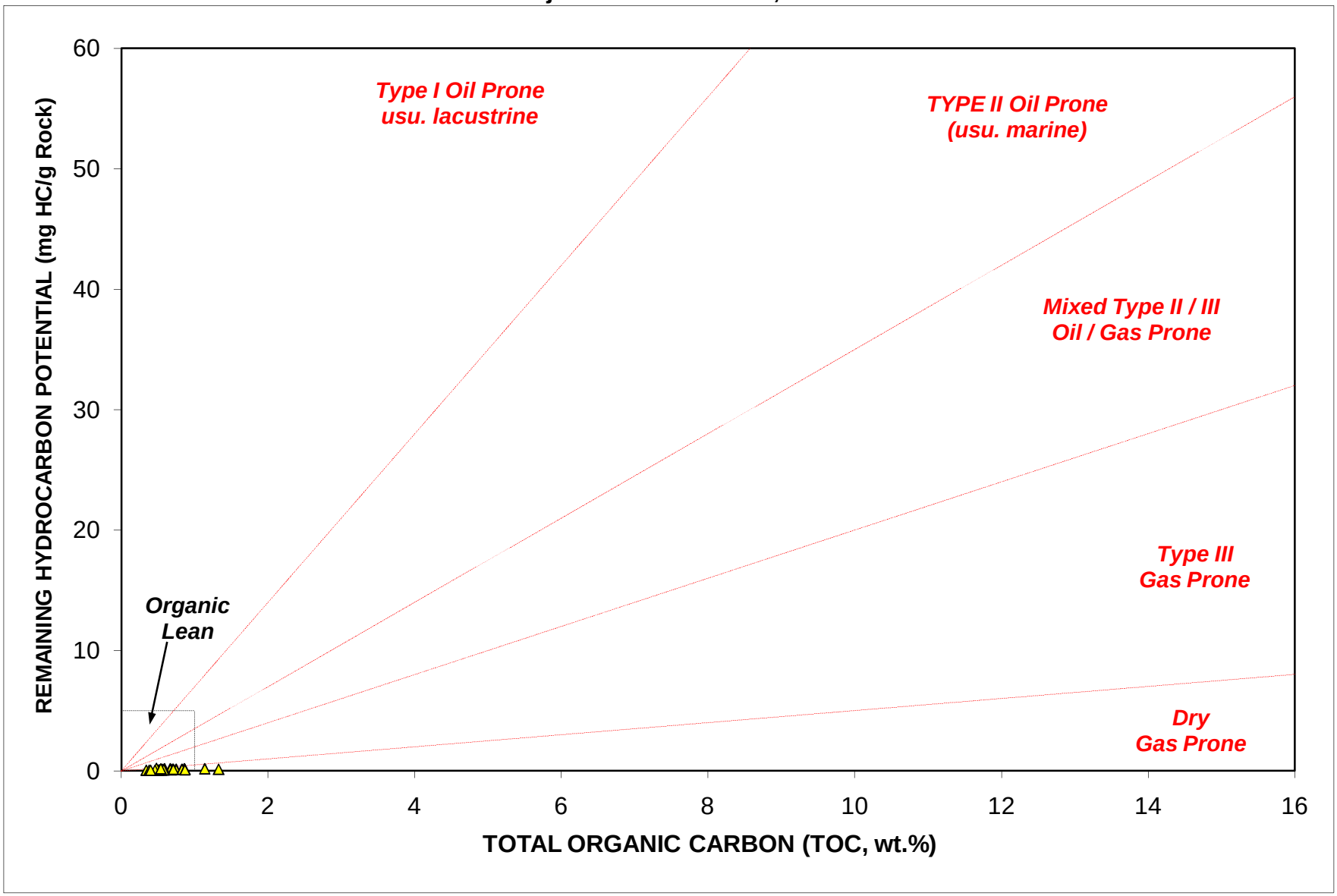

Figure 2. Kerogen Quality

Humble Geochemical Services Division

LARCO #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

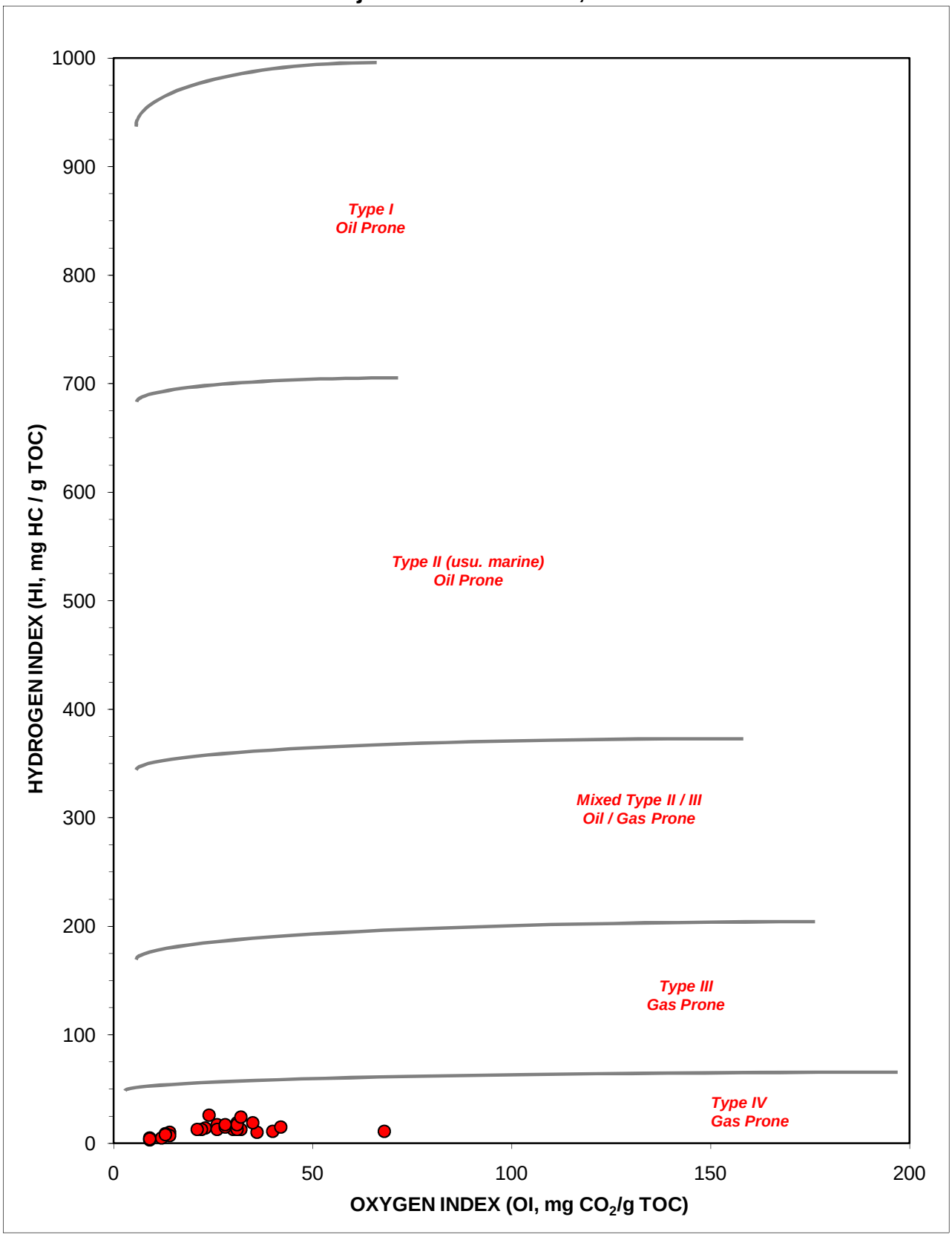

Figure 3. Kerogen type

LARCO #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

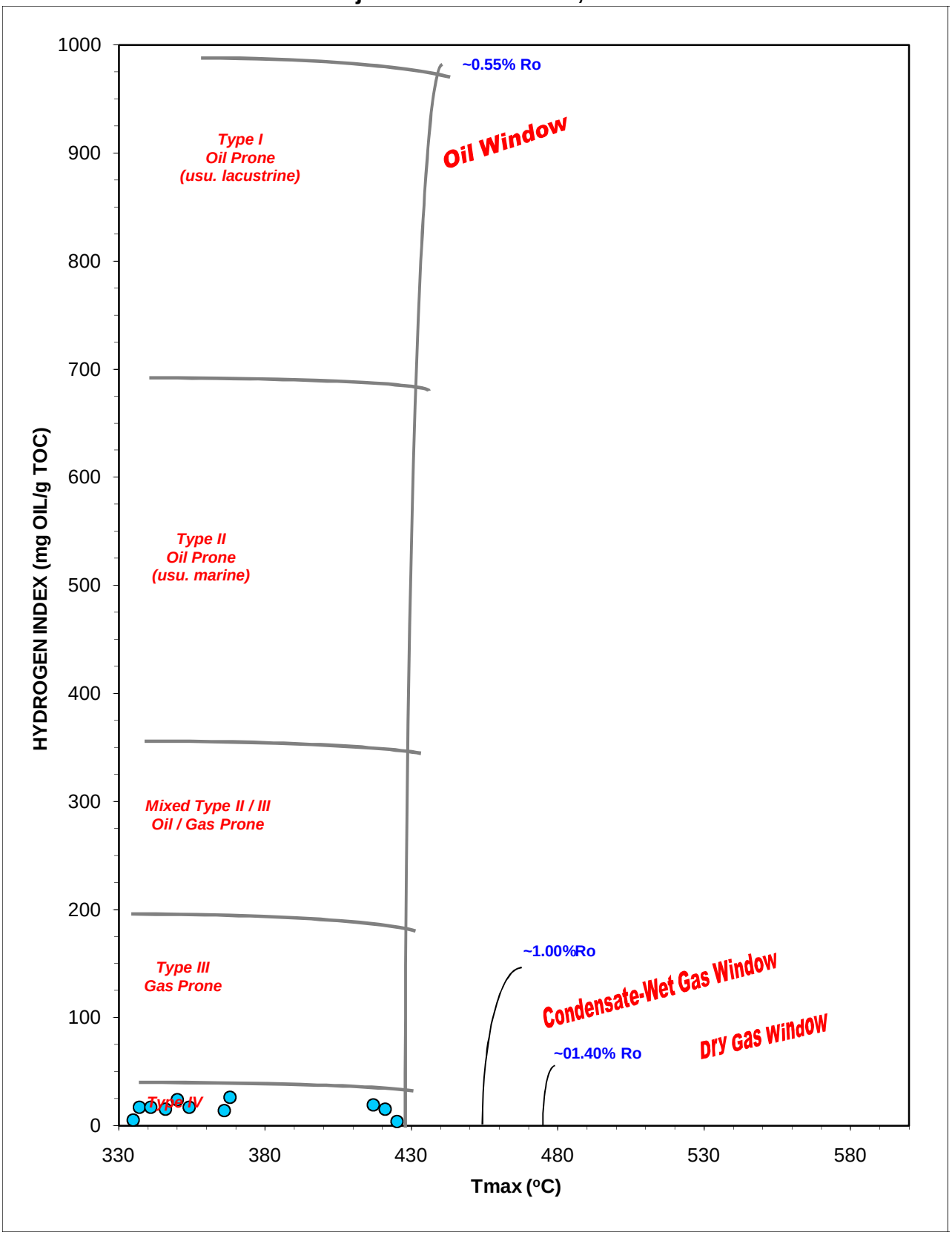

Figure 4a. Kerogen Type and Maturity (Tmax)

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LARCO #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

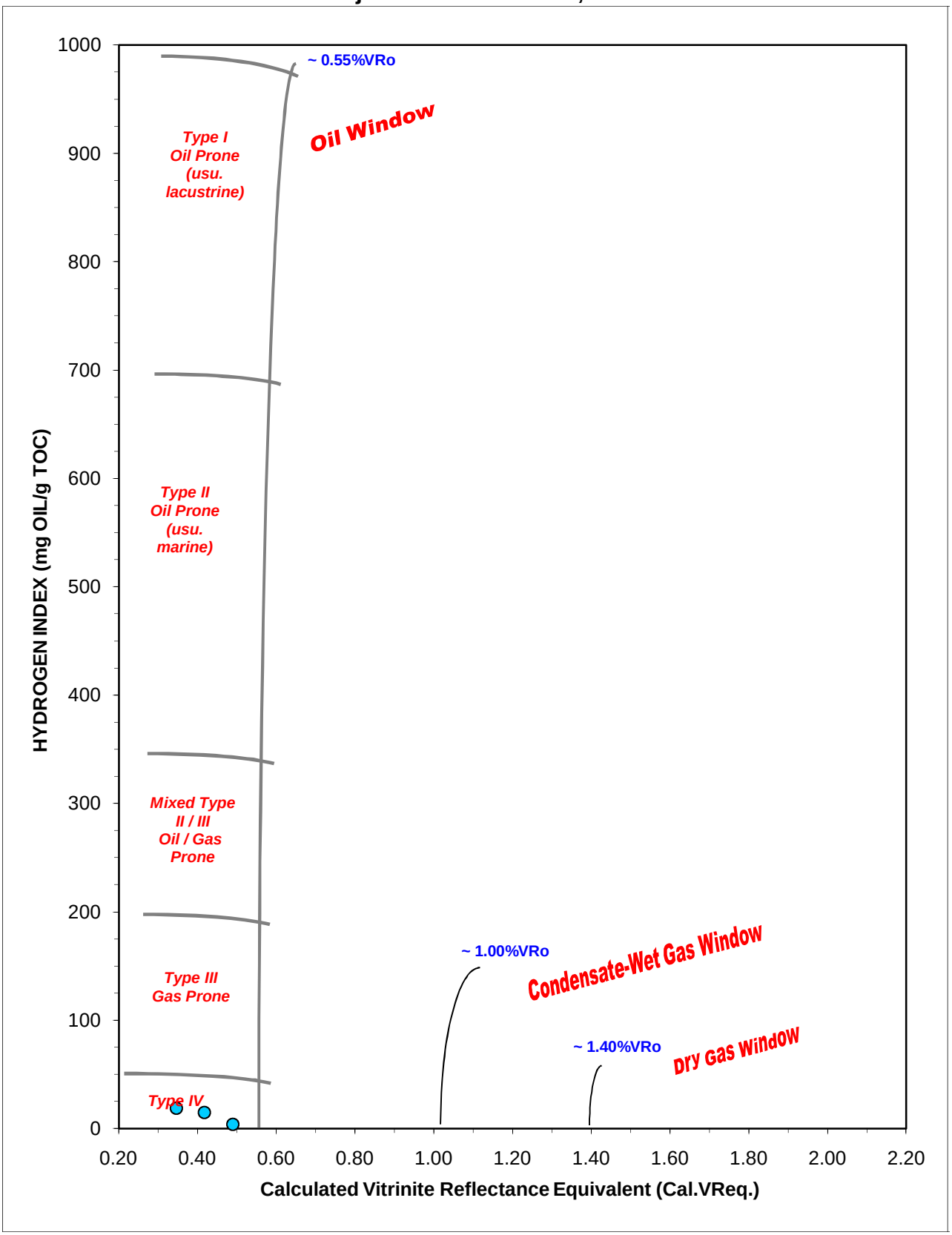

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

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LARCO #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

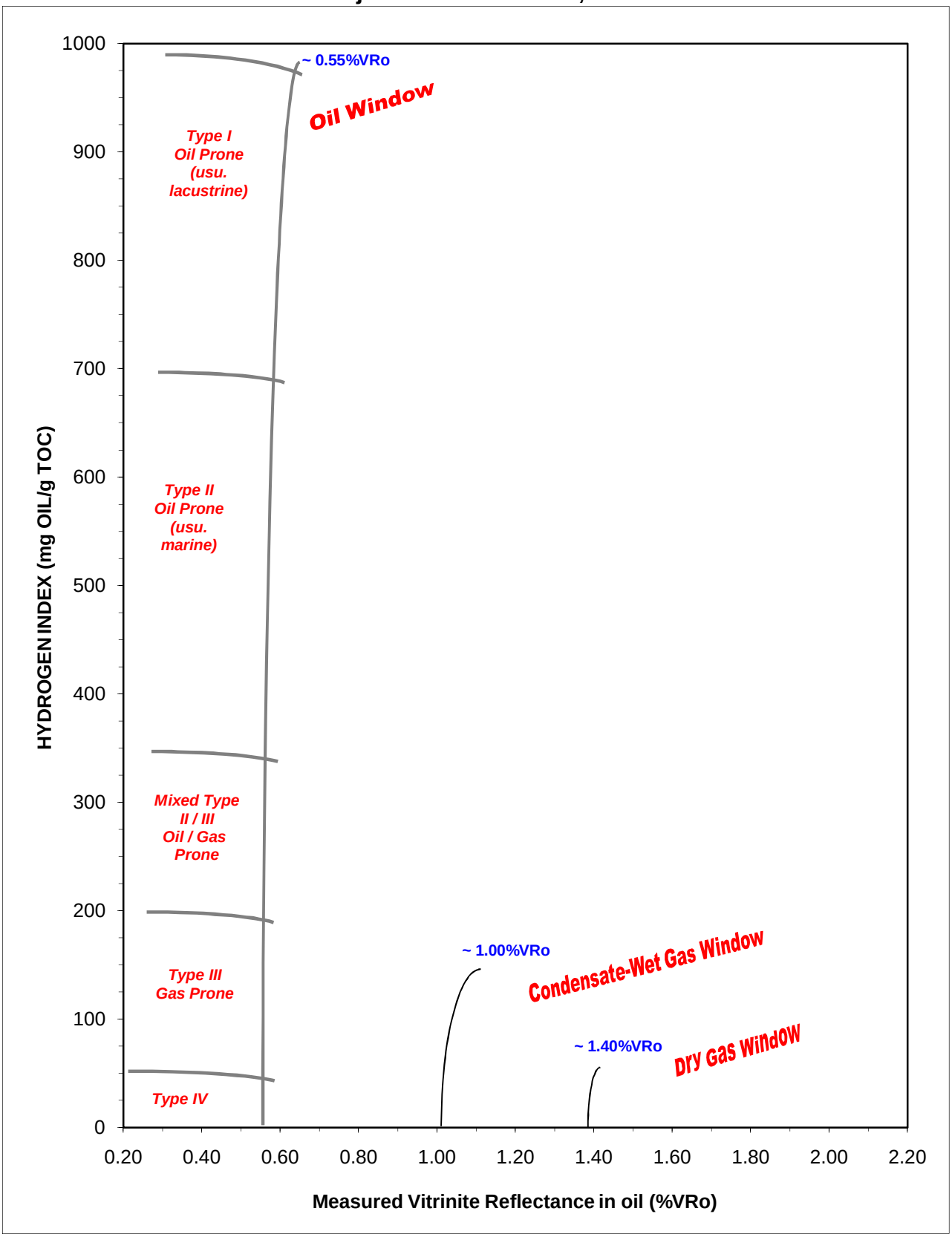

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

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LARCO #1

AGC Project - Arkoma Basin, Arkansas

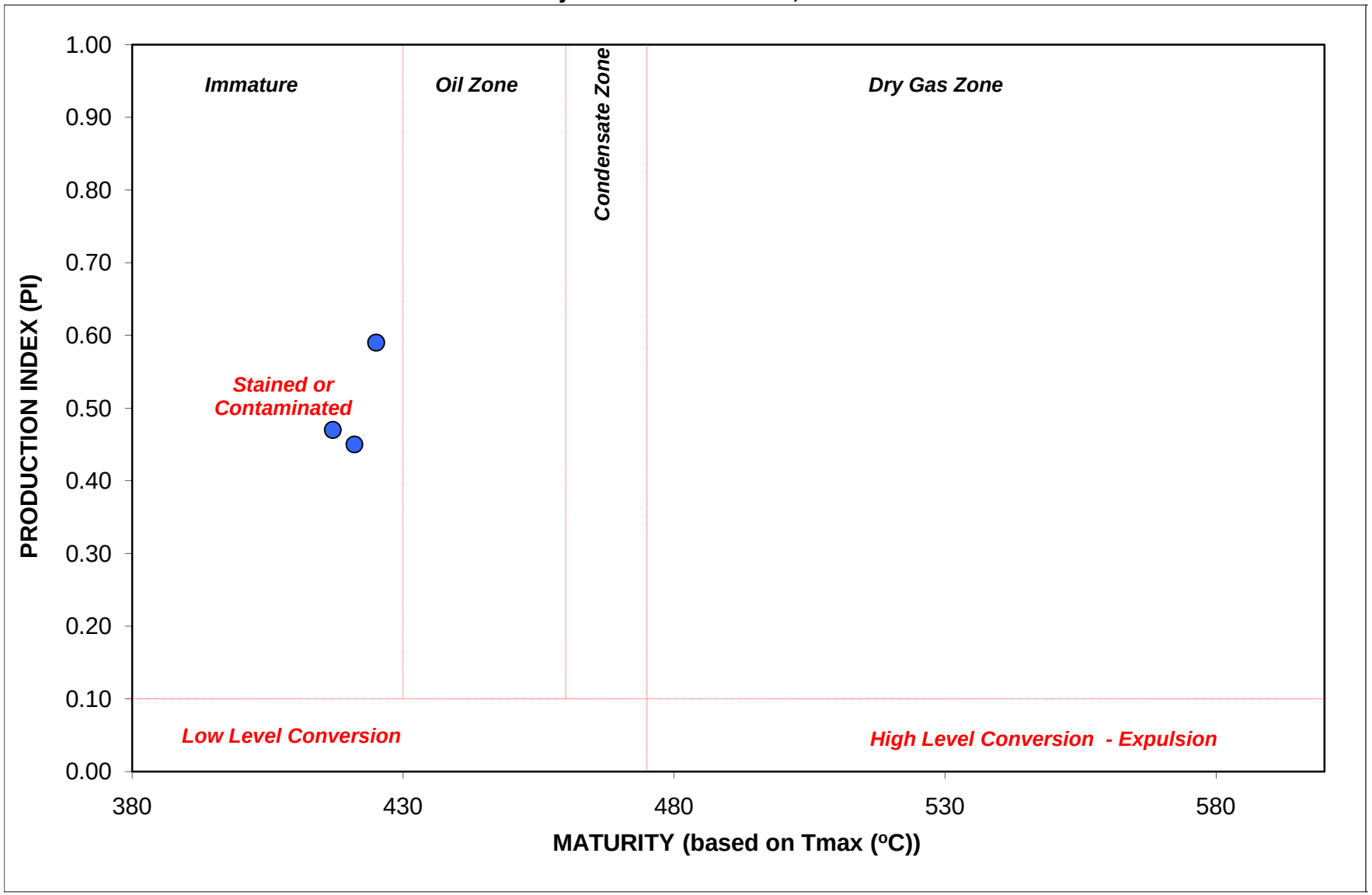

Figure 5a. Kerogen conversion and maturity (based on Tmax).

LARCO #1

AGC Project - Arkoma Basin, Arkansas

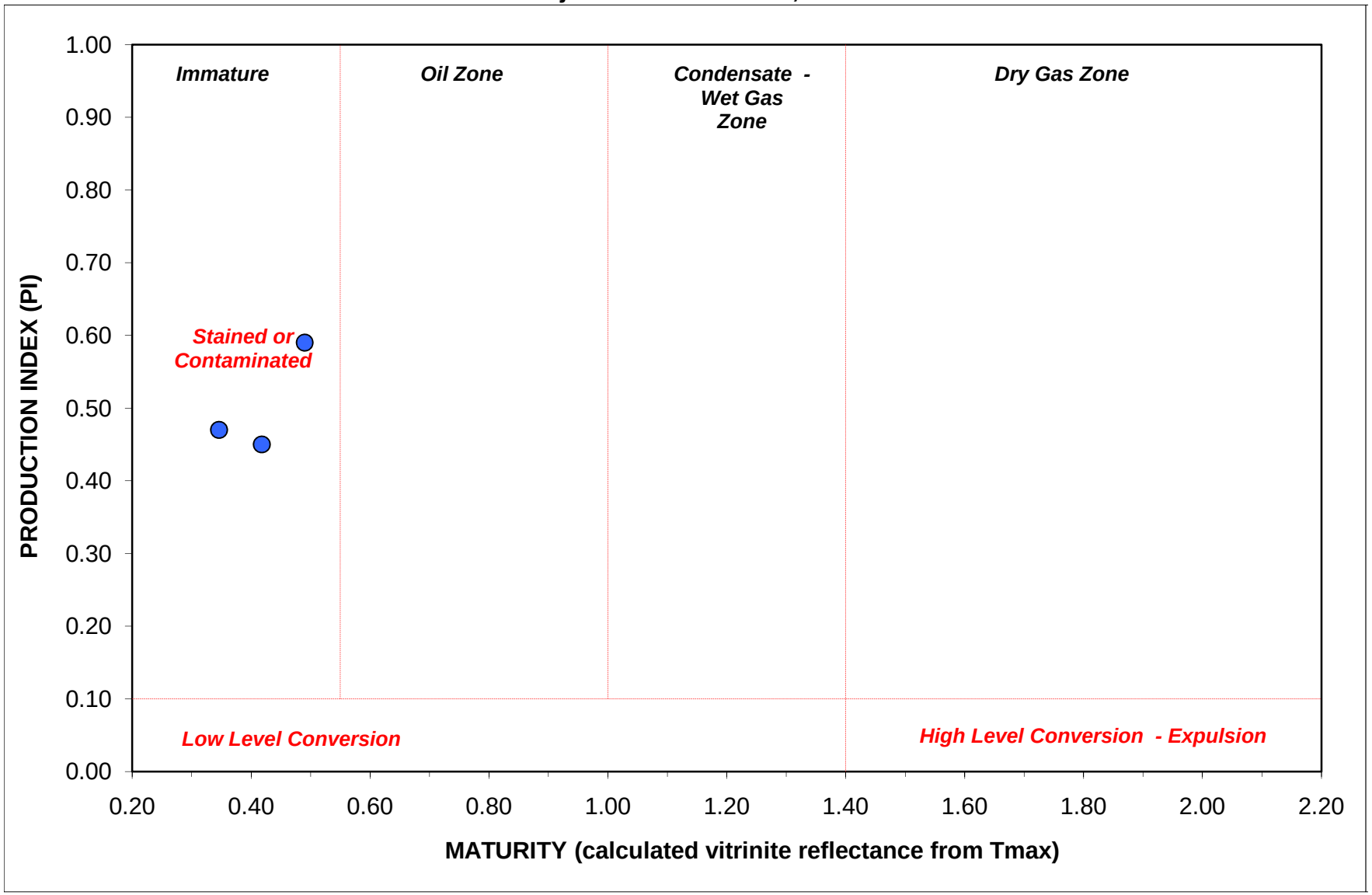

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

LARCO #1

AGC Project - Arkoma Basin, Arkansas

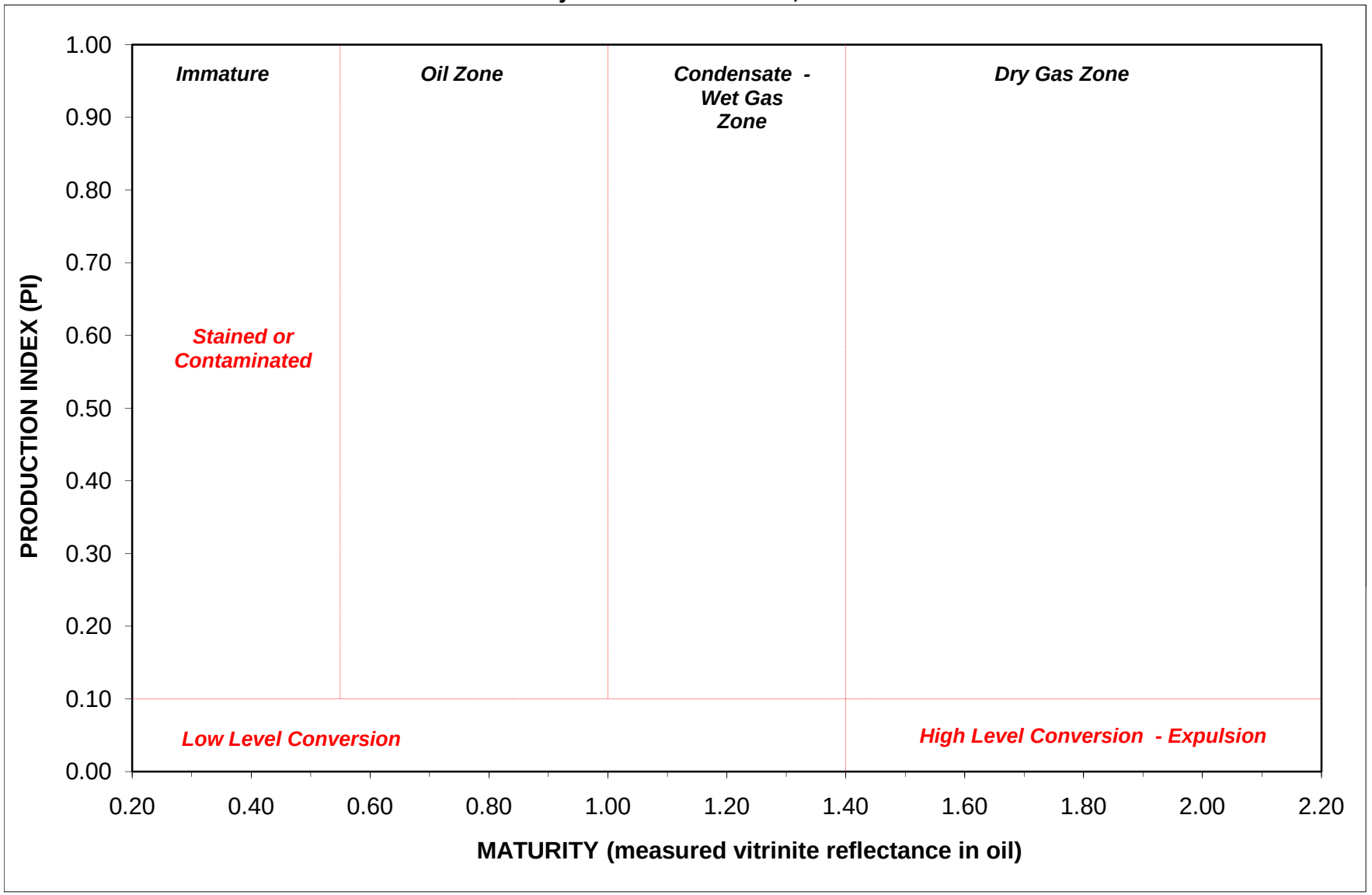

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 9. Geochemical and thermal maturity analyses for the well cutting samples from the Nixon #1

NIXON #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-162872	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	4900	4920	4910		cuttings	pWR	1.17	0.84	0.28	0.42	0.44	433	*	0.63	2.01	C	36	38	1	24	0.40
06-3936-162873	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	5680	5700	5690		cuttings	pWR	0.93	0.62	0.15	0.25	0.45	453	*	0.99			27	48	1	16	0.38
06-3936-162874	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	6830	6850	6840		cuttings	pWR	1.11	0.81	0.07	0.09	0.33	343	*	-1.00			8	30	0	6	0.44
06-3936-162875	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7190	7120	7155		cuttings	pWR	0.53	0.28	0.05	0.08	0.15	351	*	-1.00			15	28	1	9	0.38
06-3936-162876	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7900	7910	7905		cuttings	pWR	1.04	0.84	0.22	0.39	0.27	395	*	-1.00			38	26	1	21	0.36
06-3936-162877	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7720	7730	7725		cuttings	pWR	3.59	3.62	0.83	0.66	0.42	394		-1.00			18	12	2	23	0.56
06-3936-162878	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7730	7740	7735	Fayetteville	cuttings	pWR	1.10	0.67	0.12	0.12	0.27	366	*	-1.00			11	25	0	11	0.50
06-3936-162879	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7740	7750	7745	Fayetteville	cuttings	pWR	1.03	0.67	0.14	0.15	0.23	374	*	-1.00			15	22	1	14	0.48
06-3936-162880	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7750	7760	7755	Fayetteville	cuttings	pWR	1.06	0.68	0.10	0.16	0.33	333	*	-1.00			15	31	0	9	0.38
06-3936-162881	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7760	7770	7765	Fayetteville	cuttings	pWR	1.61	1.33	0.26	0.31	0.41	403	*	0.09			19	25	1	16	0.46
06-3936-162882	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7770	7780	7775	Fayetteville	cuttings	pWR	4.42	4.47	0.65	0.20	0.50	379	*	-1.00			5	11	0	15	0.76
06-3936-162883	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7780	7790	7785	Fayetteville	cuttings	pWR	4.23	4.77	0.50	0.15	0.54	386	*	-1.00			4	13	0	12	0.77
06-3936-162884	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7790	7800	7795	Fayetteville	cuttings	pWR	4.32	4.82	0.54	0.27	0.60	419	*	0.38			6	14	0	12	0.67
06-3936-162885	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7800	7810	7805	Fayetteville	cuttings	pWR	4.50	5.03	0.62	0.29	0.51	406	*	0.15			6	11	1	14	0.68
06-3936-162886	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7810	7820	7815	Fayetteville	cuttings	pWR	4.46	4.93	0.67	0.37	0.46	420	*	0.40			8	10	1	15	0.64
06-3936-162887	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7820	7830	7825		cuttings	pWR	3.46	3.48	0.55	0.76	0.46	403		0.09			22	13	2	16	0.42
06-3936-162888	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7830	7840	7835		cuttings	pWR	1.42	1.30	0.67	0.51	0.32	429		0.56			36	23	2	47	0.57
06-3936-162889	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7950	7960	7955		cuttings	pWR	0.90	0.69	0.21	0.22	0.22	400	*	-1.00			24	24	1	23	0.49
06-3936-162890	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7960	7970	7965		cuttings	pWR	2.34	2.32	0.29	0.33	0.25	395	*	-1.00			14	11	1	12	0.47
06-3936-162891	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7970	7980	7975		cuttings	pWR	2.64	2.59	0.36	0.31	0.33	396	*	-1.00			12	12	1	14	0.54
06-3936-162892	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7980	7990	7985	Chattanooga	cuttings	pWR	2.39	2.30	0.34	0.33	0.28	392	*	-1.00			14	12	1	14	0.51
06-3936-162893	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	7990	8000	7995	Chattanooga	cuttings	pWR	4.03	4.44	0.28	0.35	0.42	372	*	-1.00			9	10	1	7	0.44
06-3936-162894	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	8000	8010	8005	Chattanooga	cuttings	pWR	4.49	5.49	0.20	0.17	0.54	383	*	-1.00			4	12	0	4	0.54
06-3936-162895	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	8010	8020	8015	Chattanooga	cuttings	pWR	4.56	4.65	0.38	0.31	0.37	387	*	-1.00			7	8	1	8	0.55
06-3936-162896	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	8020	8030	8025	Chattanooga	cuttings	pWR	4.09	3.78	0.24	0.18	0.32	345	*	-1.00			4	8	1	6	0.57
06-3936-162897	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	8030	8040	8035	Chattanooga	cuttings	pWR	4.50	4.20	0.22	0.18	0.27	392	*	-1.00			4	6	1	5	0.55
06-3936-162898	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	8040	8050	8045	Chattanooga	cuttings	pWR	3.43	3.04	0.28	0.18	0.28	388	*	-1.00			5	8	1	8	0.61
06-3936-162899	Arkoma	03131000220000	HUBER J M CORP	JOE NIXON	1	SEBASTIAN	AR	8050	8060	8055	Chattanooga	cuttings	pWR	3.70	3.55	0.35	0.23	0.26	404	*	0.11			6	7	1	9	0.60

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

NIXON #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

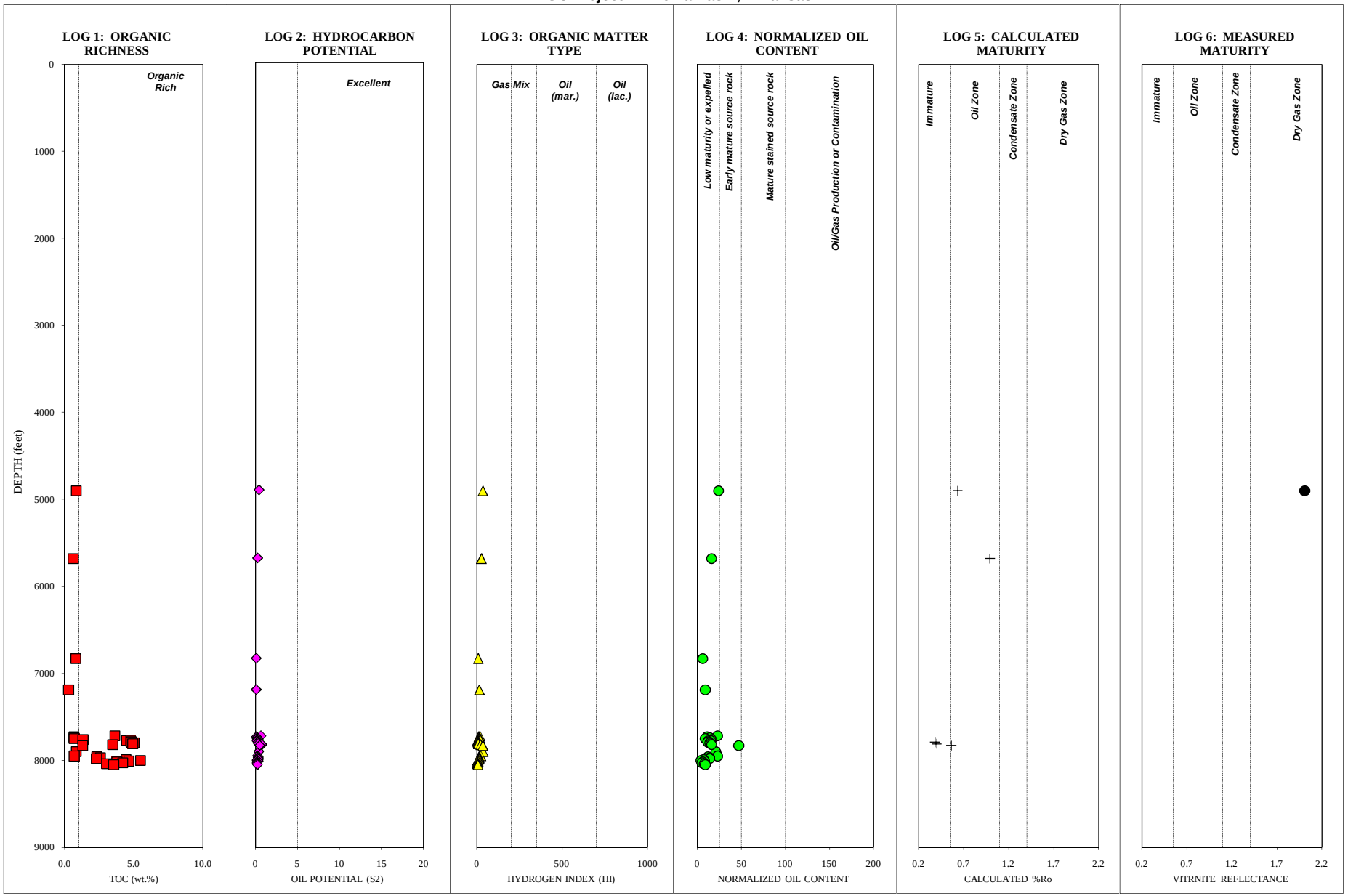

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

NIXON #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

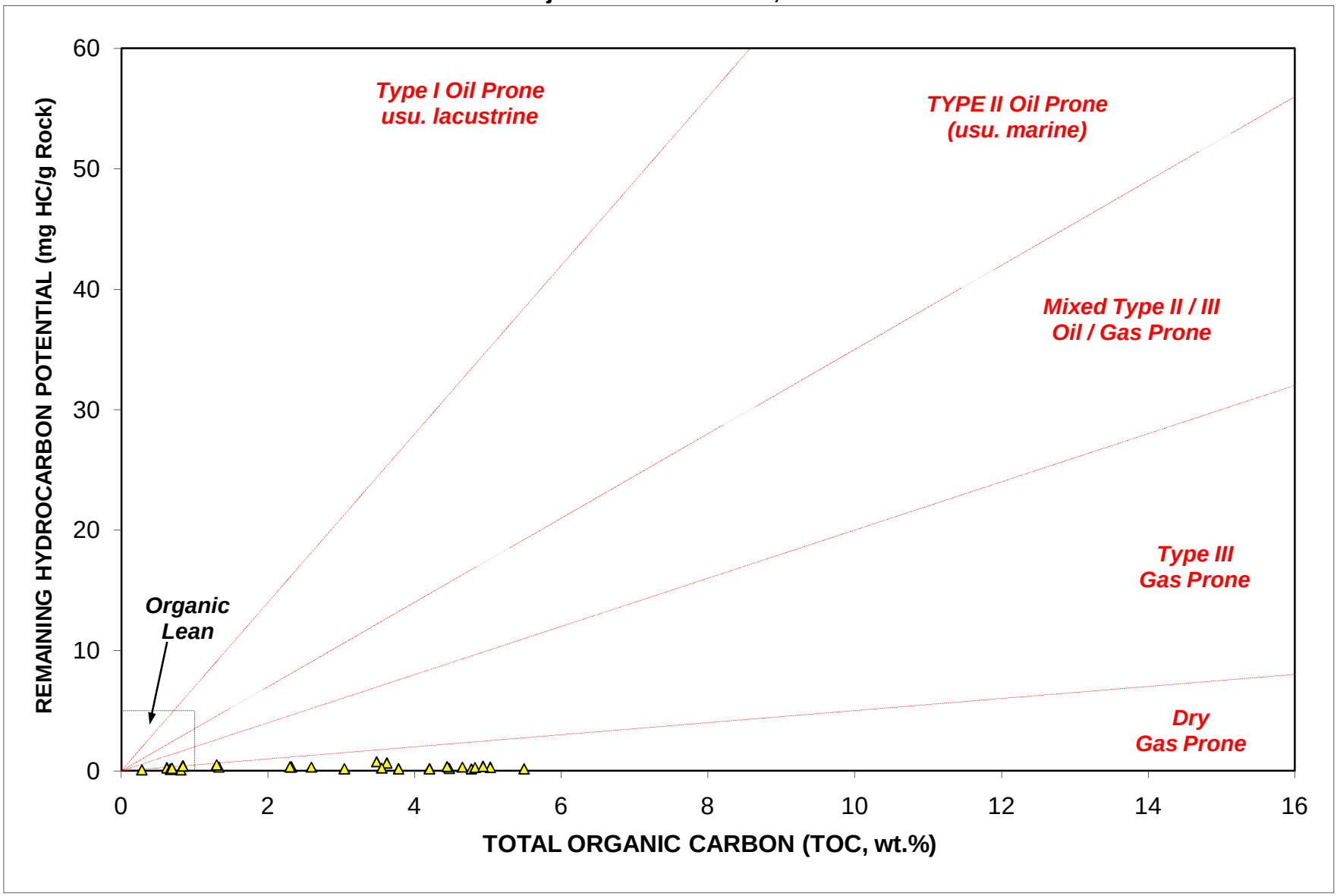

Figure 2. Kerogen Quality

Humble Geochemical Services Division

NIXON #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

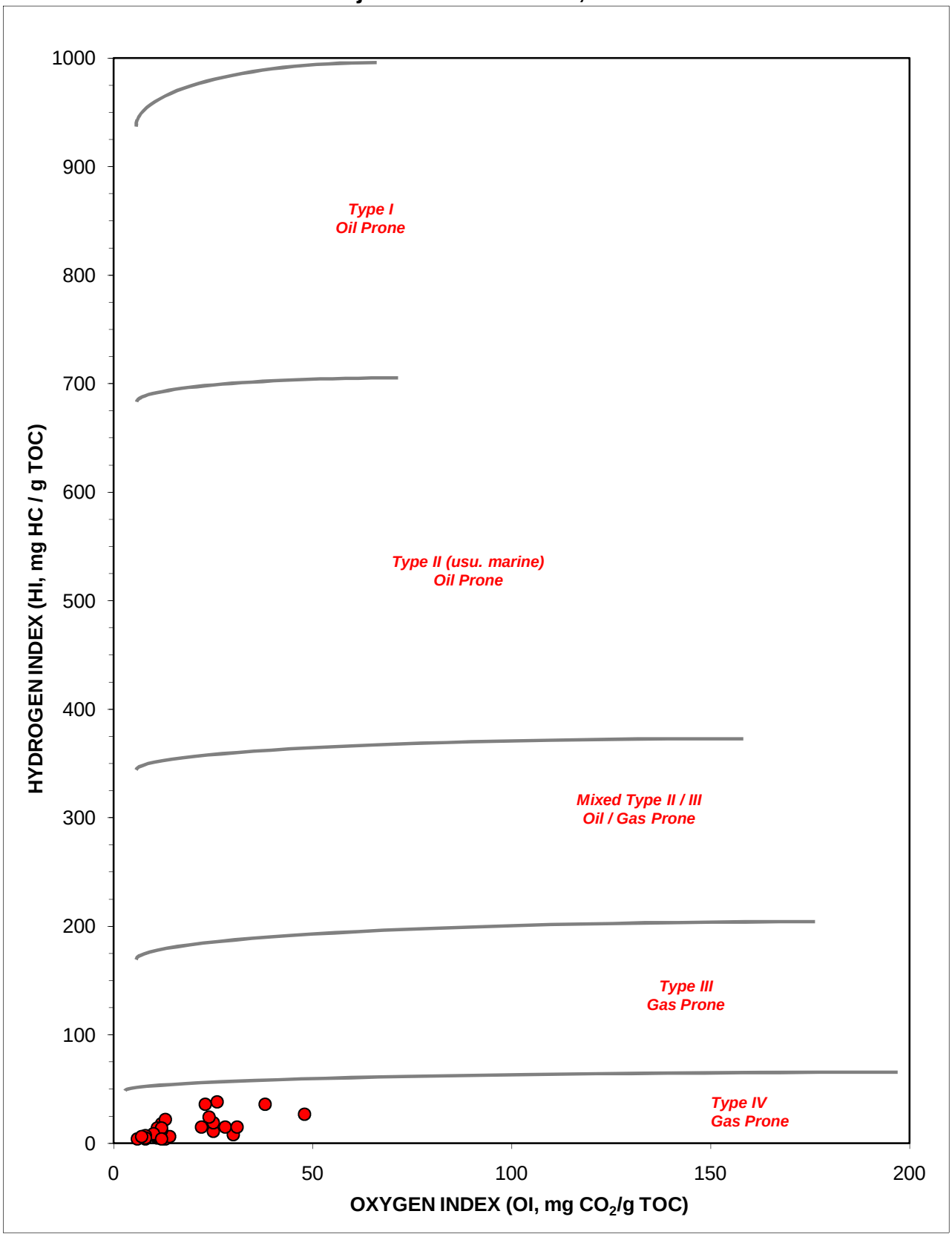

Figure 3. Kerogen type

NIXON #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

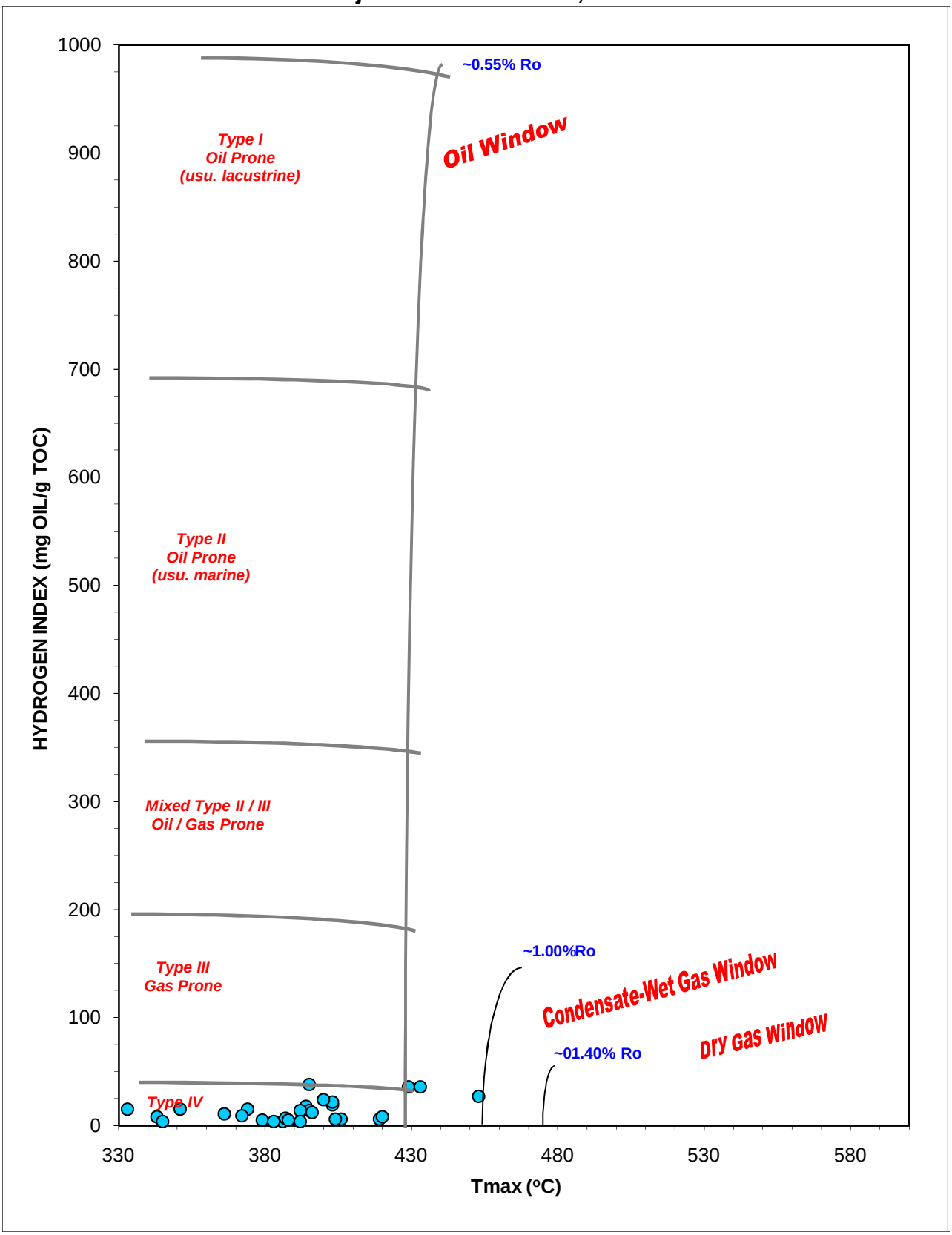

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

NIXON #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

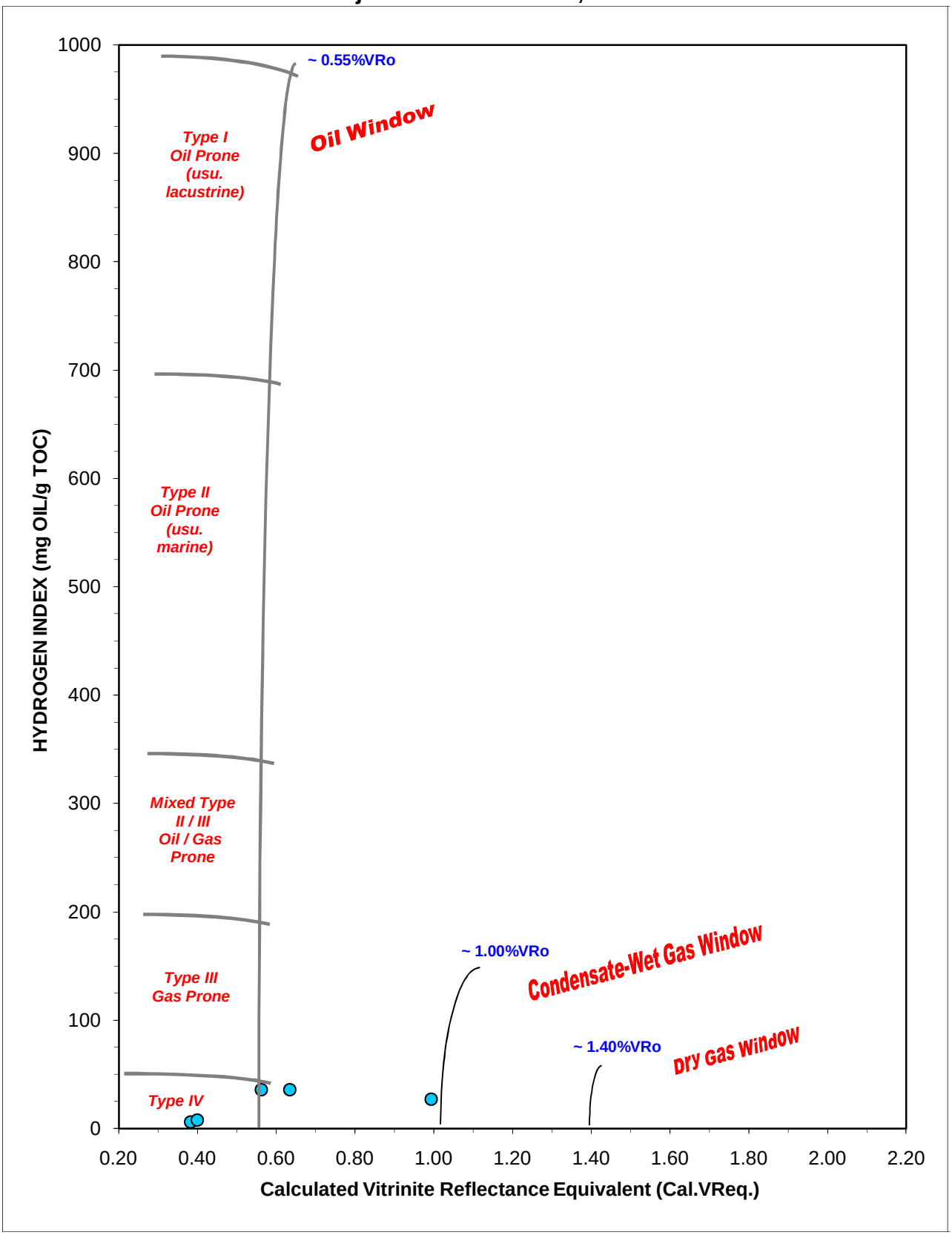

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

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NIXON #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

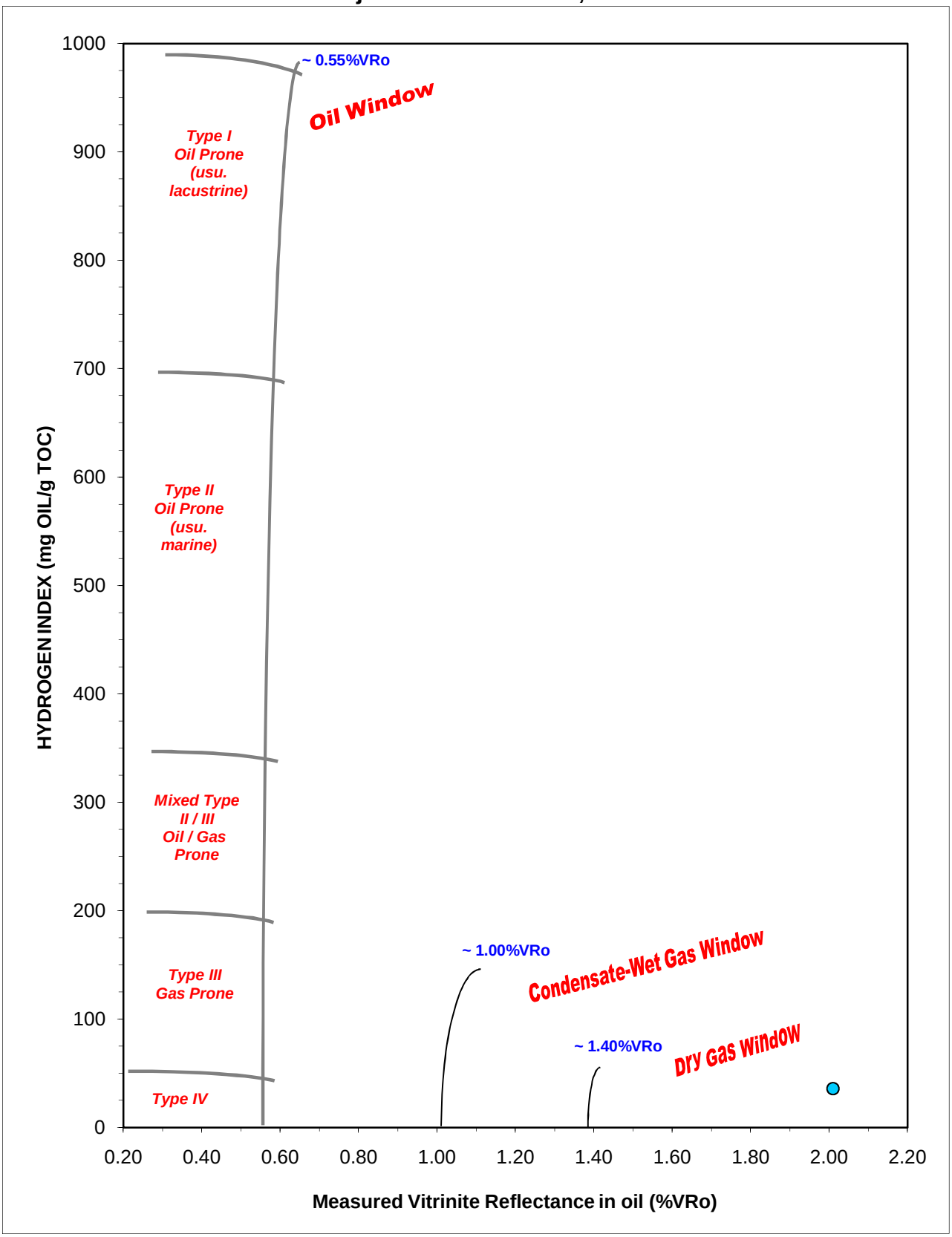

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

NIXON #1

AGC Project - Arkoma Basin, Arkansas

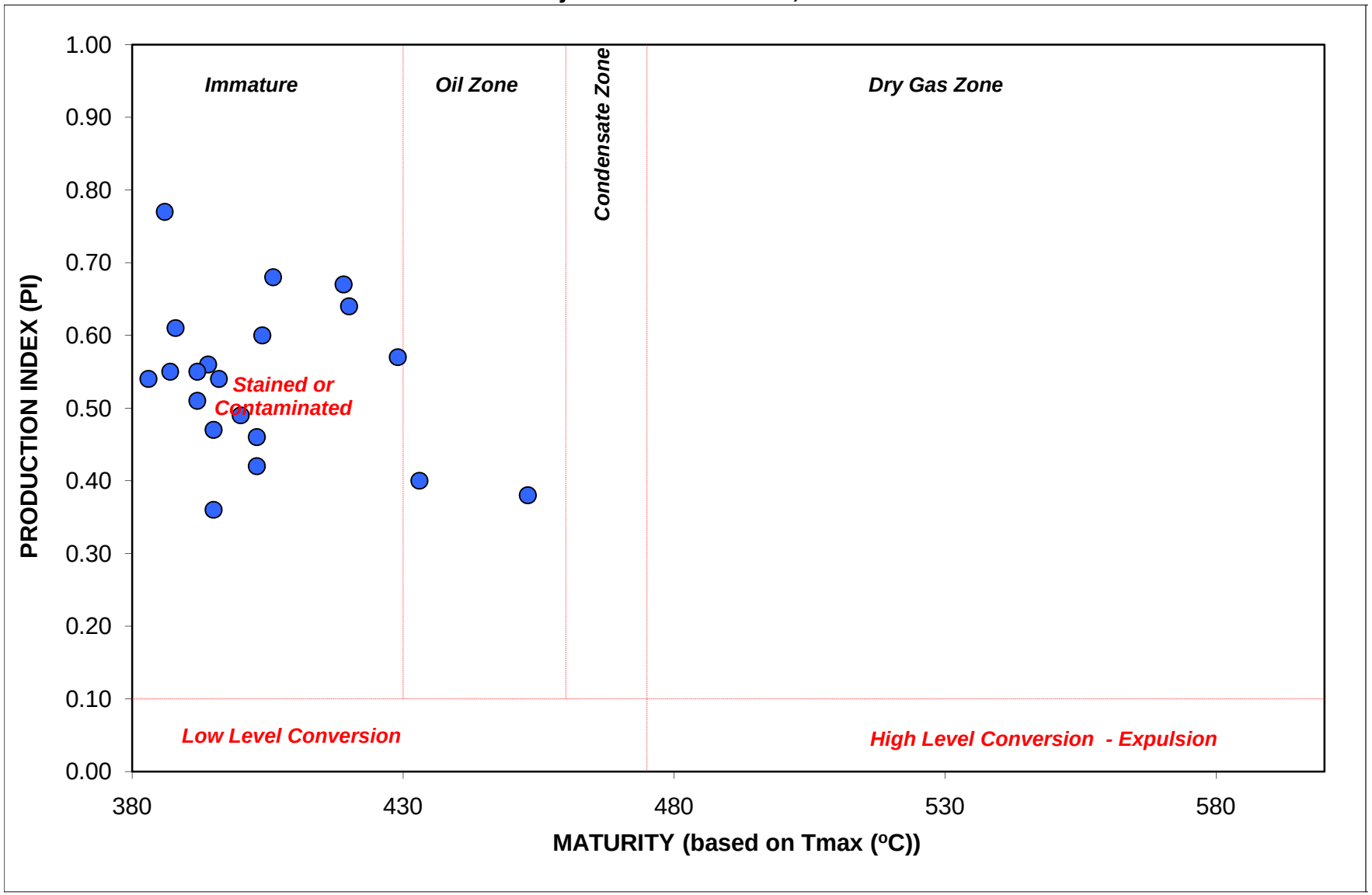

Figure 5a. Kerogen conversion and maturity (based on Tmax).

NIXON #1

AGC Project - Arkoma Basin, Arkansas

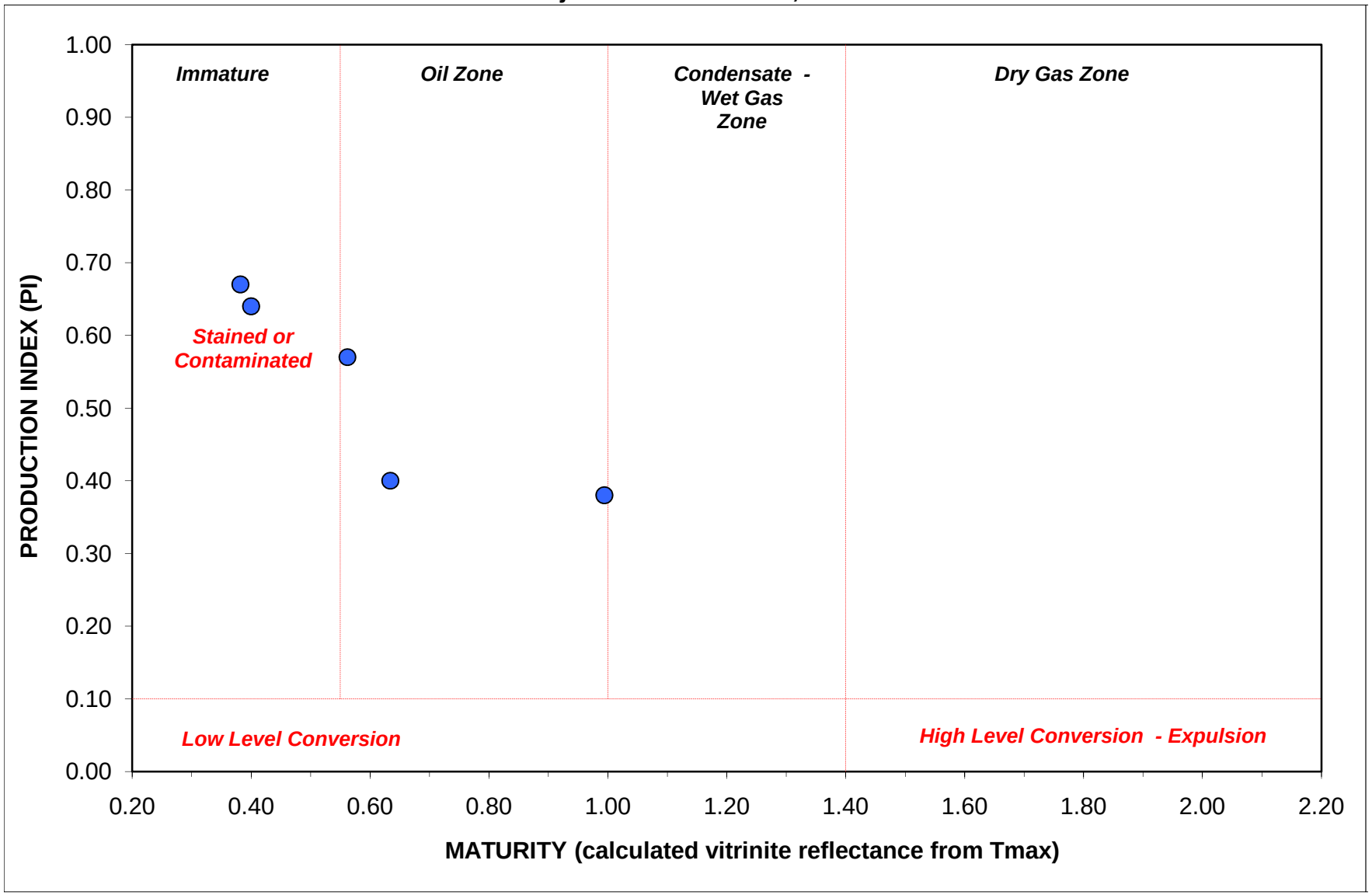

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

NIXON #1

AGC Project - Arkoma Basin, Arkansas

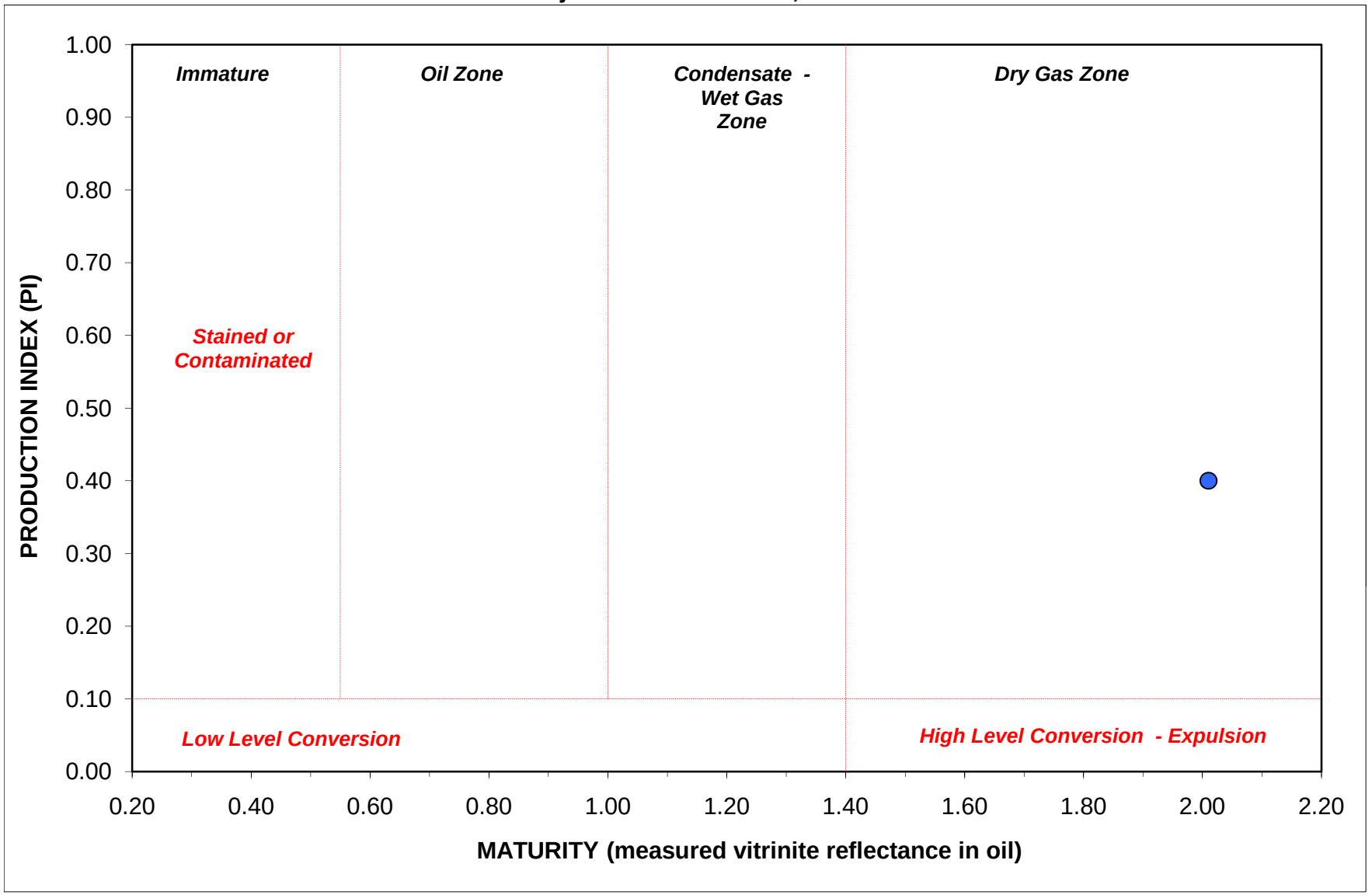

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 10. Geochemical and thermal maturity analyses for the well cutting samples from the Price #1 - 11

PRICE #1 - 11

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-157860	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	7650	7670	7660		cuttings	pWR	0.89	0.52	0.18	0.21	0.48	363	*	-1.00			24	54	0	20	0.46
06-3936-157861	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	8440	8470	8455		cuttings	pWR	0.99	0.52	0.14	0.09	0.47	355	*	-1.00			9	47	0	14	0.61
06-3936-157862	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9690	9710	9700		cuttings	pWR	0.63	0.24	0.11	0.07	0.37	337	*	-1.00			11	59	0	17	0.61
06-3936-157863	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9710	9730	9720		cuttings	pWR	0.62	0.25	0.11	0.09	0.36	306	*	-1.00			15	58	0	18	0.55
06-3936-157864	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	8960	8970	8965	Fayetteville	cuttings	pWR	0.72	0.36	0.16	0.11	0.43	378	*	-1.00			15	60	0	22	0.59
06-3936-157865	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	8970	8980	8975	Fayetteville	cuttings	pWR	0.79	0.38	0.16	0.13	0.50	368	*	-1.00			16	63	0	20	0.55
06-3936-157866	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	8980	8990	8985	Fayetteville	cuttings	pWR	0.76	0.35	0.13	0.09	0.39	302	*	-1.00			12	51	0	17	0.59
06-3936-157867	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	8990	9000	8995	Fayetteville	cuttings	pWR	0.71	0.36	0.14	0.11	0.40	356	*	-1.00			15	56	0	20	0.56
06-3936-157868	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9000	9010	9005	Fayetteville	cuttings	pWR	1.04	0.64	0.16	0.12	0.54	349	*	-1.00			12	52	0	15	0.57
06-3936-157869	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9010	9020	9015	Fayetteville	cuttings	pWR	1.03	0.67	0.18	0.19	0.63	355	*	-1.00			18	61	0	17	0.49
06-3936-157870	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9020	9030	9025	Fayetteville	cuttings	pWR	1.04	0.75	0.15	0.11	0.69	348	*	-1.00			11	66	0	14	0.58
06-3936-157871	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9030	9040	9035	Fayetteville	cuttings	pWR	1.01	0.73	0.16	0.13	0.55	359	*	-1.00			13	54	0	16	0.55
06-3936-157872	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9040	9050	9045	Fayetteville	cuttings	pWR	1.02	0.70	0.17	0.10	0.57	348	*	-1.00			10	56	0	17	0.63
06-3936-157873	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9050	9060	9055	Fayetteville	cuttings	pWR	4.19	4.18	1.10	0.34	0.68	347	*	-1.00			8	16	1	26	0.76
06-3936-157874	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9060	9070	9065	Fayetteville	cuttings	pWR	4.15	4.06	0.89	0.21	0.70	342	*	-1.00	2.99	C	5	17	0	21	0.81
06-3936-157875	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9070	9100	9085		cuttings	pWR	4.05	4.16	0.96	0.33	0.61	343	*	-1.00			8	15	1	24	0.74
06-3936-157876	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9100	9130	9115		cuttings	pWR	2.08	2.01	0.45	0.20	0.58	350	*	-1.00			10	28	0	22	0.69
06-3936-157877	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9130	9160	9145		cuttings	pWR	1.85	1.71	0.50	0.12	0.50	349	*	-1.00			6	27	0	27	0.81
06-3936-157878	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9160	9190	9175		cuttings	pWR	1.81	1.72	0.44	0.16	0.67	349	*	-1.00			9	37	0	24	0.73
06-3936-157879	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9310	9320	9315		cuttings	pWR	1.80	1.79	0.69	0.30	0.50	353	*	-1.00			17	28	1	38	0.70
06-3936-157880	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9320	9330	9325	Chattanooga	cuttings	pWR	1.84	1.76	0.65	0.29	0.55	349	*	-1.00			16	30	1	35	0.69
06-3936-157881	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9330	9340	9335	Chattanooga	cuttings	pWR	1.79	1.75	0.61	0.37	0.62	348	*	-1.00			21	35	1	34	0.62
06-3936-157882	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9340	9350	9345	Chattanooga	cuttings	pWR	1.75	1.72	0.49	0.26	0.54	355	*	-1.00			15	31	0	28	0.65
06-3936-157883	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9350	9360	9355	Chattanooga	cuttings	pWR	1.59	1.44	0.40	0.15	0.59	350	*	-1.00			9	37	0	25	0.73
06-3936-157884	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9360	9370	9365	Chattanooga	cuttings	pWR	1.57	1.44	0.38	0.12	0.58	326	*	-1.00			8	37	0	24	0.76
06-3936-157885	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9370	9380	9375	Chattanooga	cuttings	pWR	1.68	1.61	0.42	0.11	0.56	357	*	-1.00			7	33	0	25	0.79
06-3936-157886	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9380	9390	9385	Chattanooga	cuttings	pWR	1.84	1.82	0.44	0.16	0.60	359	*	-1.00			9	33	0	24	0.73
06-3936-157887	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9390	9400	9395	Chattanooga	cuttings	pWR	1.95	1.93	0.47	0.15	0.54	354	*	-1.00			8	28	0	24	0.76
06-3936-157888	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9400	9410	9405	Chattanooga	cuttings	pWR	3.90	4.28	0.76	0.39	0.57	353	*	-1.00			10	15	1	19	0.66
06-3936-157889	Arkoma	03047101970000	ARKLA EXPL CO	PRICE	1-11	FRANKLIN	AR	9410	9420	9415		cuttings	pWR	3.89	3.96	0.83	0.47	0.60	356	*	-1.00			12	15	1	21	0.64

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

PRICE #1 - 11

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

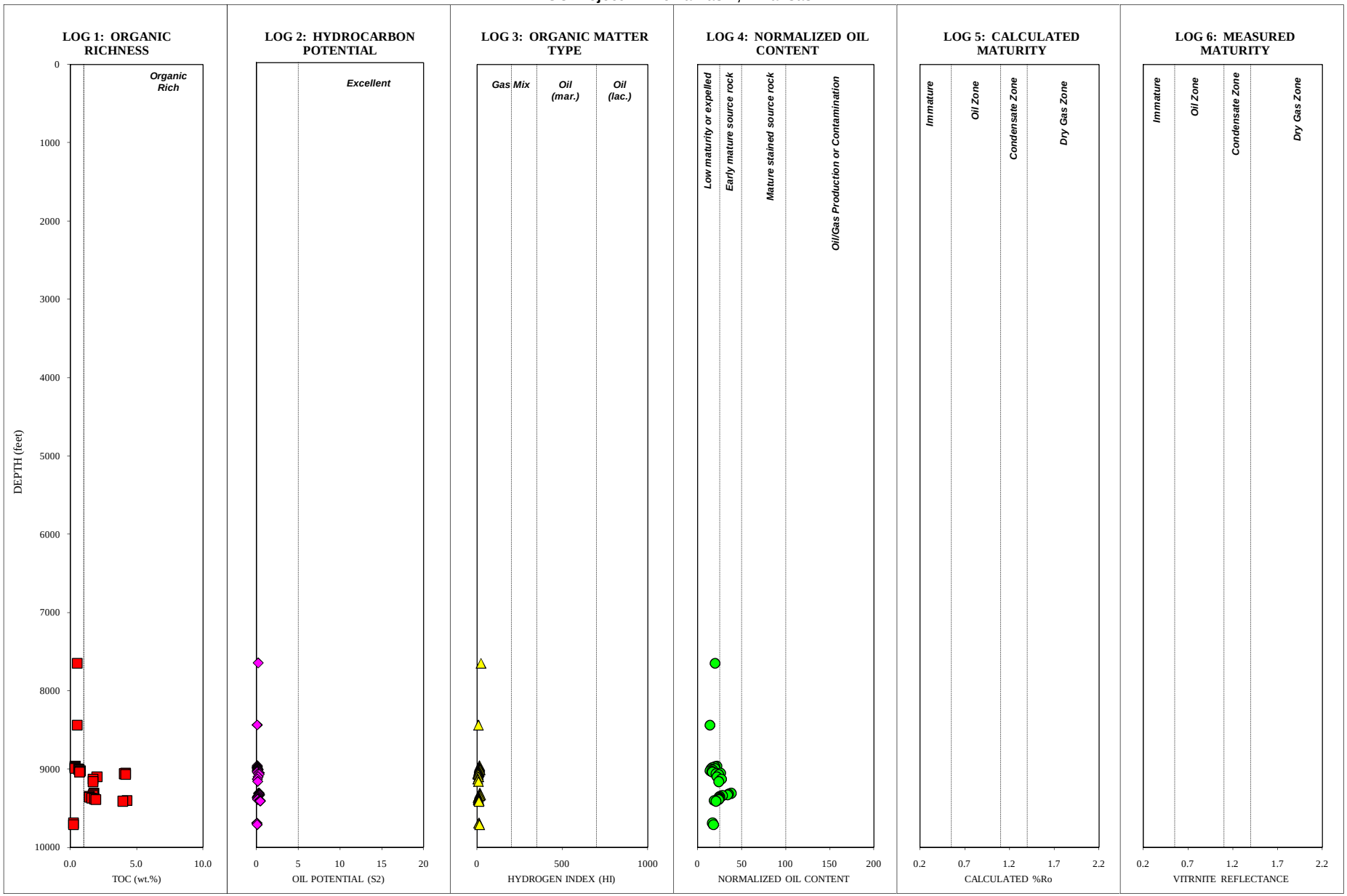

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

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KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

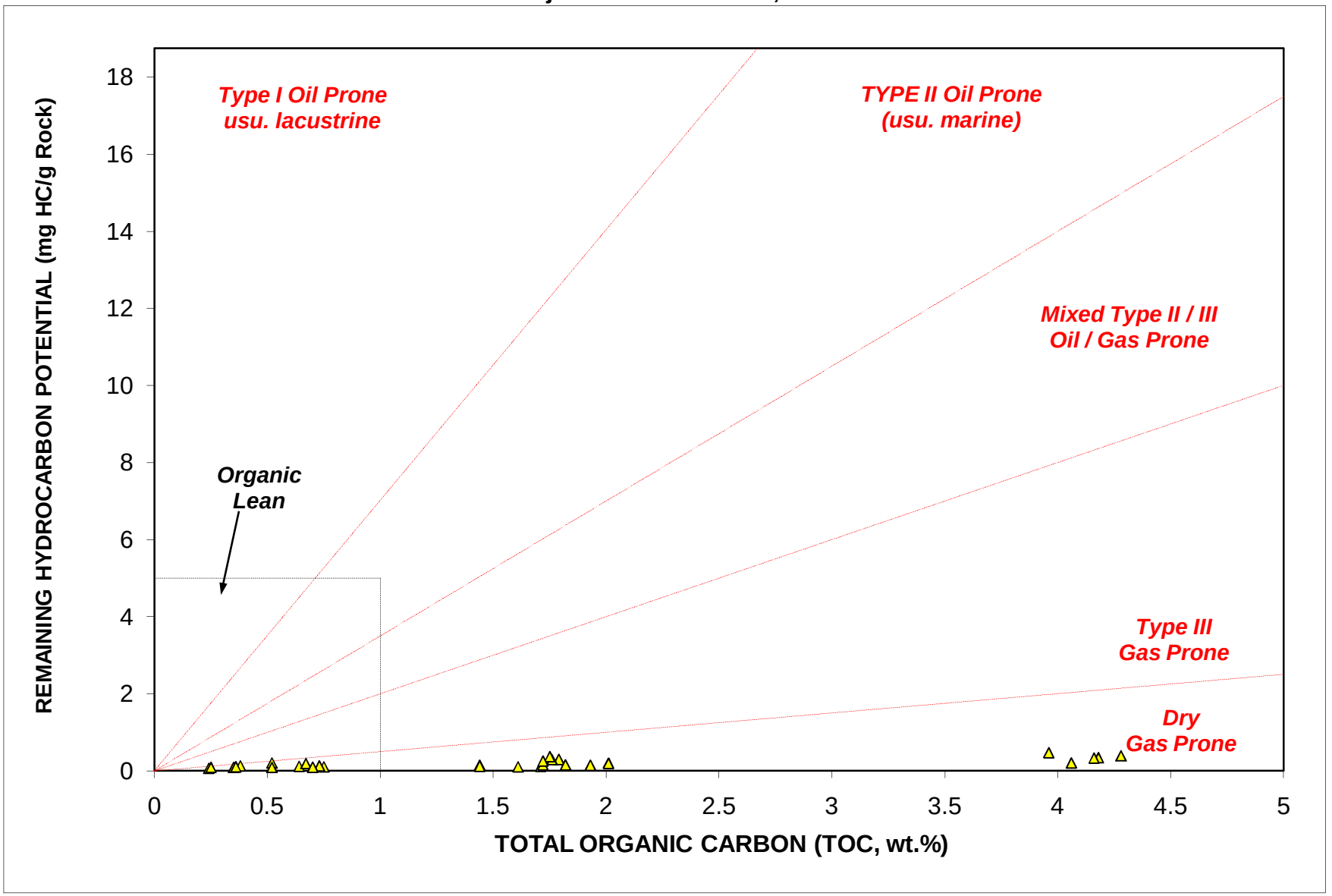

Figure 2. Kerogen Quality

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KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

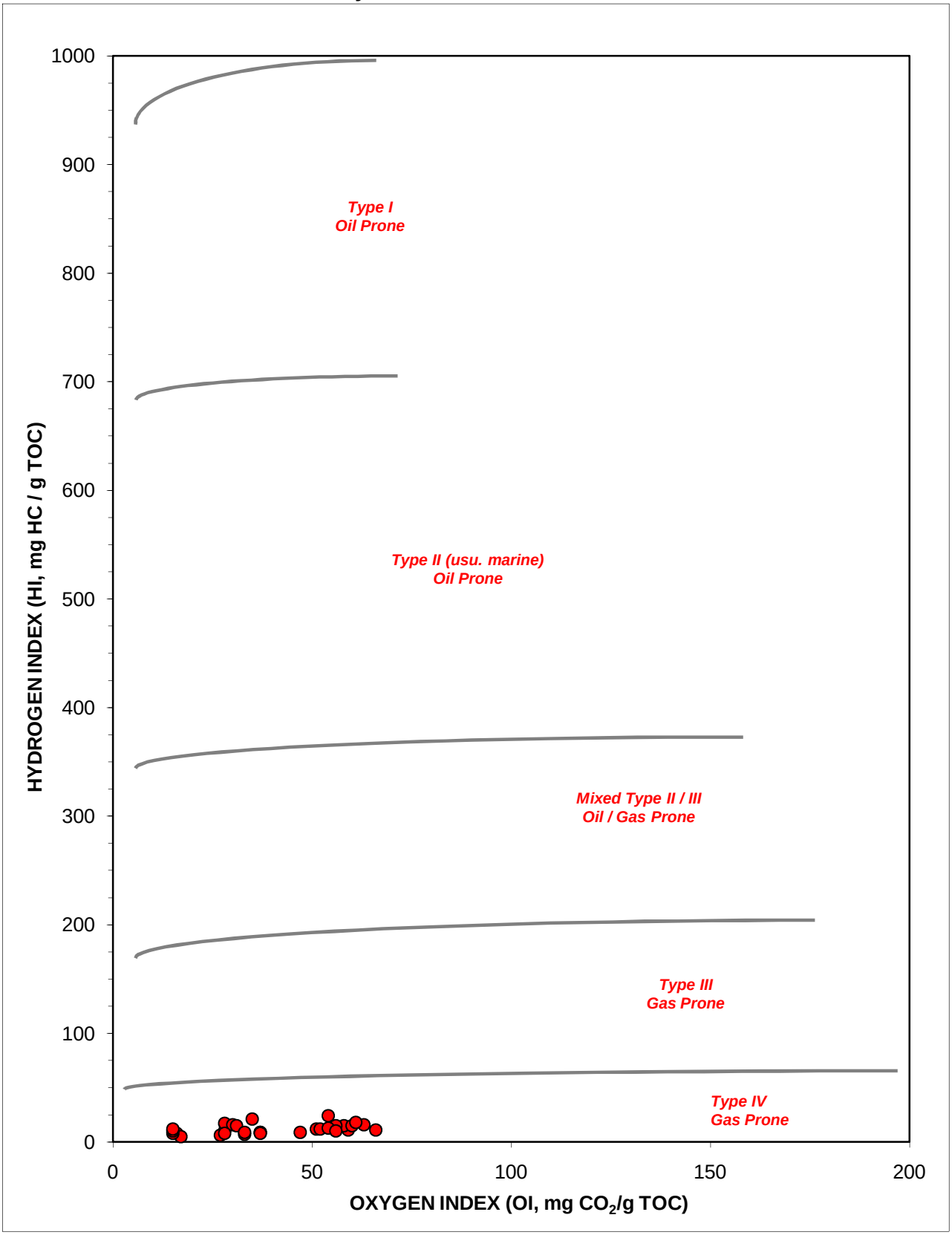

Figure 3. Kerogen type

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KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

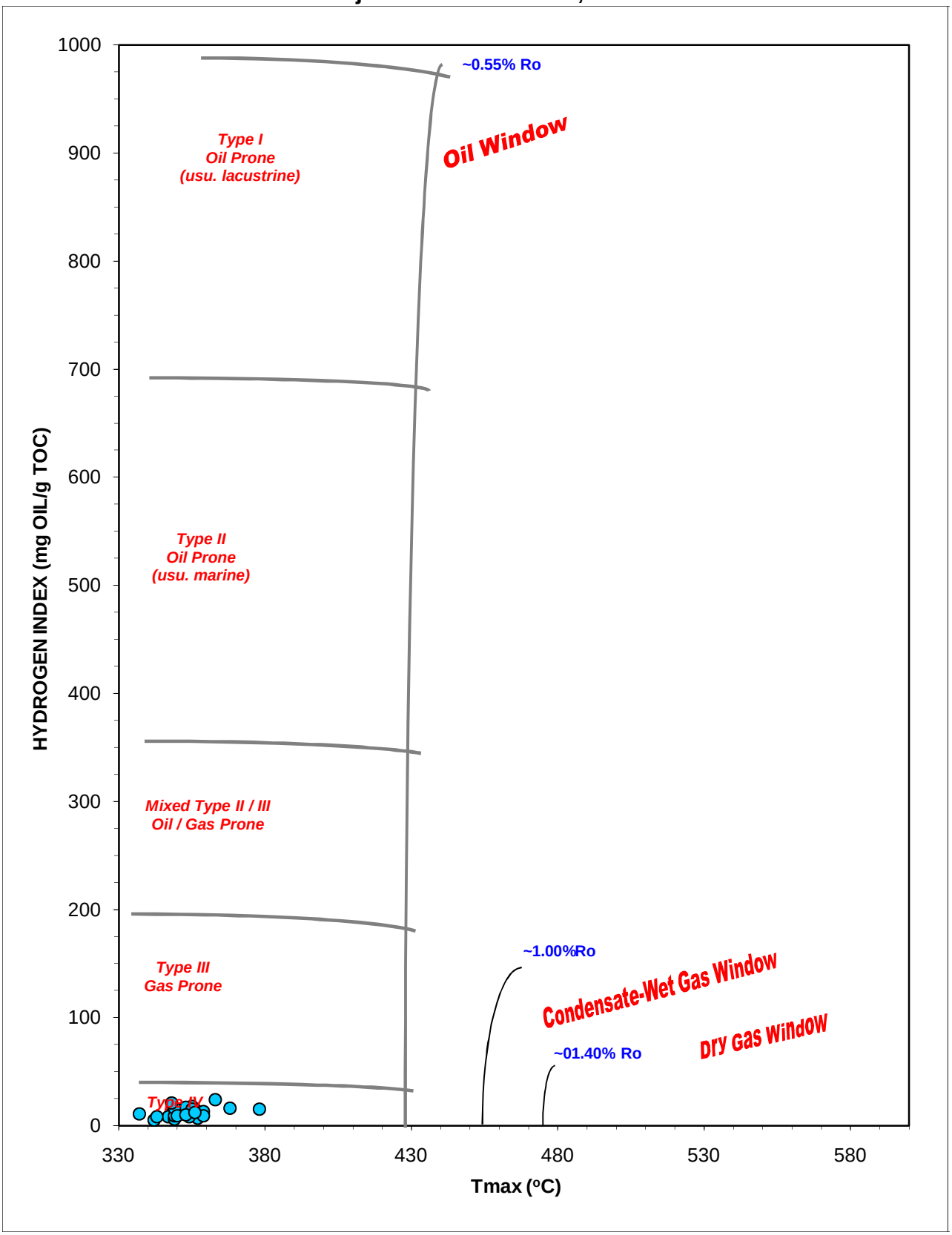

Figure 4a. Kerogen Type and Maturity (Tmax)

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KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

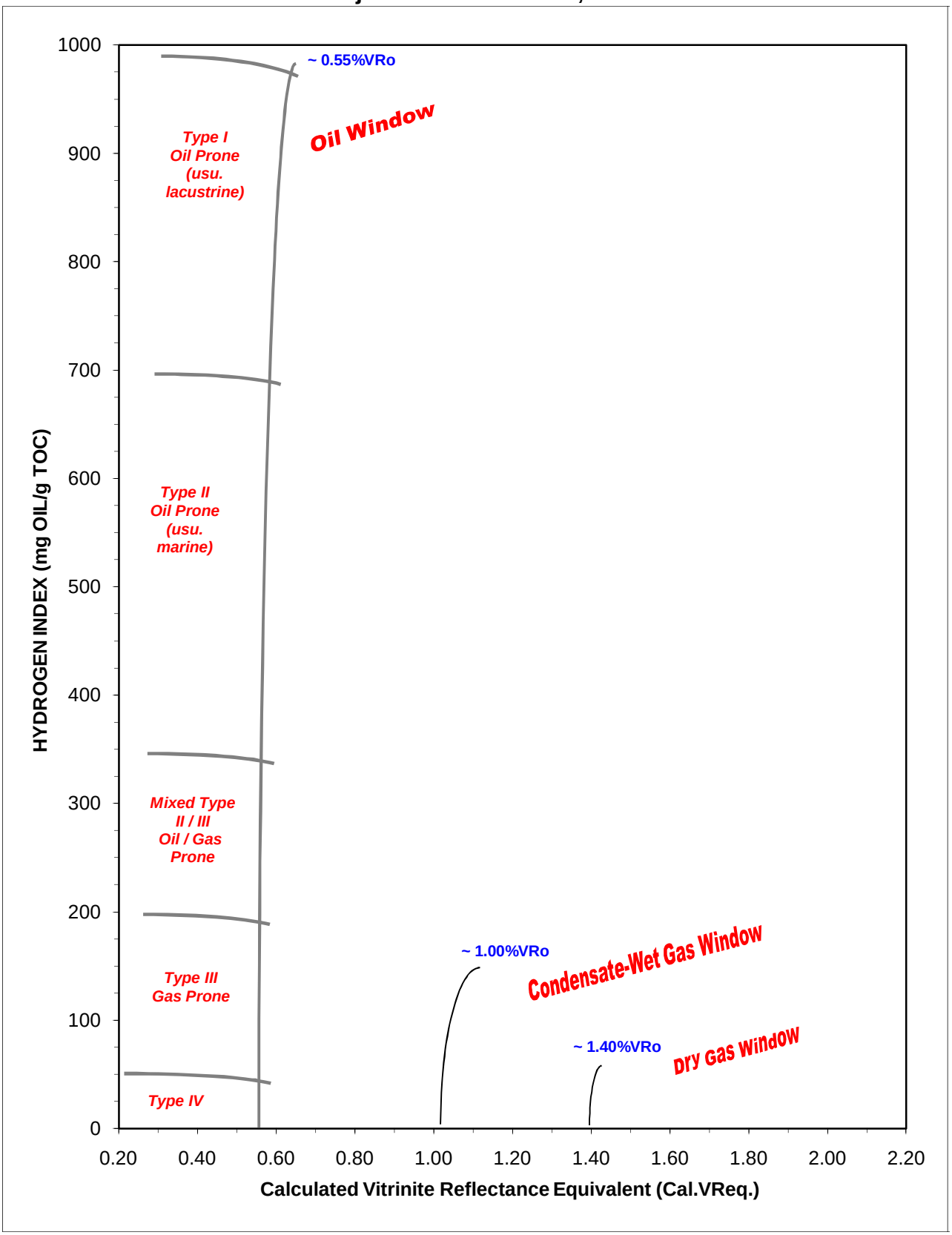

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

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KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

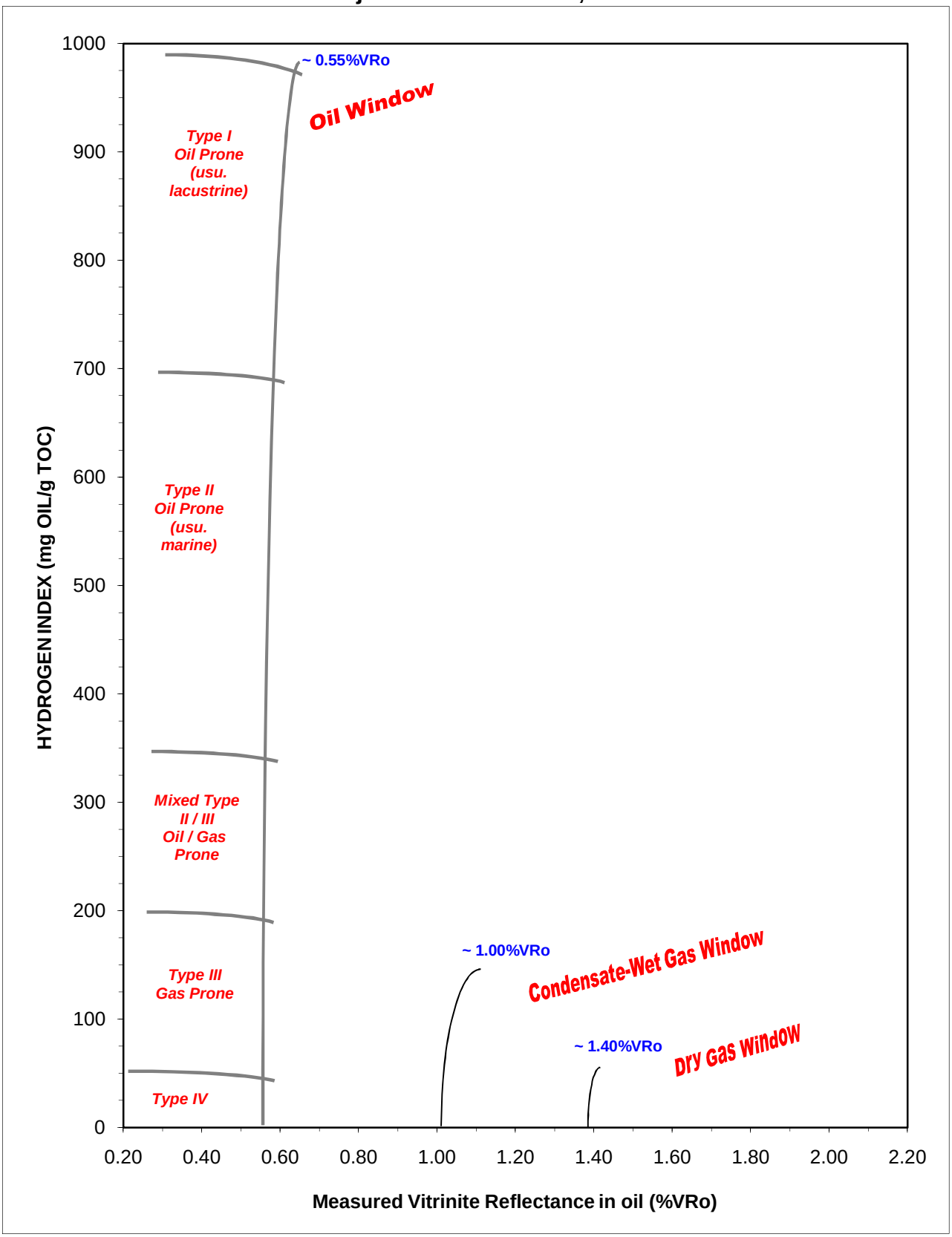

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

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PRICE #1 - 11

AGC Project - Arkoma Basin, Arkansas

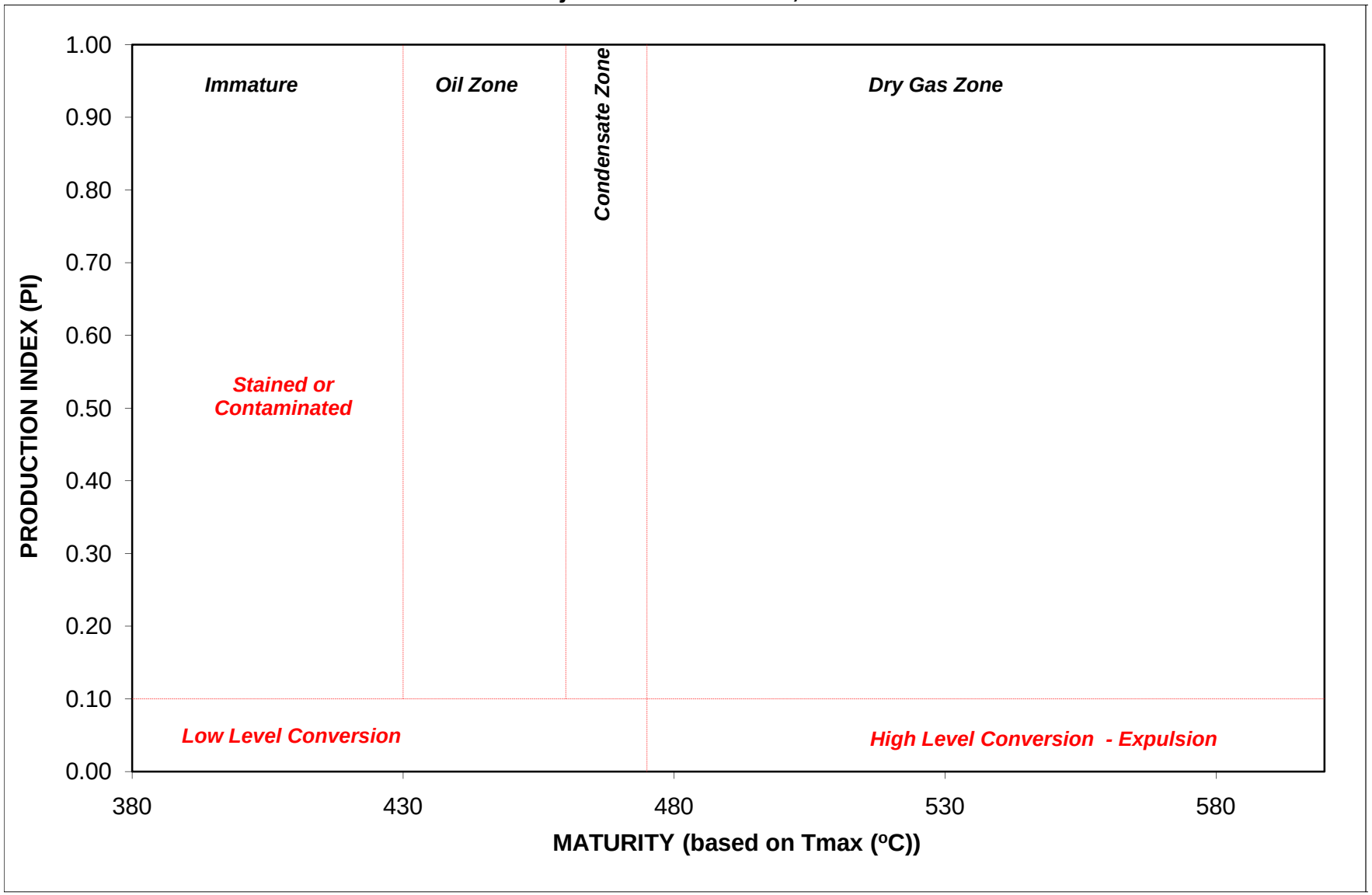

Figure 5a. Kerogen conversion and maturity (based on Tmax).

PRICE #1 - 11

AGC Project - Arkoma Basin, Arkansas

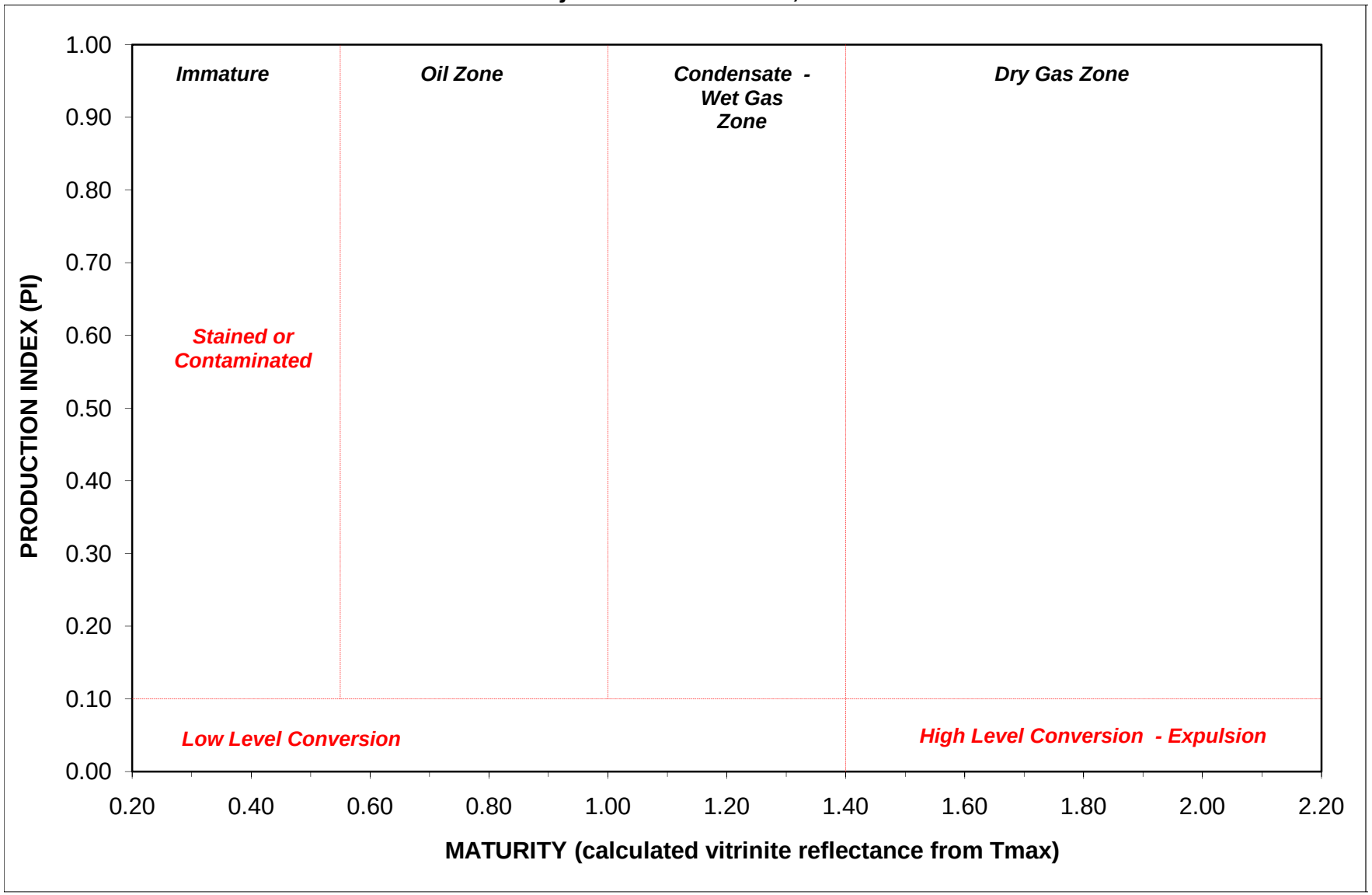

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

PRICE #1 - 11

AGC Project - Arkoma Basin, Arkansas

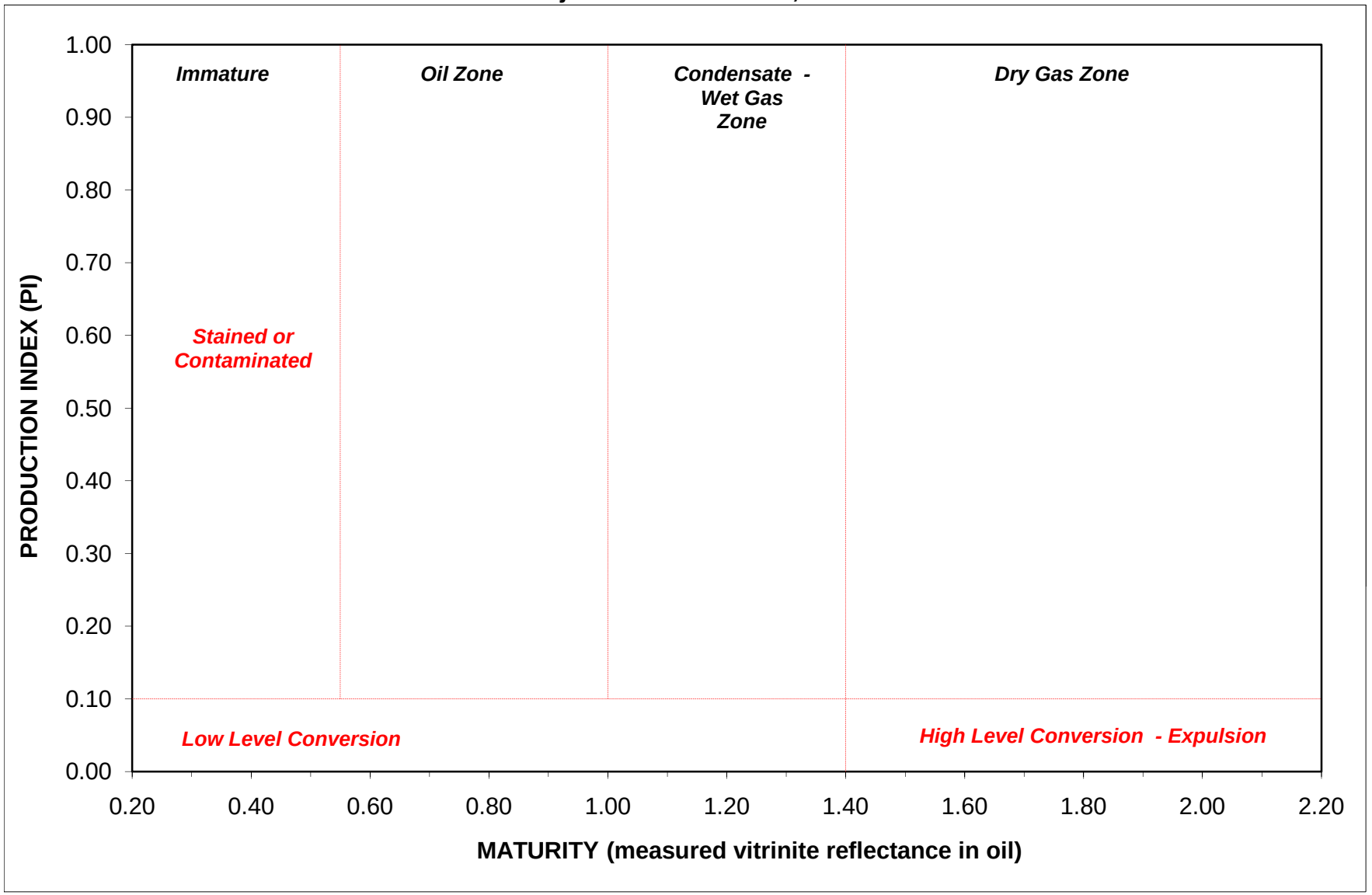

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 11. Geochemical and thermal maturity analyses for the well cutting samples from the Skinner #11

SKINNER #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-163537	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	5590	5620	5605		cuttings	pWR	1.75	1.36	0.40	0.41	1.22	365	*	-1.00	1.79	D	23	70	0	23	0.49
06-3936-163539	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	7660	7690	7675		cuttings	pWR	1.83	1.44	0.34	0.50	1.14	400		-1.00	2.97	E	27	62	0	19	0.40
06-3936-163540	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8650	8670	8660		cuttings	pWR	1.40	0.97	0.15	0.12	0.94	329	*	-1.00			9	67	0	11	0.56
06-3936-163541	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9480	9520	9500		cuttings	pWR	0.98	0.55	0.12	0.16	0.58	475	*	1.39			16	59	0	12	0.43
06-3936-163542	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8500	8530	8515		cuttings	pWR	0.97	0.62	0.17	0.10	0.87	422	*	0.44			10	90	0	18	0.63
06-3936-163543	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8530	8560	8545		cuttings	pWR	1.00	0.58	0.13	0.09	0.86	304	*	-1.00			9	86	0	13	0.59
06-3936-163544	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8560	8590	8575		cuttings	pWR	0.84	0.62	0.14	0.13	0.78	381	*	-1.00			15	93	0	17	0.52
06-3936-163545	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8590	8620	8605		cuttings	pWR	1.30	1.00	0.13	0.15	0.89	334	*	-1.00			12	68	0	10	0.46
06-3936-163546	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8620	8650	8635		cuttings	pWR	1.37	1.04	0.15	0.14	0.86	302	*	-1.00			10	63	0	11	0.52
06-3936-163547	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8650	8680	8665		cuttings	pWR	1.34	1.01	0.15	0.14	0.91	302	*	-1.00			10	68	0	11	0.52
06-3936-163548	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8680	8710	8695		cuttings	pWR	1.04	0.74	0.12	0.09	0.80	309	*	-1.00			9	77	0	12	0.57
06-3936-163549	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8710	8740	8725		cuttings	pWR	1.23	0.75	0.12	0.08	0.79	304	*	-1.00			7	64	0	10	0.60
06-3936-163550	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8740	8770	8755		cuttings	pWR	1.12	0.83	0.13	0.10	0.89	307	*	-1.00			9	79	0	12	0.57
06-3936-163551	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8770	8800	8785		cuttings	pWR	1.10	0.70	0.09	0.08	0.83	0	*	-1.00			7	75	0	8	0.53
06-3936-163552	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8800	8830	8815		cuttings	pWR	1.20	0.84	0.13	0.18	0.99	416	*	0.33			15	82	0	11	0.42
06-3936-163553	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8830	8860	8845		cuttings	pWR	1.07	0.80	0.09	0.05	0.96	0	*	-1.00			5	90	0	8	0.64
06-3936-163554	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8860	8890	8875		cuttings	pWR	1.22	0.84	0.10	0.05	0.79	0	*	-1.00			4	65	0	8	0.67
06-3936-163555	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8890	8920	8905		cuttings	pWR	1.82	1.82	0.35	0.15	0.93	300	*	-1.00	1.42	E	8	51	0	19	0.70
06-3936-163556	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8920	8950	8935		cuttings	pWR	1.74	1.46	0.30	0.15	0.89	302	*	-1.00			9	51	0	17	0.67
06-3936-163557	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8950	8980	8965		cuttings	pWR	1.79	1.72	0.33	0.11	0.93	0	*	-1.00			6	52	0	18	0.75
06-3936-163558	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	8980	9020	9000		cuttings	pWR	1.83	1.64	0.27	0.10	1.02	304	*	-1.00			5	56	0	15	0.73
06-3936-163559	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9020	9030	9025	Fayetteville	cuttings	pWR	1.83	1.57	0.33	0.20	0.93	327	*	-1.00			11	51	0	18	0.62
06-3936-163560	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9030	9040	9035	Fayetteville	cuttings	pWR	1.74	1.62	0.34	0.20	0.93	369	*	-1.00			11	53	0	20	0.63
06-3936-163561	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9040	9050	9045	Fayetteville	cuttings	pWR	1.64	1.56	0.35	0.26	1.04	372	*	-1.00			16	63	0	21	0.57
06-3936-163562	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9050	9060	9055	Fayetteville	cuttings	pWR	1.73	1.50	0.34	0.16	0.89	373	*	-1.00			9	51	0	20	0.68
06-3936-163563	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9060	9070	9065	Fayetteville	cuttings	pWR	1.61	1.54	0.28	0.14	0.98	351	*	-1.00			9	61	0	17	0.67
06-3936-163564	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9070	9080	9075	Fayetteville	cuttings	pWR	2.66	2.98	0.50	0.29	1.04	369	*	-1.00			11	39	0	19	0.63
06-3936-163566	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9090	9100	9095		cuttings	pWR	3.24	3.44	0.62	0.44	1.03	363	*	-1.00			14	32	0	19	0.58
06-3936-163567	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9100	9130	9115		cuttings	pWR	2.24	2.41	0.42	0.18	0.84	343	*	-1.00			8	37	0	19	0.70
06-3936-163568	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9130	9160	9145		cuttings	pWR	2.09	2.10	0.38	0.12	0.75	309	*	-1.00			6	36	0	18	0.76
06-3936-163569	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9160	9190	9175		cuttings	pWR	1.67	1.71	0.30	0.11	0.75	302	*	-1.00			7	45	0	18	0.73
06-3936-163570	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9190	9220	9205		cuttings	pWR	1.74	1.61	0.26	0.19	0.81	302	*	-1.00			11	47	0	15	0.58
06-3936-163571	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9220	9250	9235		cuttings	pWR	1.88	1.68	0.31	0.20	0.83	335	*	-1.00			11	44	0	16	0.61
06-3936-163572	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9250	9280	9265	Chattanooga	cuttings	pWR	1.45	1.44	0.29	0.19	0.90	325	*	-1.00			13	62	0	20	0.60
06-3936-163573	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9280	9310	9295	Chattanooga	cuttings	pWR	2.02	2.12	0.33	0.14	0.93	364	*	-1.00			7	46	0	16	0.70
06-3936-163574	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9310	9320	9315	Chattanooga	cuttings	pWR	3.40	4.00	0.62	0.34	1.04	359	*	-1.00			10	31	0	18	0.65
06-3936-163575	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9320	9330	9325	Chattanooga	cuttings	pWR	6.86	7.70	1.08	0.56	1.12	357		-1.00			8	16	1	16	0.66
06-3936-163576	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9330	9340	9335	Chattanooga	cuttings	pWR	5.60	6.56	0.95	0.60	1.29	353		-1.00			11	23	0	17	0.61
06-3936-163577	Arkoma	03131000810000	SHELL OIL CO	SKINNER	1	SEBASTIAN	AR	9340	9350	9345		cuttings	pWR	0.00	1.70	0.33	0.19	0.89	354	*	-1.00			11	52	0	19	0.63

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

SKINNER #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

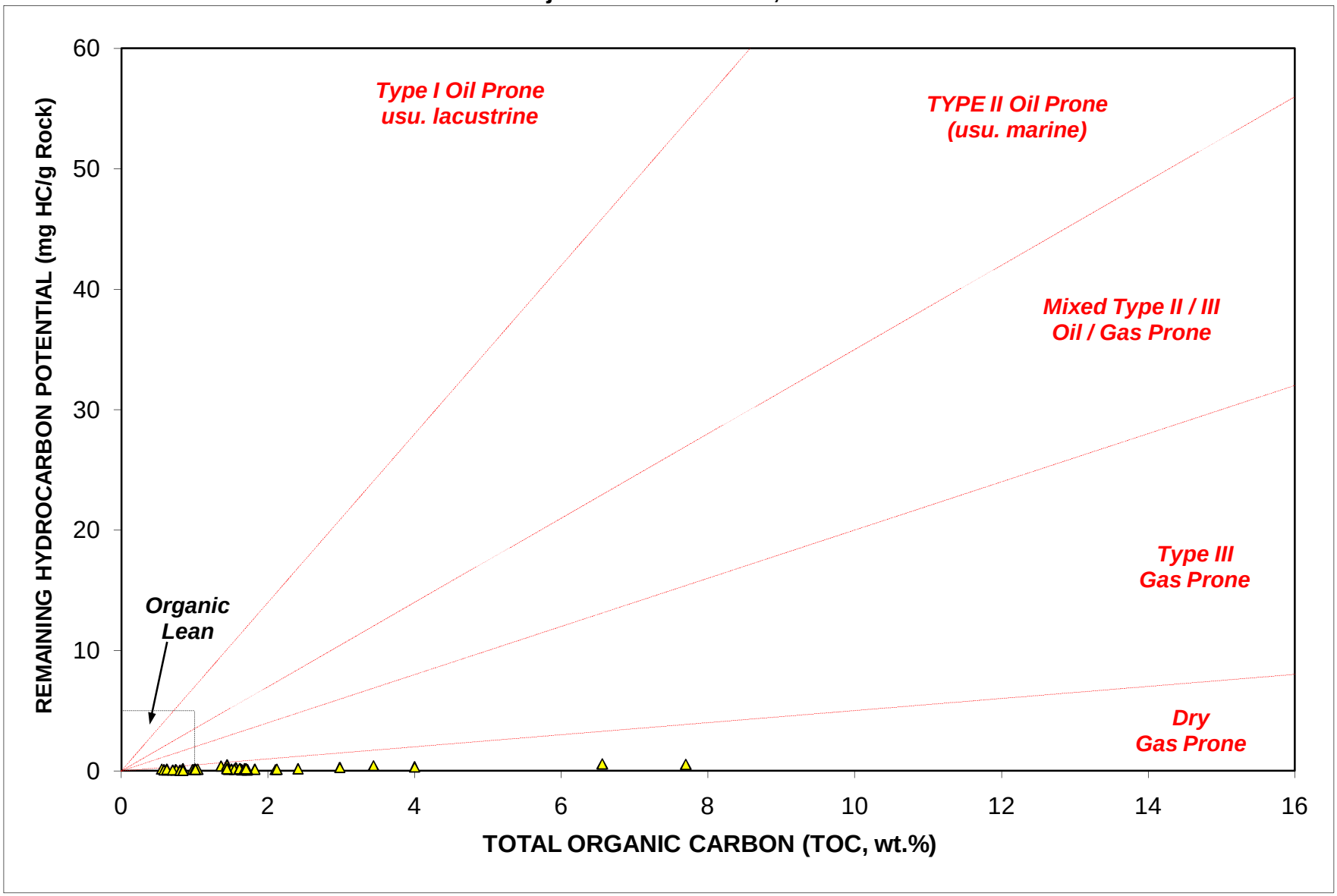

Figure 2. Kerogen Quality

Humble Geochemical Services Division

SKINNER #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

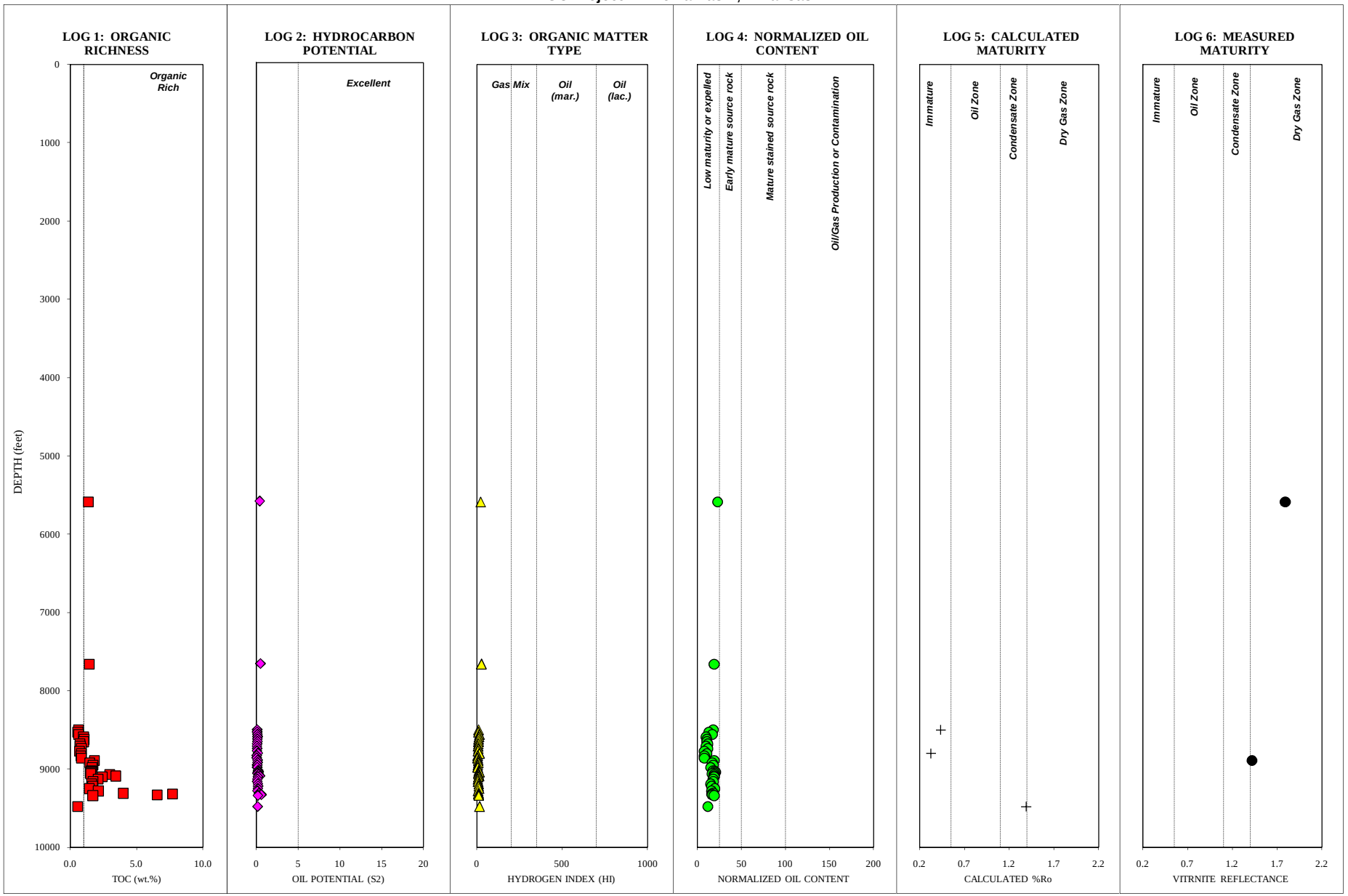

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

SKINNER #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

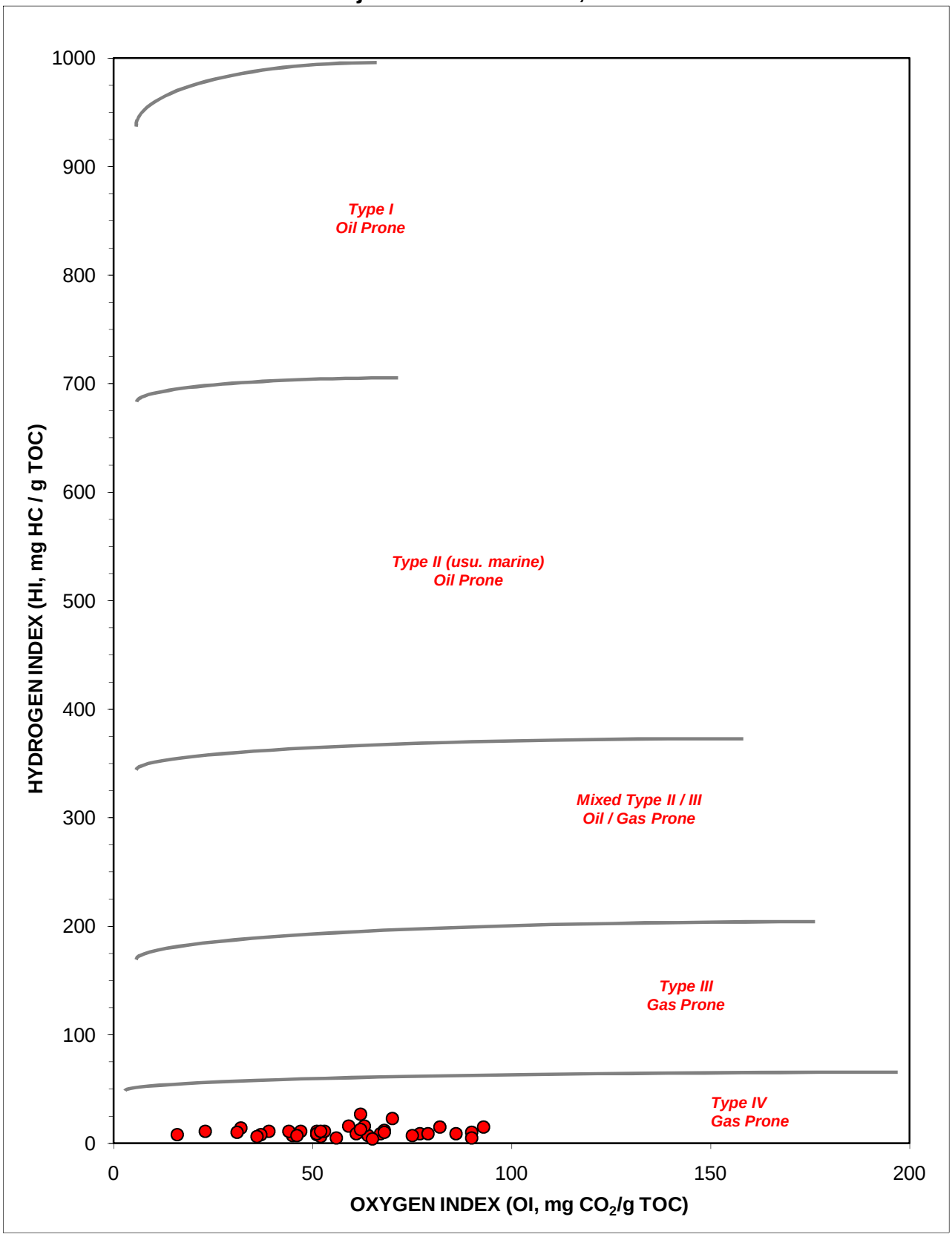

Figure 3. Kerogen type

SKINNER #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

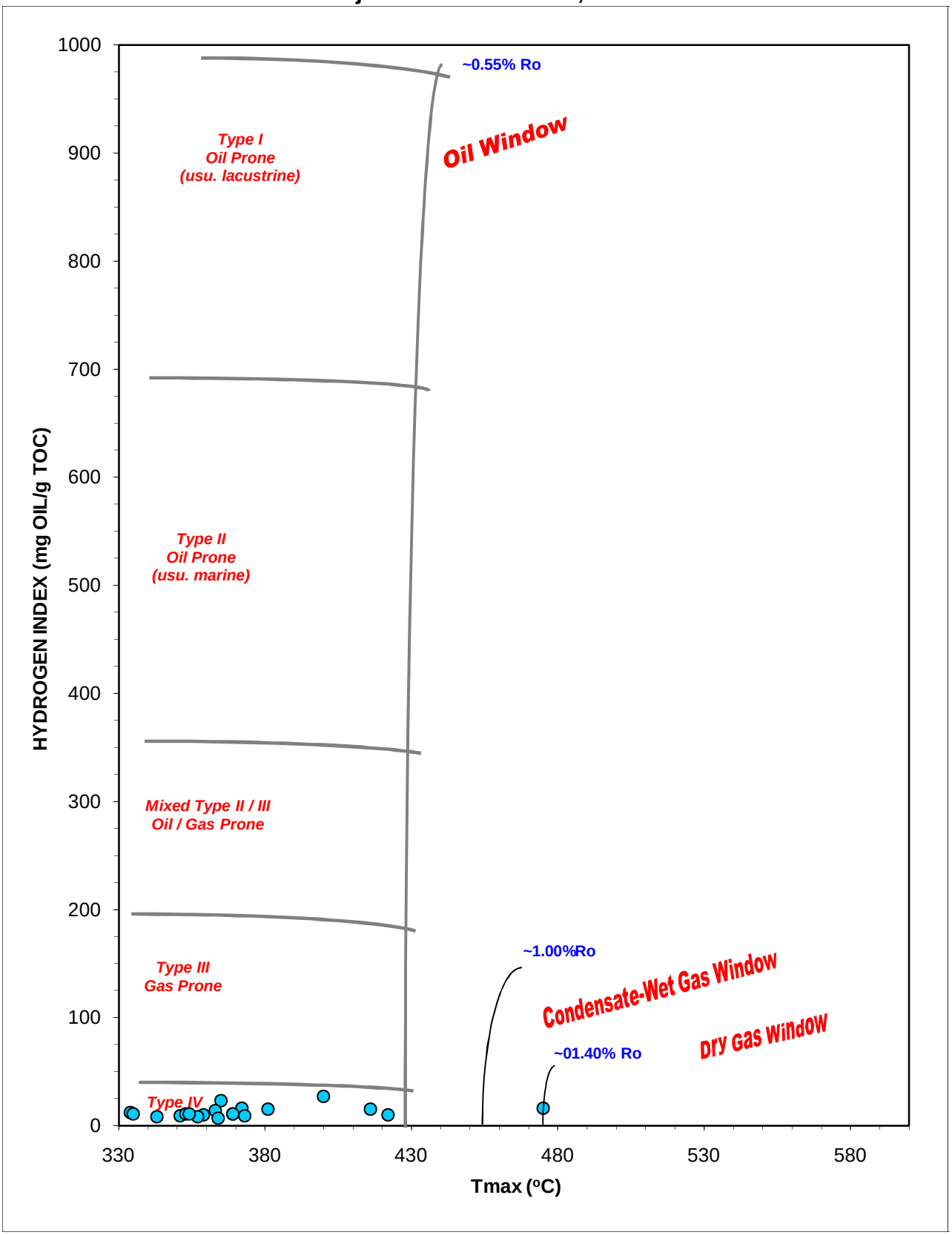

Figure 4a. Kerogen Type and Maturity (Tmax)

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SKINNER #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

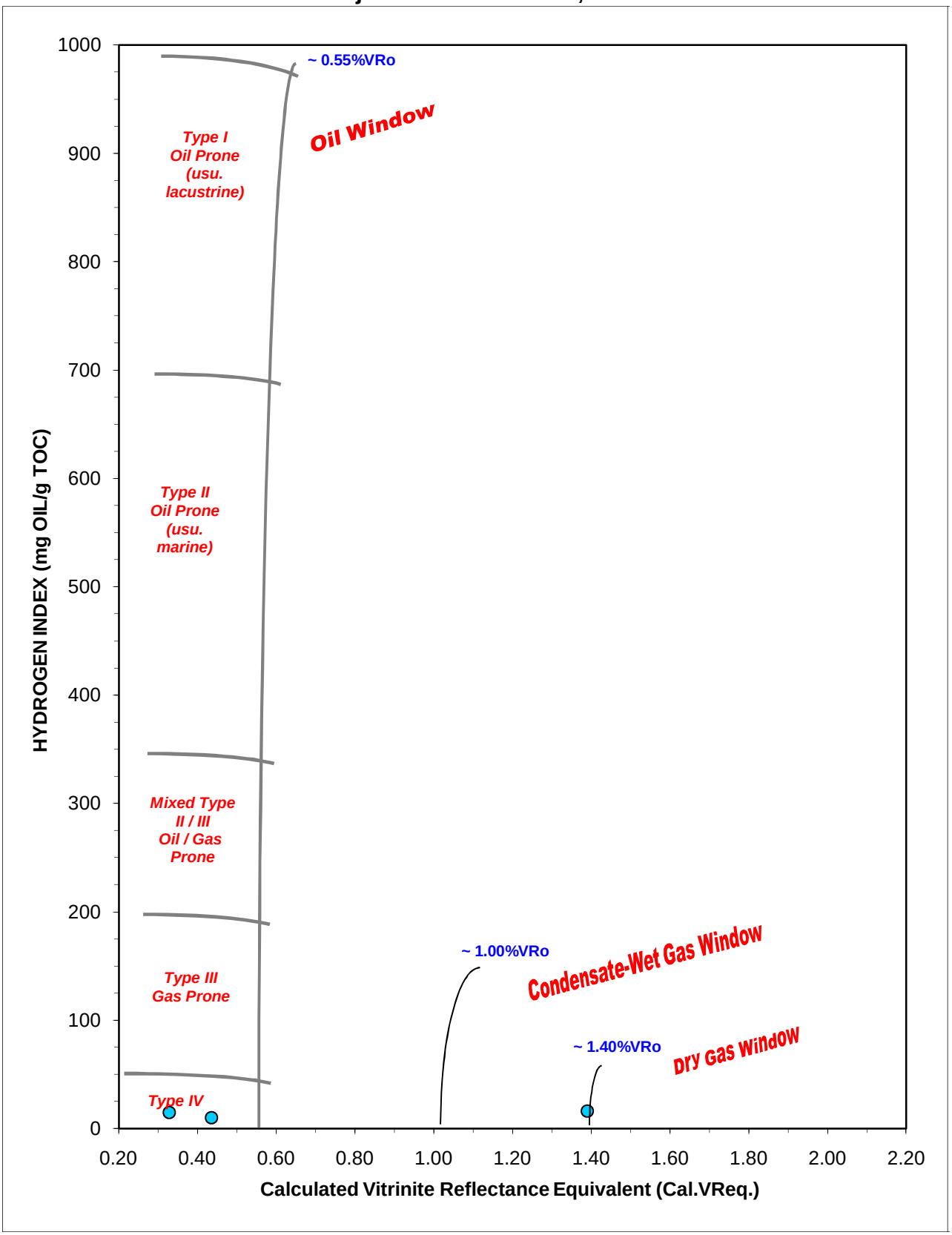

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

SKINNER #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

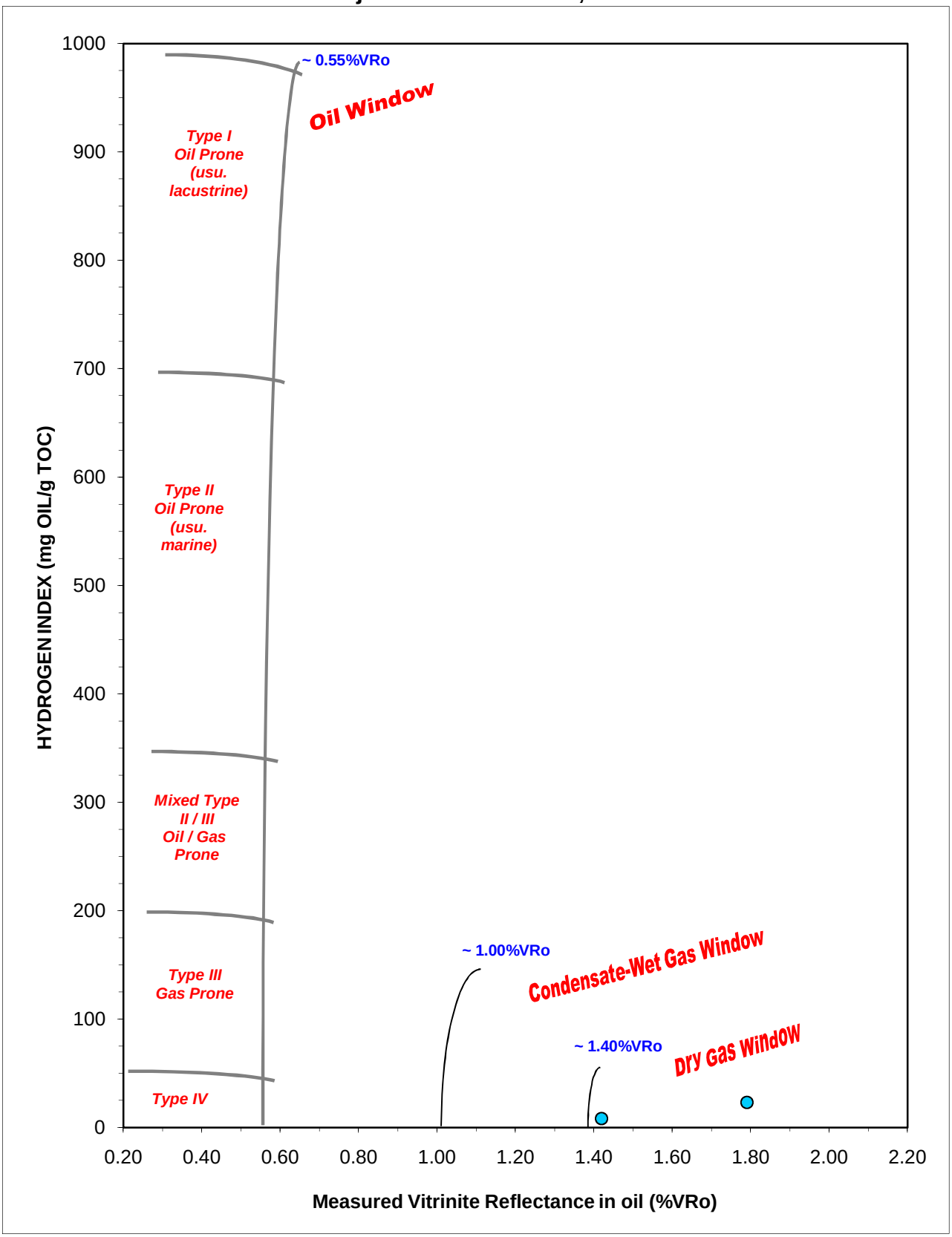

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

SKINNER #1

AGC Project - Arkoma Basin, Arkansas

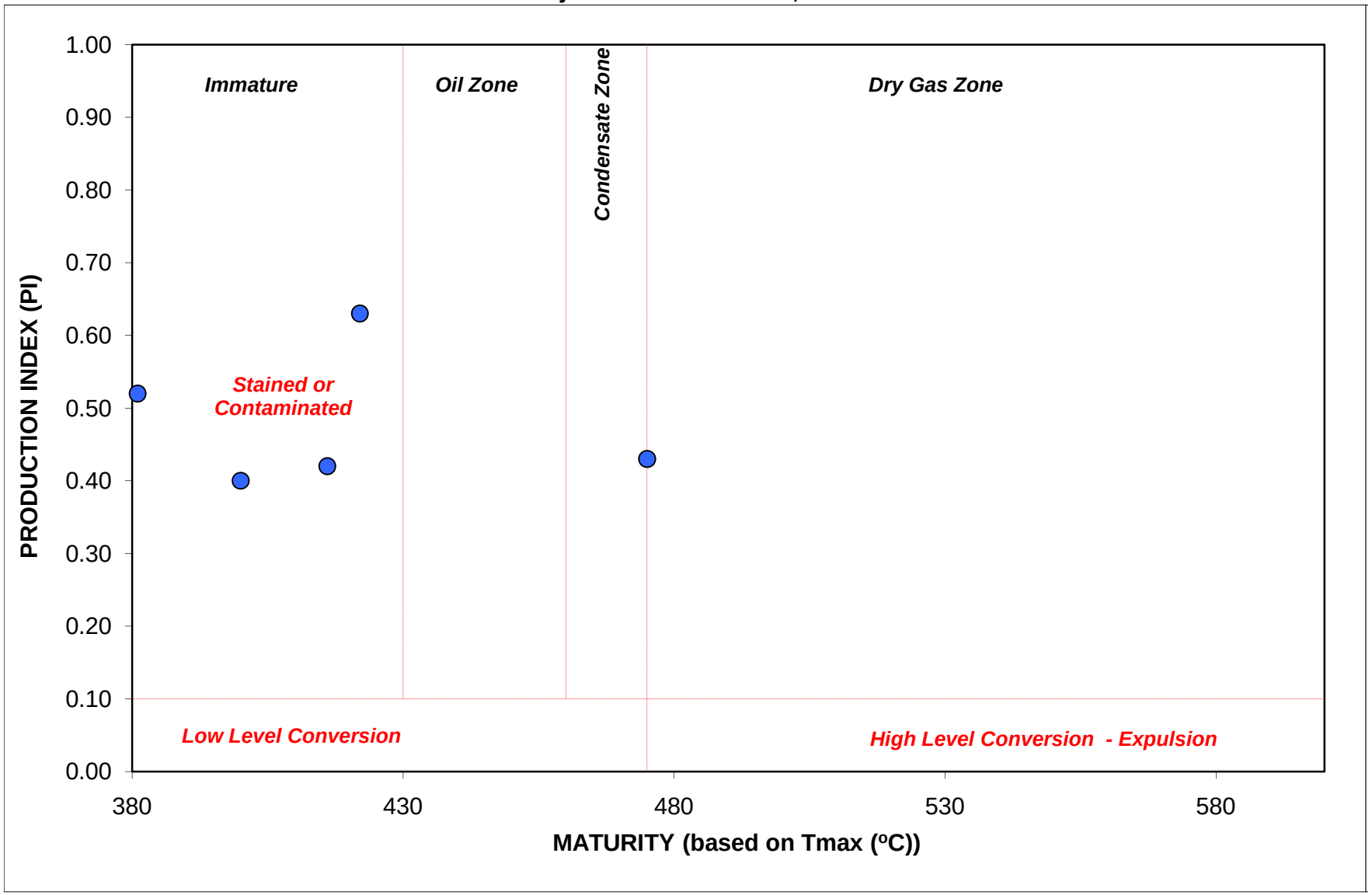

Figure 5a. Kerogen conversion and maturity (based on Tmax).

SKINNER #1

AGC Project - Arkoma Basin, Arkansas

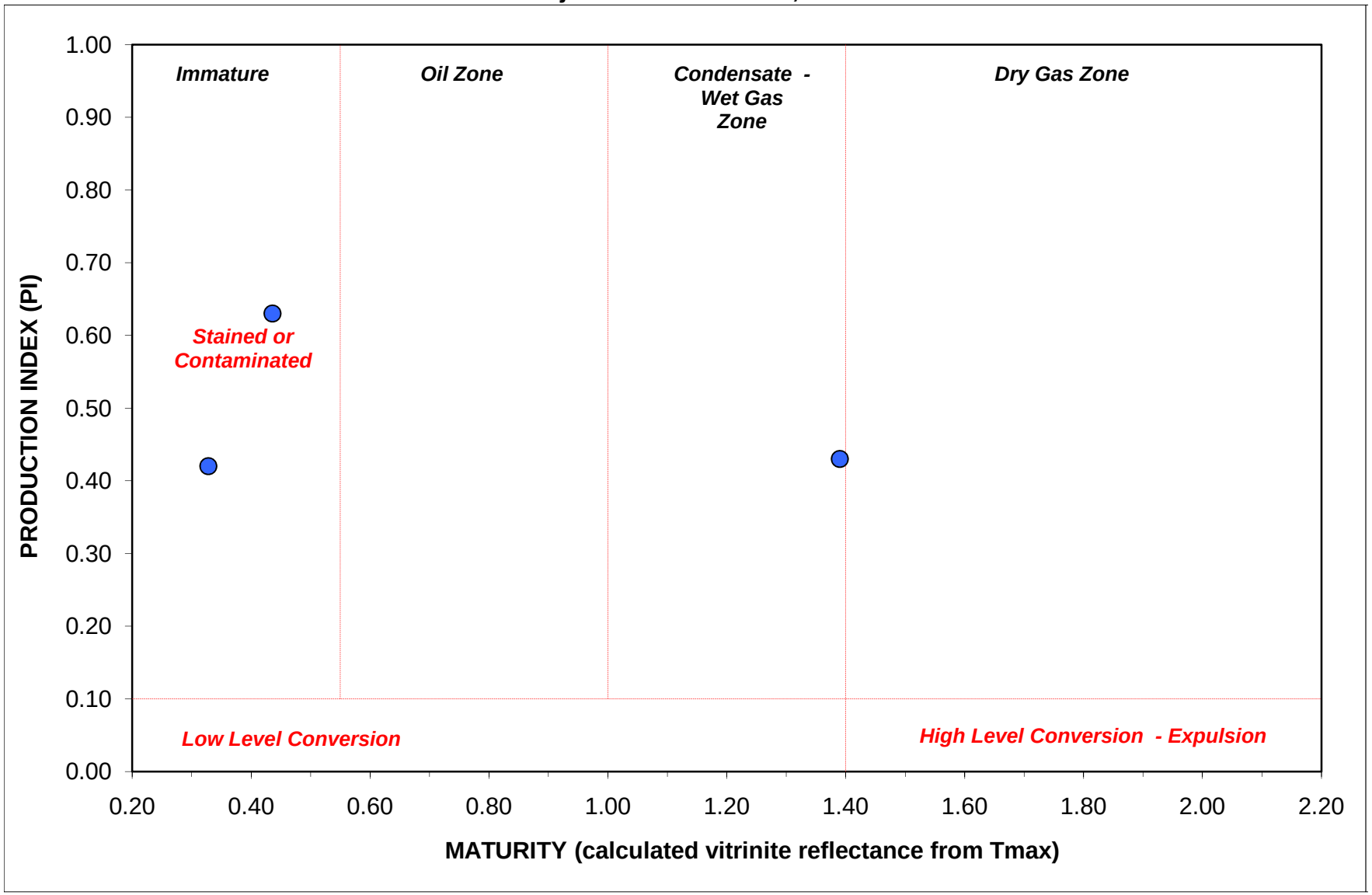

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

SKINNER #1

AGC Project - Arkoma Basin, Arkansas

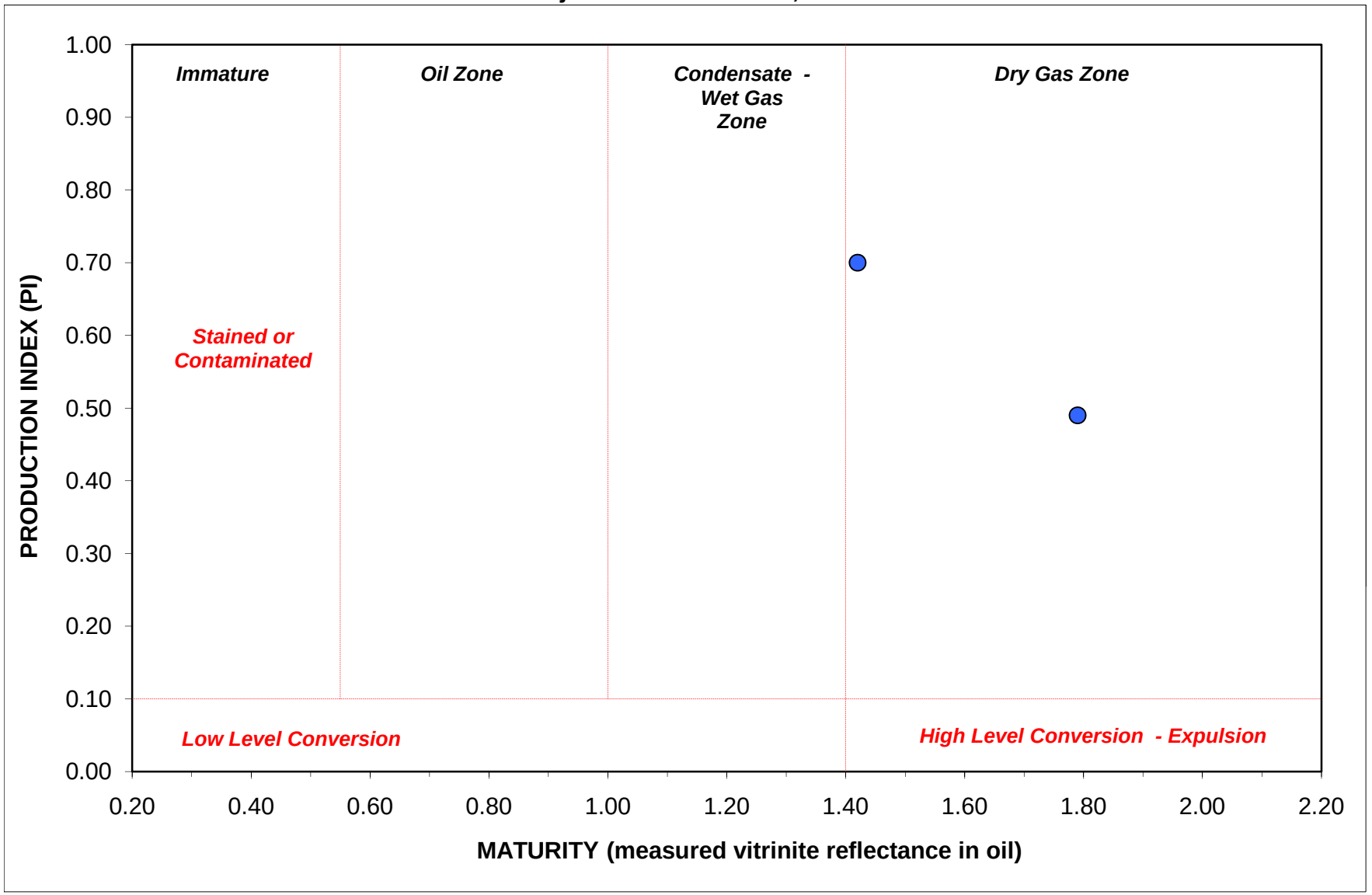

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 12. Geochemical and thermal maturity analyses for the well cutting samples from the USA #1

USA #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-3936-157799	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	4600	4630	4615		cuttings	pWR	1.95	1.69	0.85	1.79	0.73	363		-1.00	2.03	D	92	37	2	44	0.32
06-3936-157800	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	4990	5010	5000		cuttings	pWR	0.89	0.51	0.28	0.43	0.44	359	*	-1.00			48	49	1	31	0.39
06-3936-157801	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	5500	5520	5510		cuttings	pWR	0.62	0.36	0.14	0.14	0.43	403	*	0.09			23	69	0	23	0.50
06-3936-157802	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6090	6100	6095	Fayetteville	cuttings	pWR	1.13	0.80	0.35	0.51	0.35	365		-1.00			45	31	1	31	0.41
06-3936-157803	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6100	6110	6105	Fayetteville	cuttings	pWR	1.39	1.07	0.60	0.97	0.50	370		-1.00			70	36	2	43	0.38
06-3936-157804	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6110	6120	6115	Fayetteville	cuttings	pWR	1.57	1.26	1.02	1.96	0.58	372		-1.00			125	37	3	65	0.34
06-3936-157805	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6120	6130	6125	Fayetteville	cuttings	pWR	1.53	1.15	0.95	1.89	0.57	373		-1.00			124	37	3	62	0.33
06-3936-157806	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6130	6140	6135	Fayetteville	cuttings	pWR	1.30	1.00	0.49	0.81	0.50	365		-1.00			62	38	2	38	0.38
06-3936-157807	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6140	6150	6145	Fayetteville	cuttings	pWR	1.29	1.02	0.43	0.79	0.46	373		-1.00			61	36	2	33	0.35
06-3936-157808	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6150	6160	6155		cuttings	pWR	1.38	1.09	0.50	1.07	0.54	377		-1.00			78	39	2	36	0.32
06-3936-157809	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6160	6190	6175		cuttings	pWR	2.71	2.75	0.78	0.86	0.48	365		-1.00	2.12	C	32	18	2	29	0.48
06-3936-157810	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6190	6220	6205		cuttings	pWR	1.66	1.44	1.63	2.97	0.46	379		-1.00			179	28	6	98	0.35
06-3936-157811	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6220	6250	6235		cuttings	pWR	1.44	1.23	1.61	2.35	0.44	385		-1.00			163	31	5	112	0.41
06-3936-157812	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6250	6280	6265		cuttings	pWR	1.24	1.02	2.31	2.66	0.50	374		-1.00			215	40	5	186	0.46
06-3936-157813	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6280	6310	6295		cuttings	pWR	0.96	0.69	0.45	0.83	0.54	383		-1.00			86	56	2	47	0.35
06-3936-157814	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6310	6340	6325		cuttings	pWR	0.91	0.60	0.26	0.25	0.41	374	*	-1.00			27	45	1	29	0.51
06-3936-157815	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6340	6370	6355		cuttings	pWR	0.89	0.61	0.24	0.15	0.40	366	*	-1.00			17	45	0	27	0.62
06-3936-157816	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6430	6440	6435	Chattanooga	cuttings	pWR	0.63	0.36	0.15	0.16	0.37	374	*	-1.00			25	59	0	24	0.48
06-3936-157817	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6440	6450	6445	Chattanooga	cuttings	pWR	1.01	0.70	0.17	0.14	0.29	371	*	-1.00			14	29	0	17	0.55
06-3936-157818	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6450	6460	6455	Chattanooga	cuttings	pWR	0.98	0.68	0.16	0.14	0.28	377	*	-1.00			14	29	1	16	0.53
06-3936-157819	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6460	6470	6465	Chattanooga	cuttings	pWR	0.85	0.54	0.14	0.08	0.25	372	*	-1.00			9	29	0	16	0.64
06-3936-157820	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6470	6480	6475	Chattanooga	cuttings	pWR	0.87	0.64	0.30	0.28	0.36	378	*	-1.00			32	41	1	34	0.52
06-3936-157821	Arkoma	03033100150000	HANNA OIL & GAS CO	U S A	1	CRAWFORD	AR	6480	6490	6485		cuttings	pWR	2.86	2.93	0.50	0.21	0.43	362	*	-1.00	2.46	C	7	15	0	17	0.70

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

USA #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

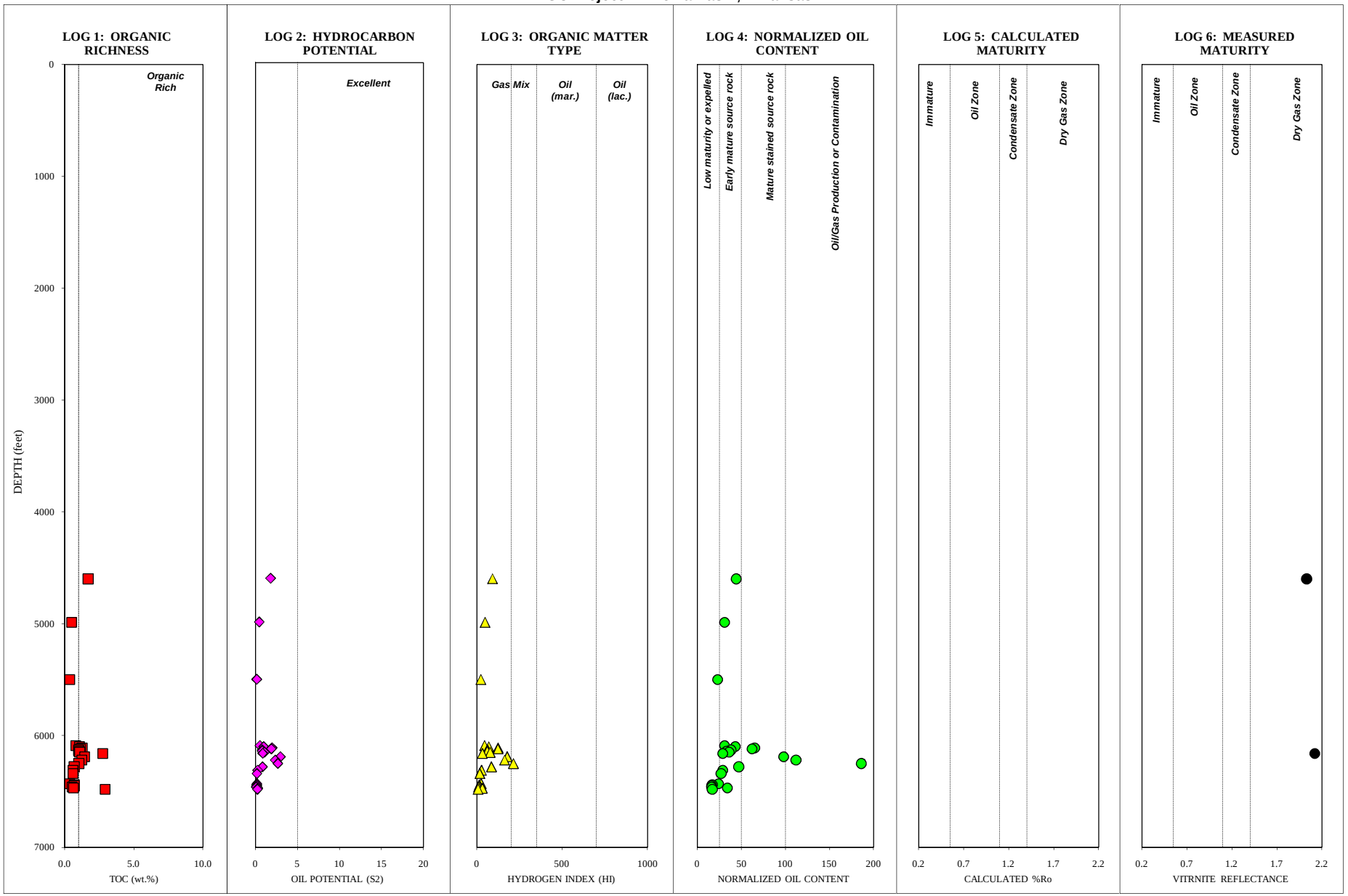

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

USA #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

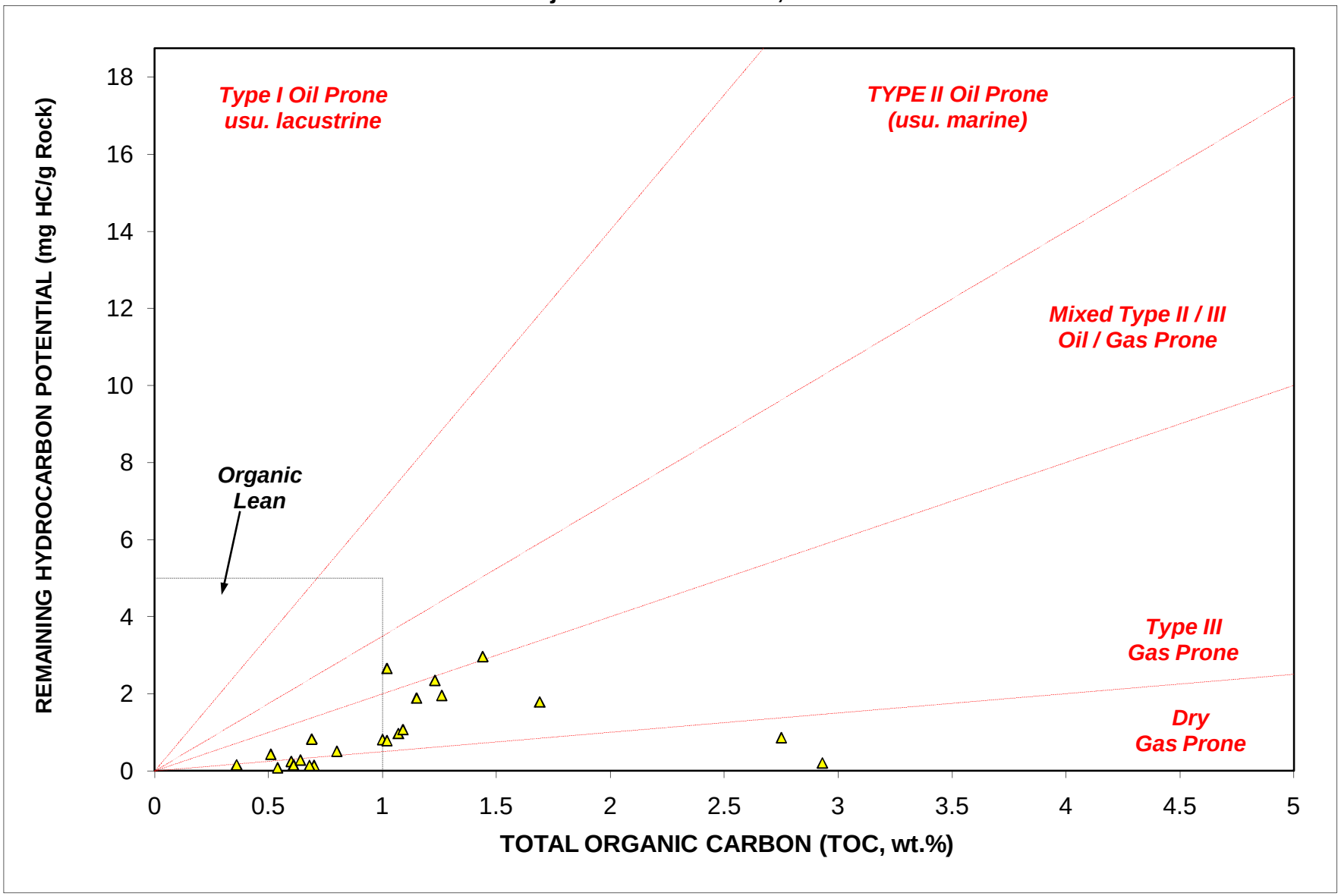

Figure 2. Kerogen Quality

Humble Geochemical Services Division

USA #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

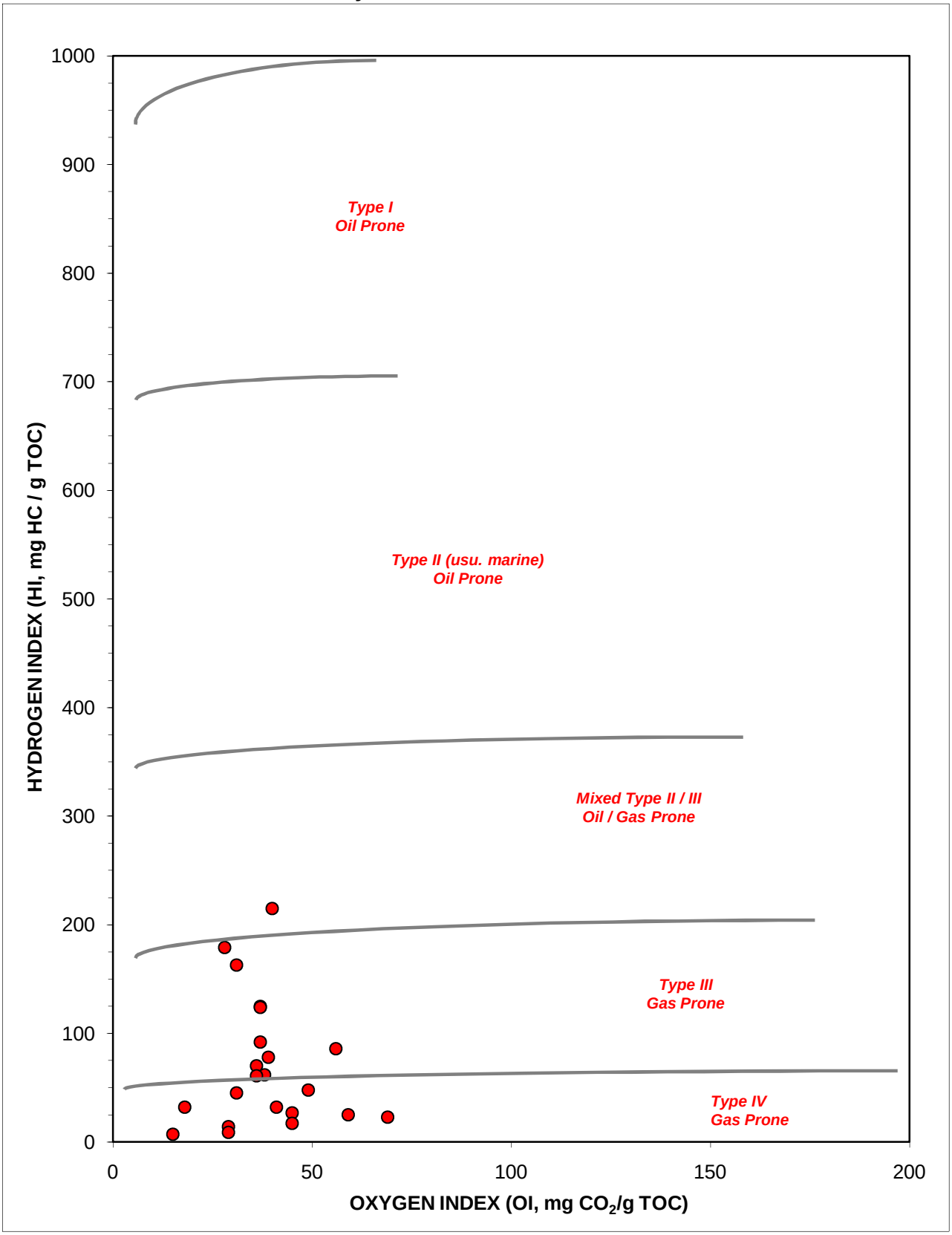

Figure 3. Kerogen type

USA #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

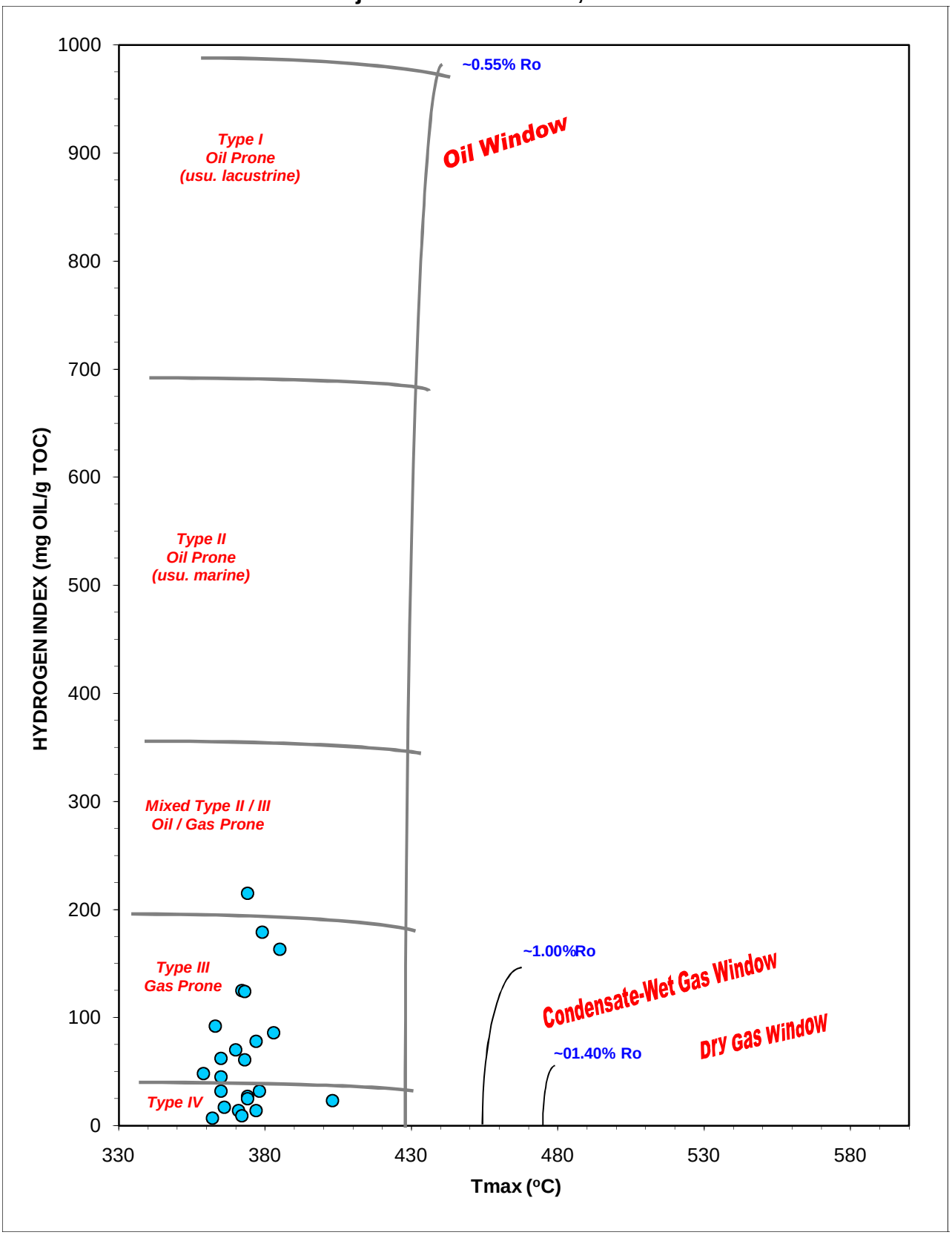

Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

USA #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

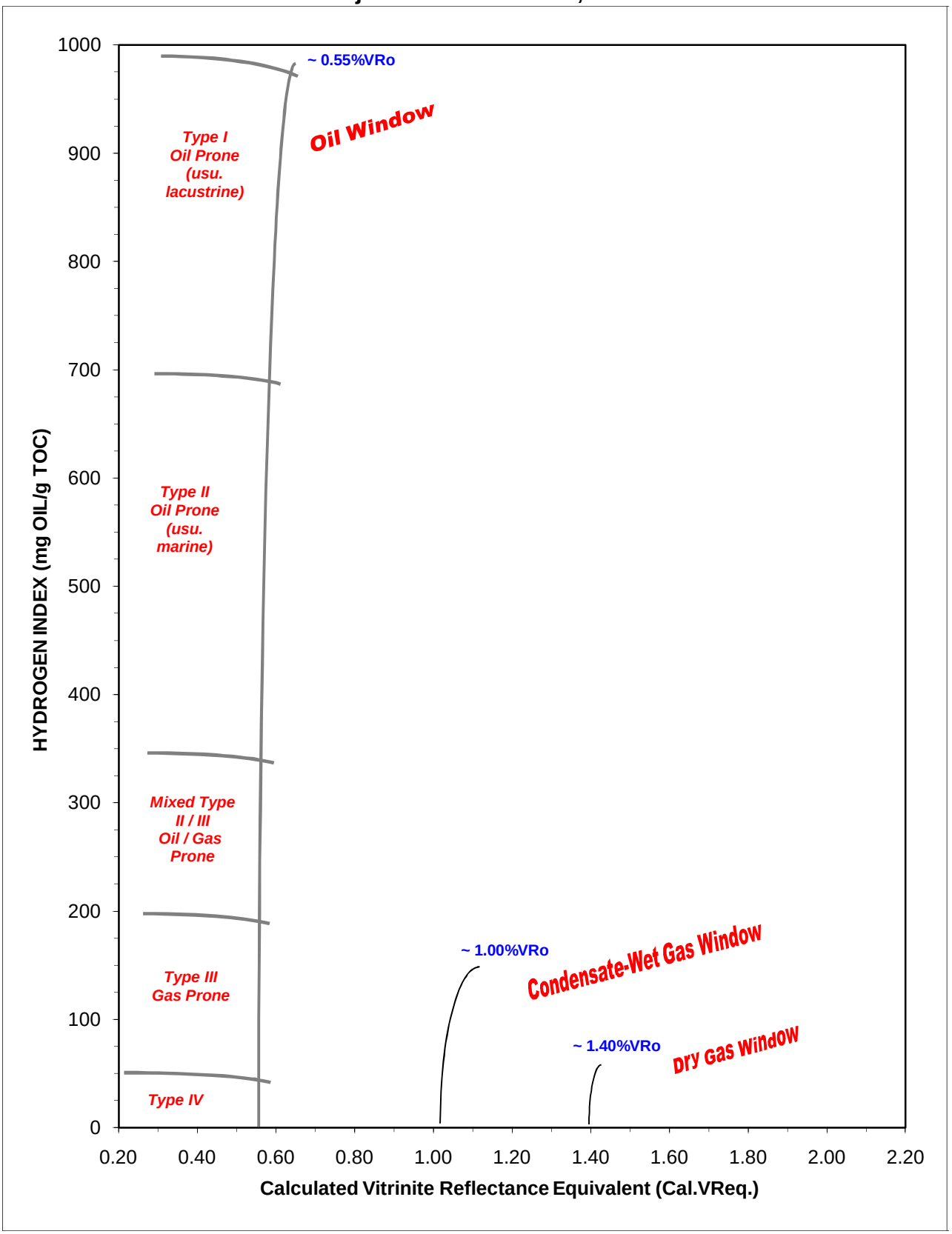

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

USA #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

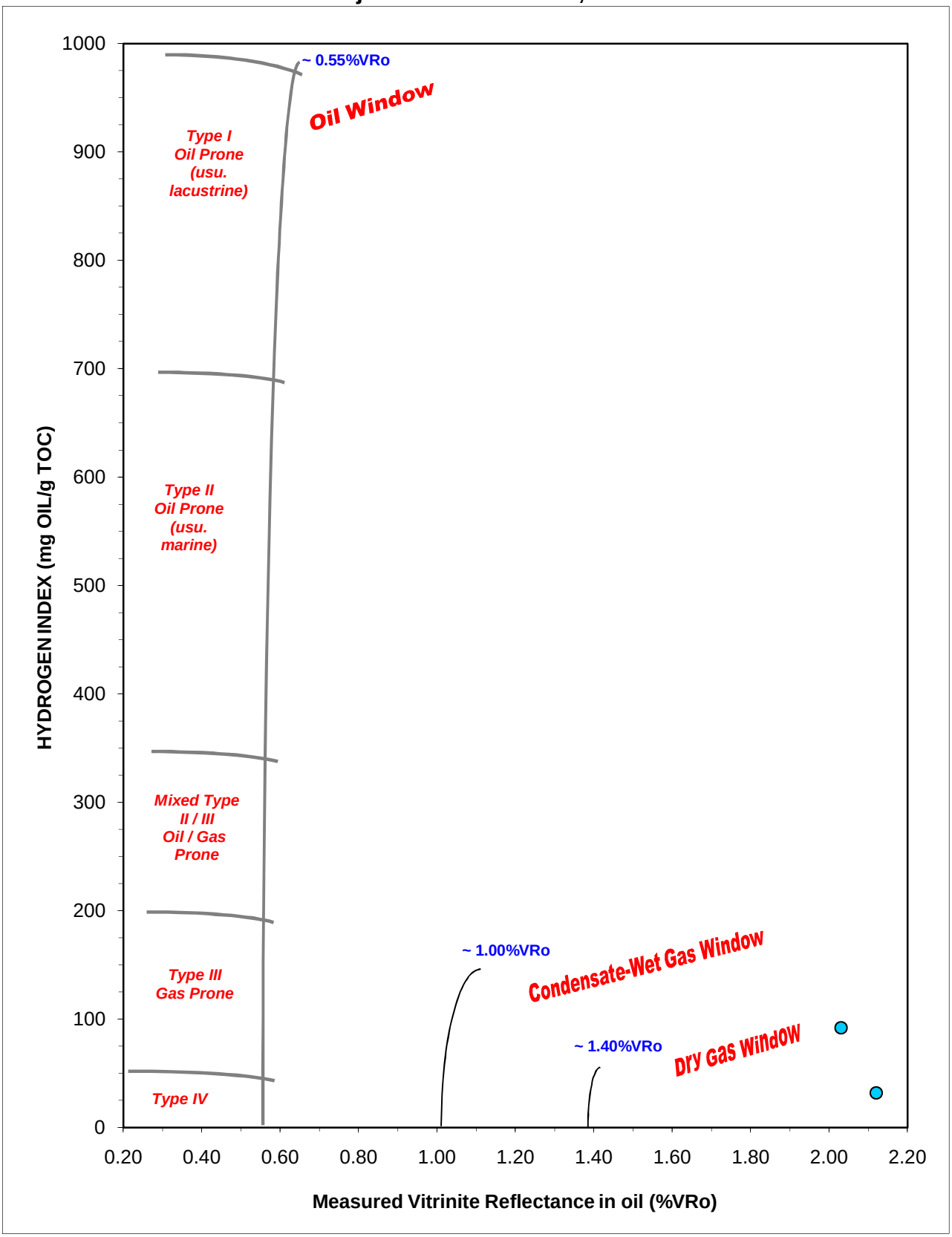

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

USA #1

AGC Project - Arkoma Basin, Arkansas

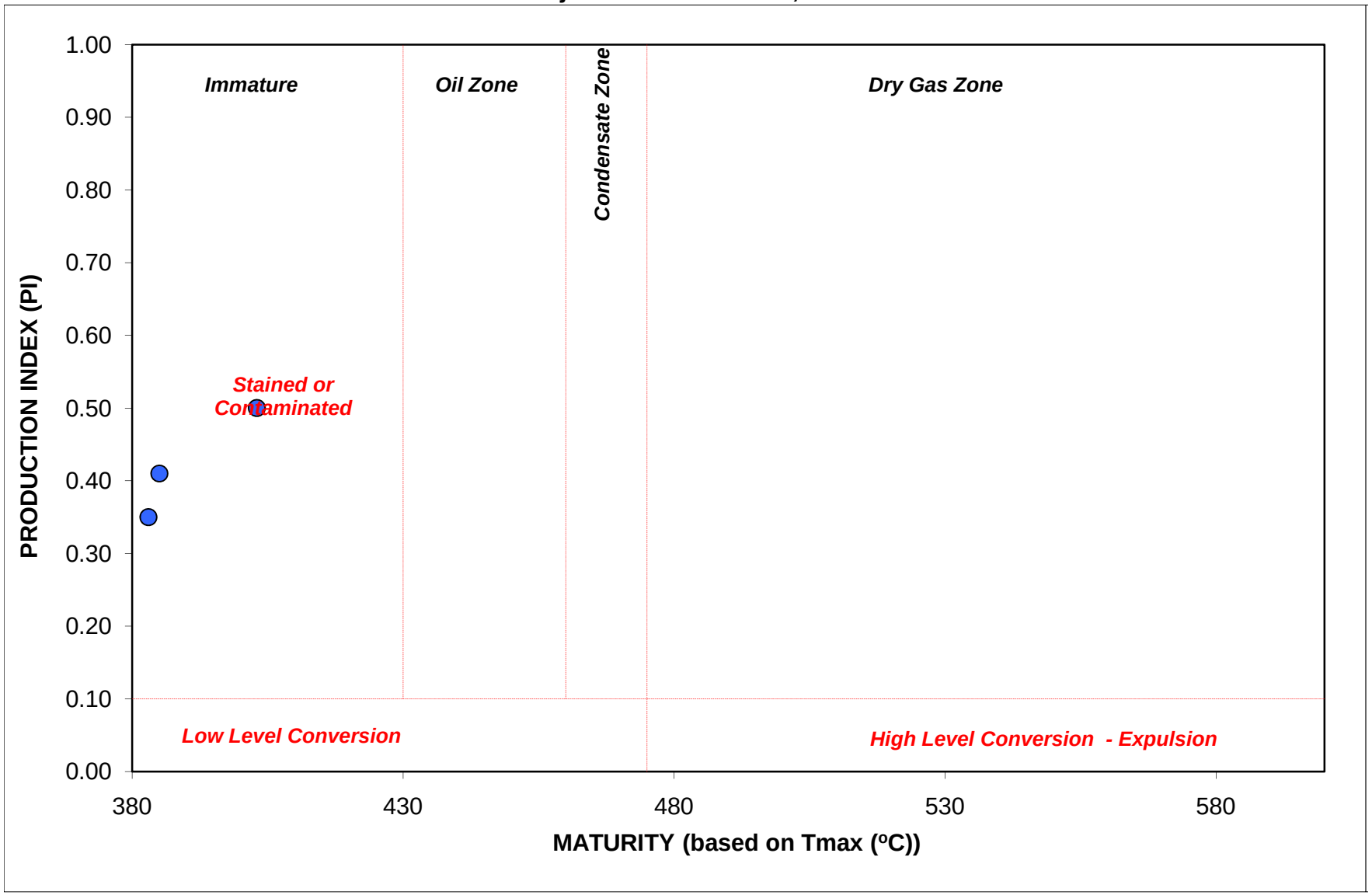

Figure 5a. Kerogen conversion and maturity (based on Tmax).

USA #1

AGC Project - Arkoma Basin, Arkansas

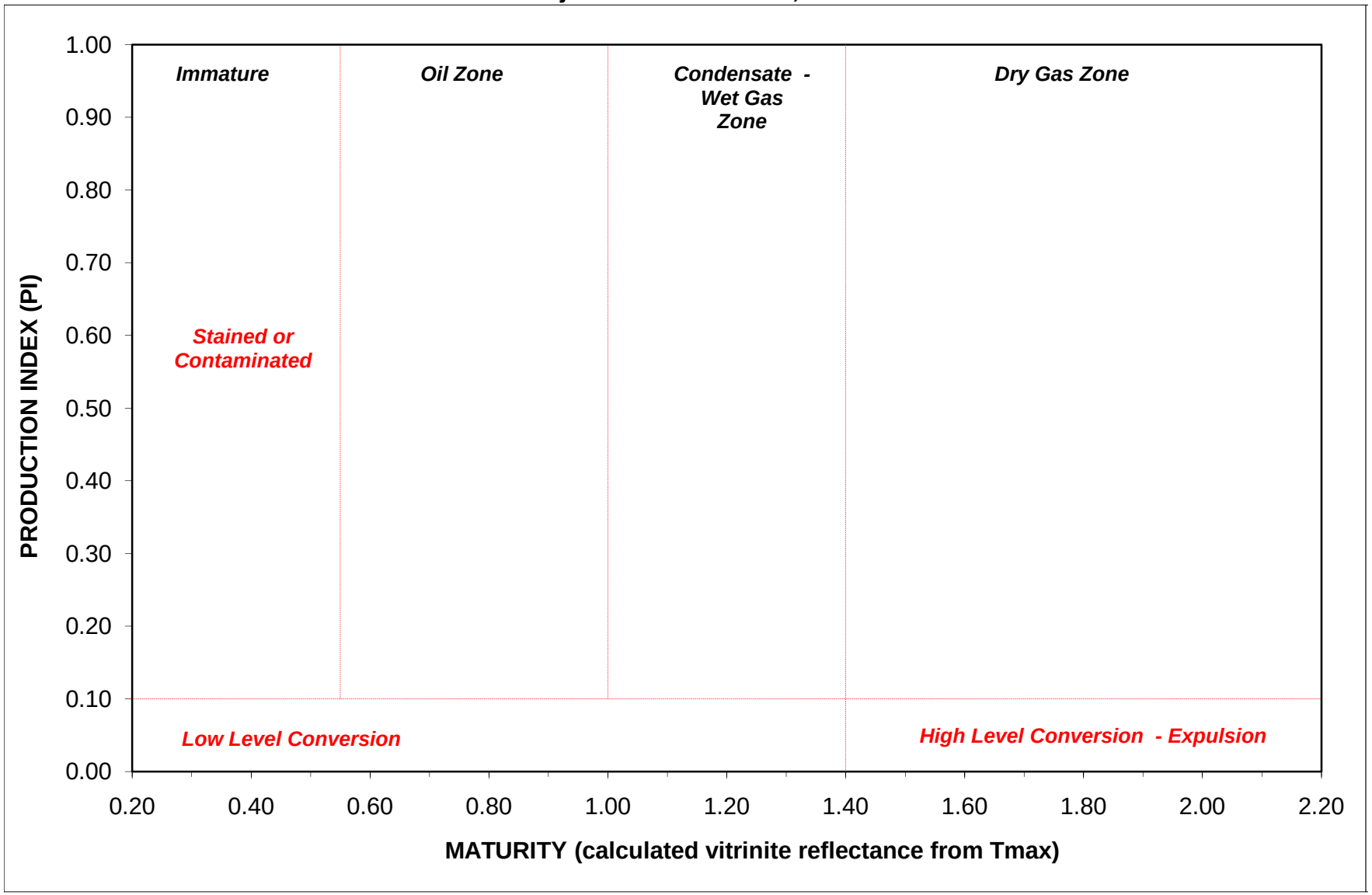

Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

USA #1

AGC Project - Arkoma Basin, Arkansas

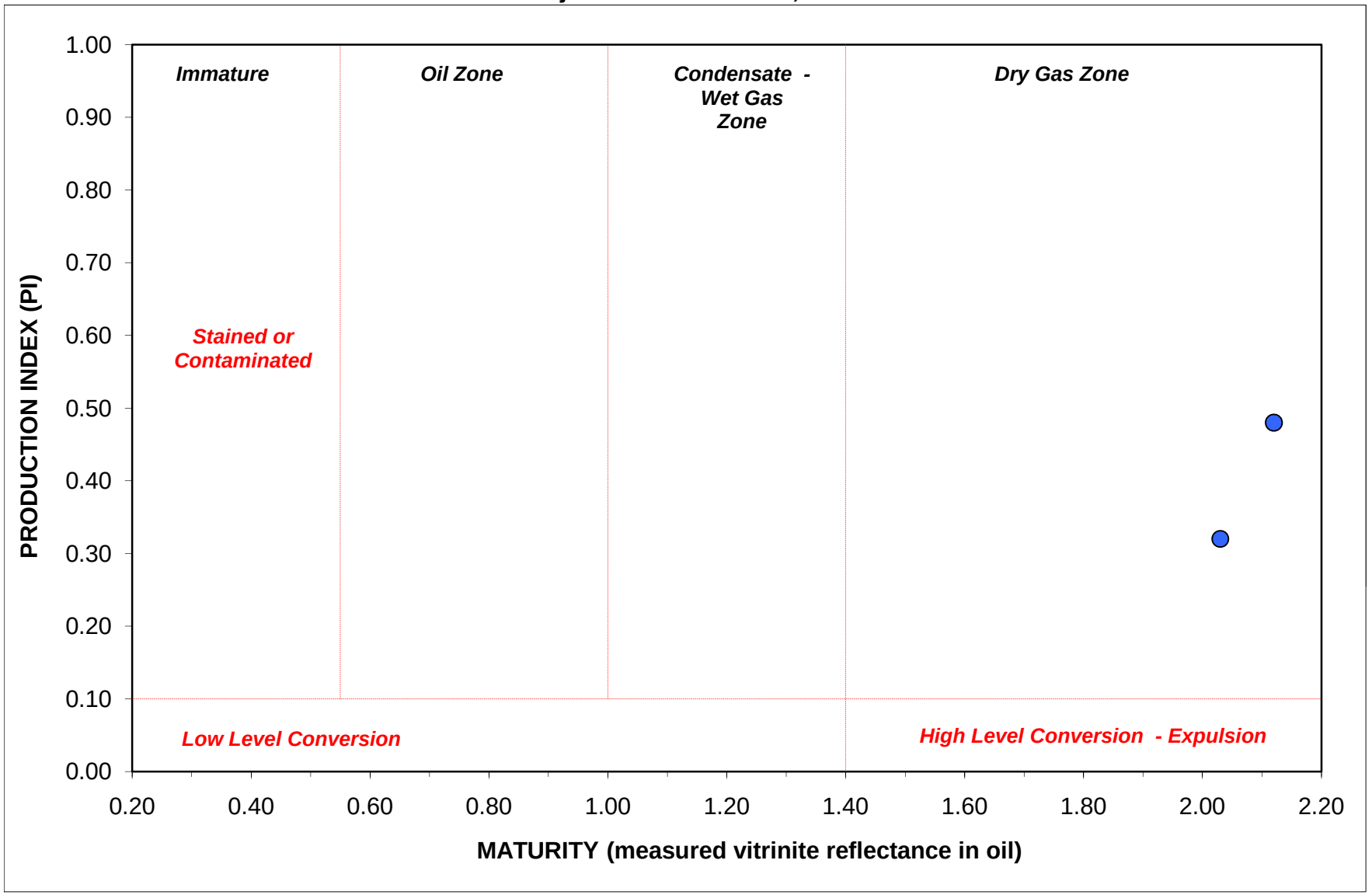

Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 13. Geochemical and thermal maturity analyses for the well cutting samples from the USA #1 - 10

USA #1 - 10

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-4168-165082	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	3900	3920	3910		cuttings	NORM	1.34	1.15	0.31	0.37	1.05	381	*	-1.00	1.29	E	28	78	0	23	0.46
06-4168-165083	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	5000	5020	5010		cuttings	NORM	1.47	1.37	0.28	0.51	0.86	386		-1.00	1.72	E	35	59	1	19	0.35
06-4168-165084	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	6350	6370	6360		cuttings	NORM	1.41	1.16	0.35	0.80	0.72	365		-1.00	2.39	D	57	51	1	25	0.30
06-4168-165085	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	7900	7920	7910		cuttings	NORM	1.22	0.96	0.19	0.27	0.74	353	*	-1.00	2.80	D	22	61	0	16	0.41
06-4168-165086	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	8800	8830	8815		cuttings	NORM	1.26	0.98	0.11	0.24	0.47	389	*	-1.00			19	37	1	9	0.31
06-4168-165087	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	8830	8860	8845		cuttings	NORM	1.12	0.89	0.10	0.19	0.44	4	*	-1.00			17	39	0	9	0.34
06-4168-165088	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	8860	8890	8875		cuttings	NORM	1.27	0.89	0.09	0.16	0.43	332	*	-1.00			13	34	0	7	0.36
06-4168-165089	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	8890	8920	8905		cuttings	NORM	1.11	0.87	0.08	0.11	0.37	4	*	-1.00	2.97	D	10	33	0	7	0.42
06-4168-165090	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9160	9170	9165	Fayetteville	cuttings	NORM	1.20	0.95	0.09	0.15	0.39	4	*	-1.00			12	32	0	8	0.38
06-4168-165091	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9170	9180	9175	Fayetteville	cuttings	NORM	1.01	0.77	0.08	0.15	0.41	4	*	-1.00			15	41	0	8	0.35
06-4168-165092	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9180	9190	9185	Fayetteville	cuttings	NORM	1.17	0.86	0.11	0.14	0.35	422	*	0.44			12	30	0	9	0.44
06-4168-165093	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9190	9200	9195	Fayetteville	cuttings	NORM	1.03	0.83	0.09	0.13	0.39	338	*	-1.00			13	38	0	9	0.41
06-4168-165094	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9200	9210	9205	Fayetteville	cuttings	NORM	1.70	1.57	0.18	0.18	0.45	356	*	-1.00			11	26	0	11	0.50
06-4168-165095	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9210	9220	9215	Fayetteville	cuttings	NORM	2.01	2.03	0.24	0.21	0.55	360	*	-1.00			10	27	0	12	0.53
06-4168-165096	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9220	9230	9225	Fayetteville	cuttings	NORM	1.50	1.36	0.14	0.15	0.44	354	*	-1.00			10	29	0	9	0.48
06-4168-165097	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9230	9260	9245	Fayetteville	cuttings	NORM	1.57	1.44	0.15	0.16	0.37	371	*	-1.00			10	24	0	10	0.48
06-4168-165098	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9260	9290	9275	Fayetteville	cuttings	NORM	1.90	1.86	0.18	0.15	0.39	4	*	-1.00			8	21	0	9	0.55
06-4168-165099	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9290	9320	9305		cuttings	NORM	2.16	2.21	0.29	0.20	0.44	4	*	-1.00	3.46	D	9	20	0	13	0.59
06-4168-165100	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9320	9350	9335		cuttings	NORM	1.78	1.71	0.22	0.39	0.45	396	*	-1.00			22	25	1	12	0.36
06-4168-165101	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9350	9380	9365		cuttings	NORM	1.52	1.53	0.18	0.19	0.36	4	*	-1.00			12	24	1	12	0.49
06-4168-165102	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9570	9580	9575		cuttings	NORM	1.24	1.08	0.13	0.17	0.45	391	*	-1.00			14	36	0	10	0.43
06-4168-165103	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9580	9590	9585	Chattanooga	cuttings	NORM	1.26	1.00	0.12	0.13	0.36	324	*	-1.00			10	29	0	10	0.48
06-4168-165104	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9590	9600	9595	Chattanooga	cuttings	NORM	1.32	1.13	0.16	0.13	0.34	4	*	-1.00			10	26	0	12	0.55
06-4168-165105	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9600	9610	9605	Chattanooga	cuttings	NORM	1.38	1.22	0.14	0.14	0.31	4	*	-1.00			10	22	0	10	0.50
06-4168-165106	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9610	9620	9615	Chattanooga	cuttings	NORM	2.48	2.46	0.12	0.16	0.31	4	*	-1.00			6	12	1	5	0.43
06-4168-165107	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9620	9630	9625	Chattanooga	cuttings	NORM	2.40	2.49	0.10	0.12	0.41	327	*	-1.00	3.66	D	5	17	0	4	0.45
06-4168-165108	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9630	9640	9635	Chattanooga	cuttings	NORM	1.76	1.92	0.09	0.09	0.49	425	*	0.49			5	28	0	5	0.50
06-4168-165109	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9640	9650	9645	Chattanooga	cuttings	NORM	1.86	1.74	0.17	0.11	0.34	300	*	-1.00			6	18	0	9	0.61
06-4168-165110	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9650	9660	9655	Chattanooga	cuttings	NORM	1.83	1.73	0.09	0.09	0.42	300	*	-1.00			5	23	0	5	0.50
06-4168-165111	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9660	9670	9665	Chattanooga	cuttings	NORM	1.87	1.64	0.11	0.09	0.41	300	*	-1.00			5	22	0	6	0.55
06-4168-165112	Arkoma	03131300470001	SHELL OIL CO	U S A	1-10	SEBASTIAN	AR	9670	9680	9675		cuttings	NORM	1.61	1.50	0.06	0.03	0.29	-2	*	-1.00			2	18	0	4	0.67

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = °C

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

USA #1 - 10

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

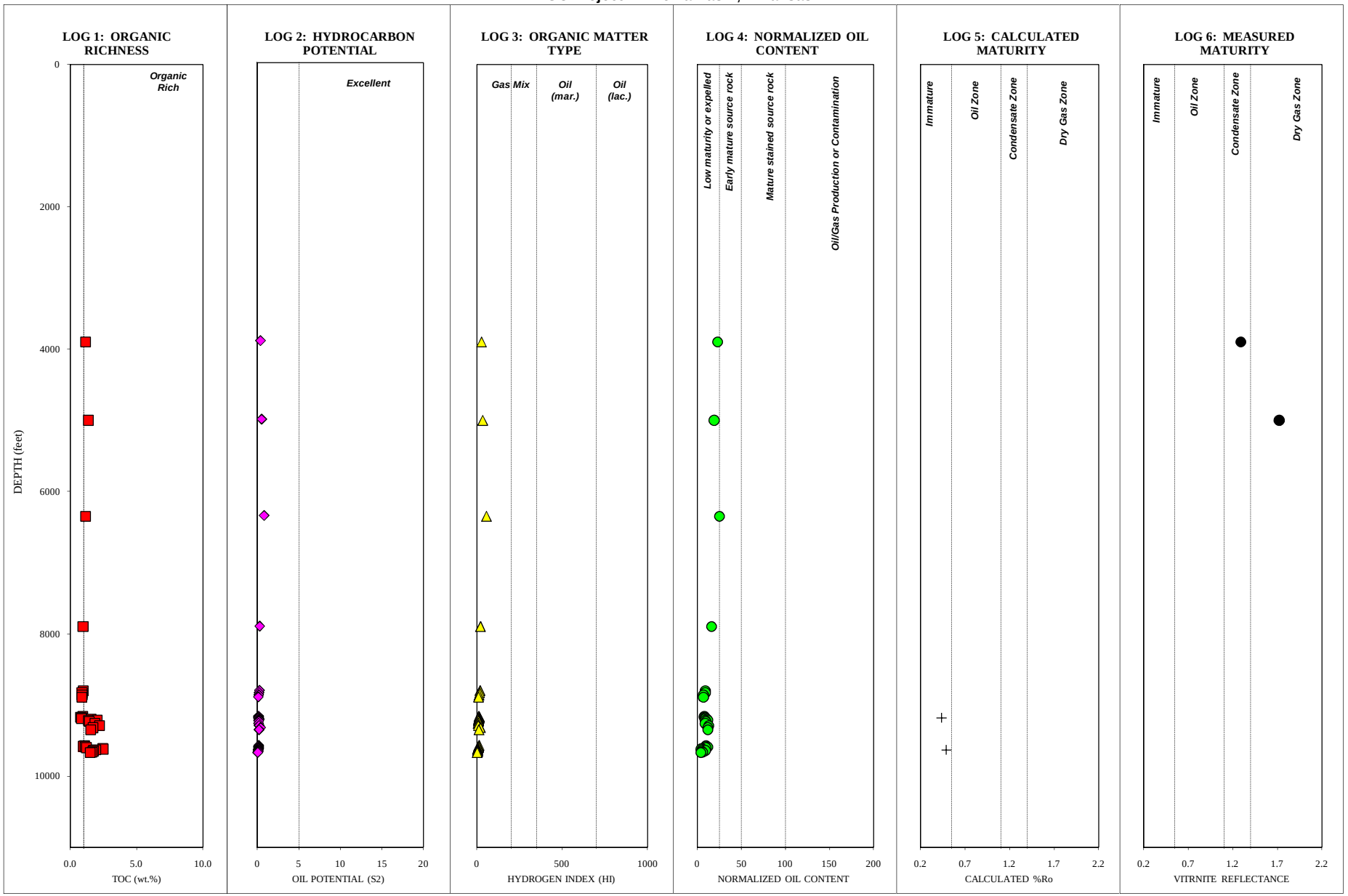

Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

USA #1 - 10

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

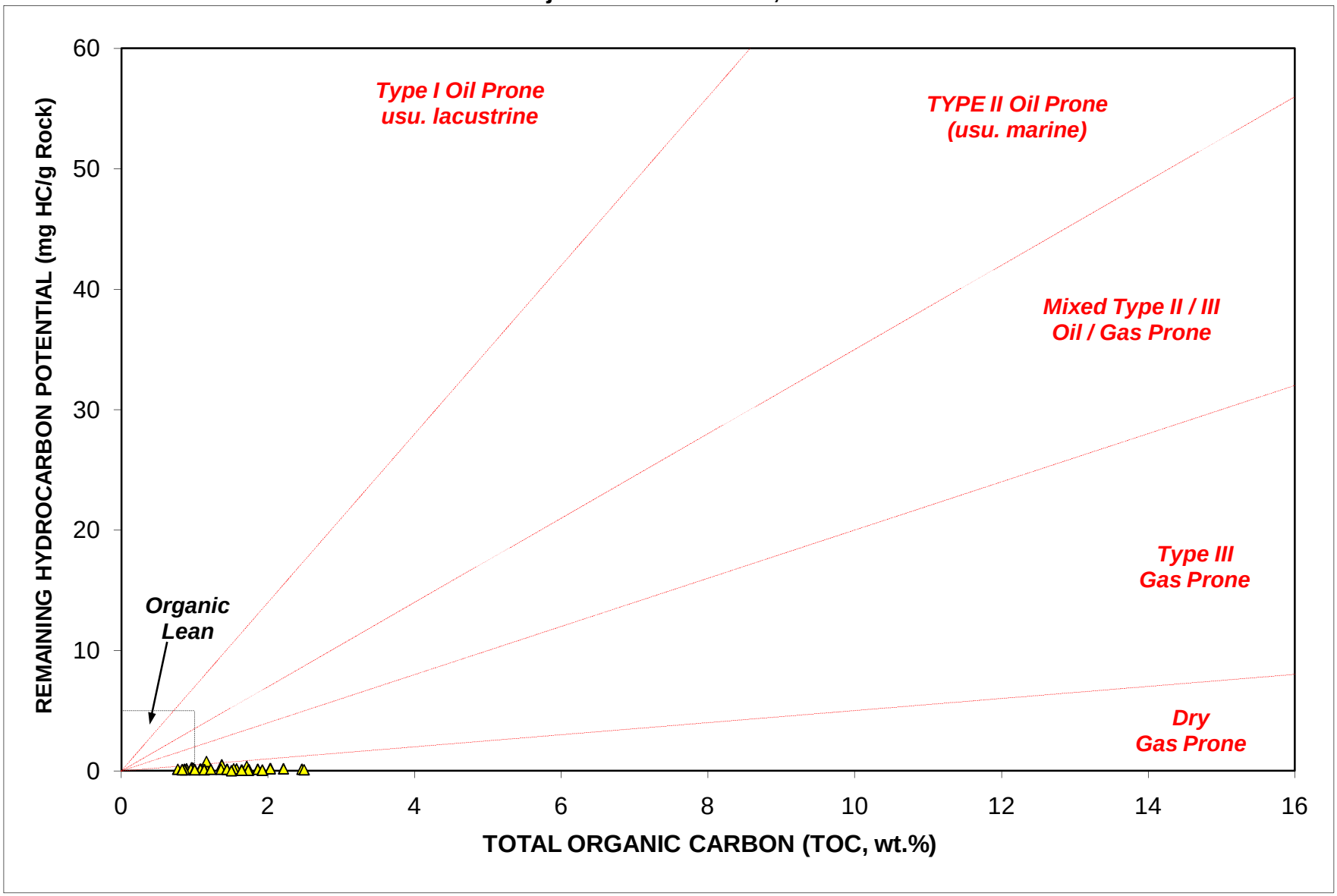

Figure 2. Kerogen Quality

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KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

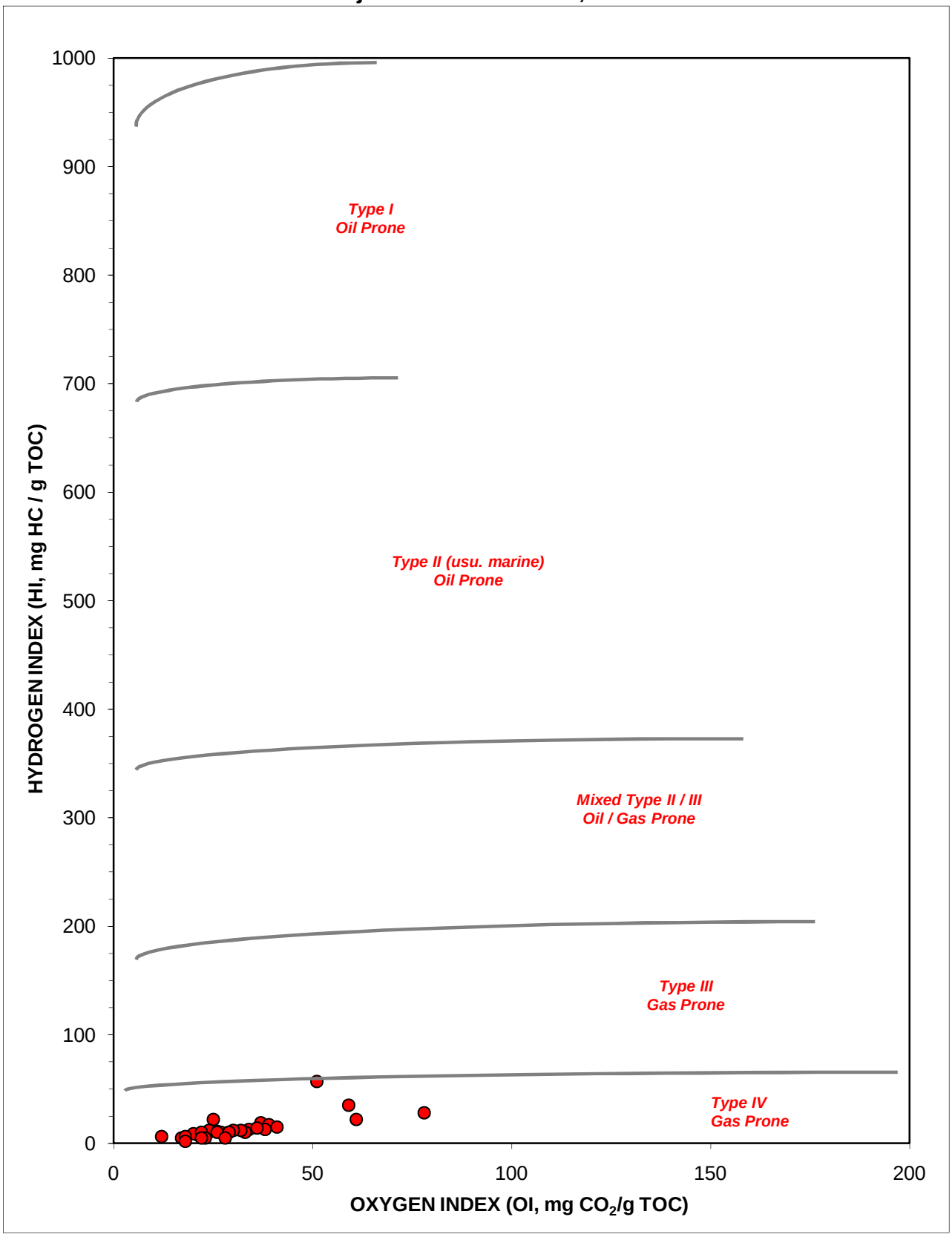

Figure 3. Kerogen type

USA #1 - 10

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

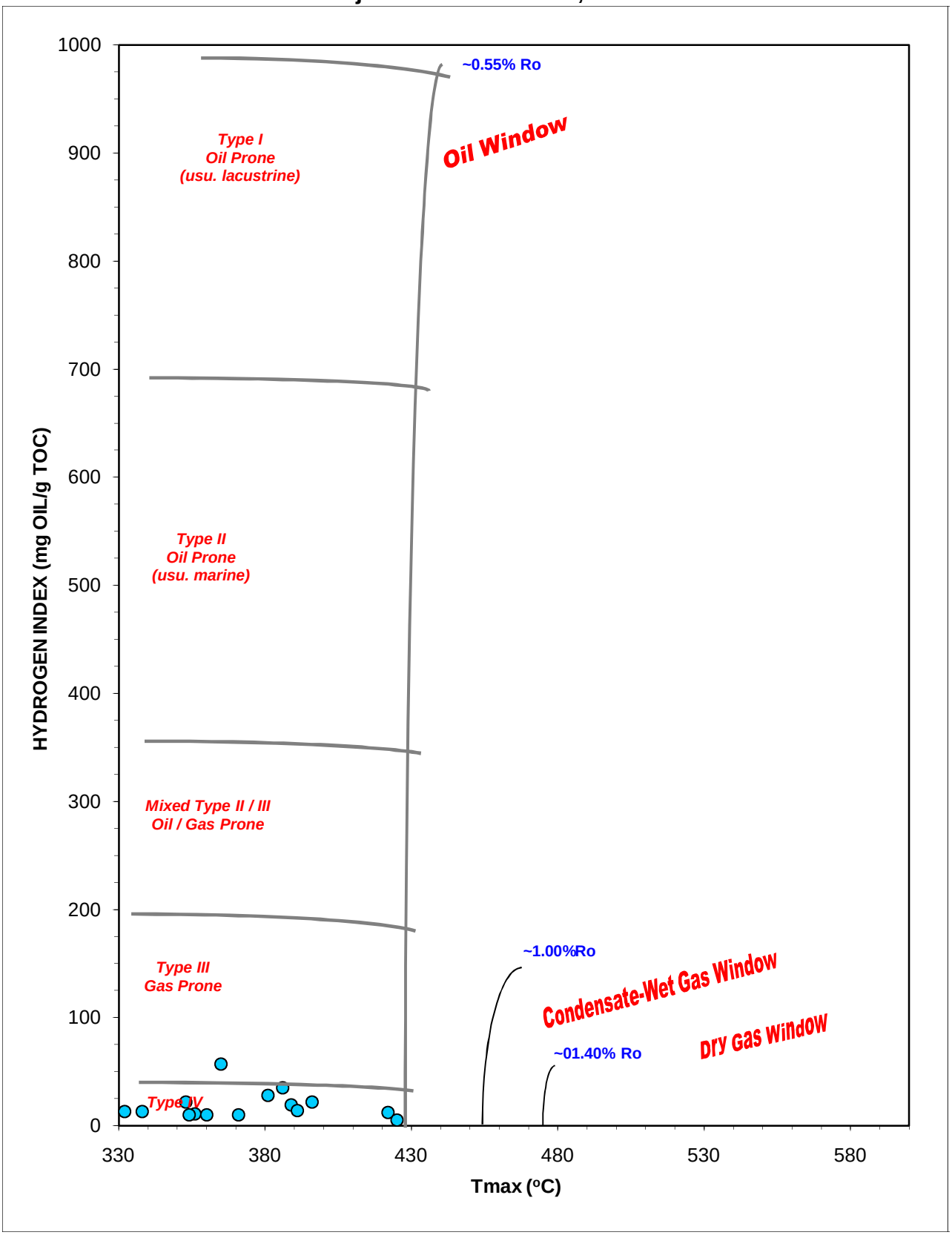

Figure 4a. Kerogen Type and Maturity (Tmax)

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USA #1 - 10

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

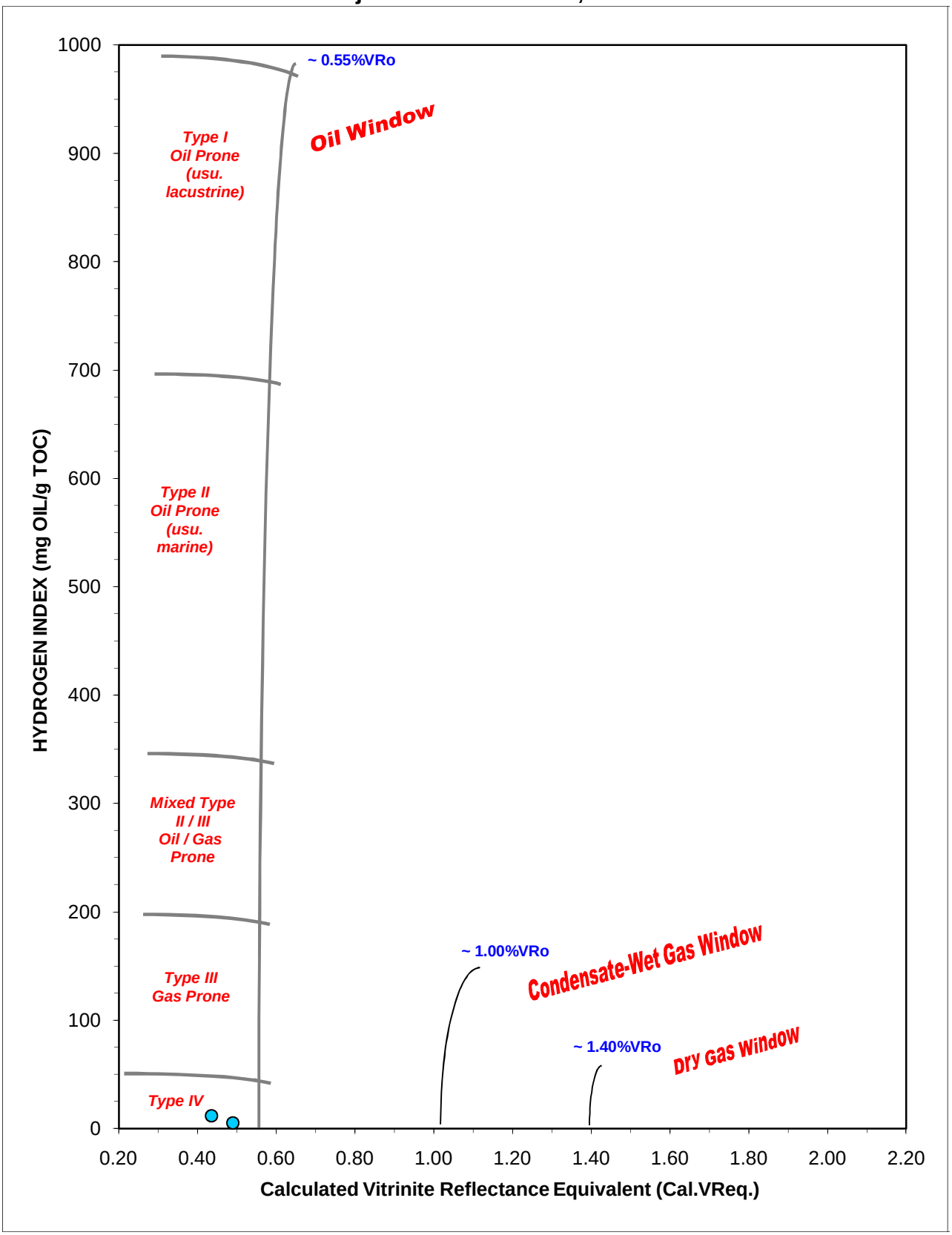

Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

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KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

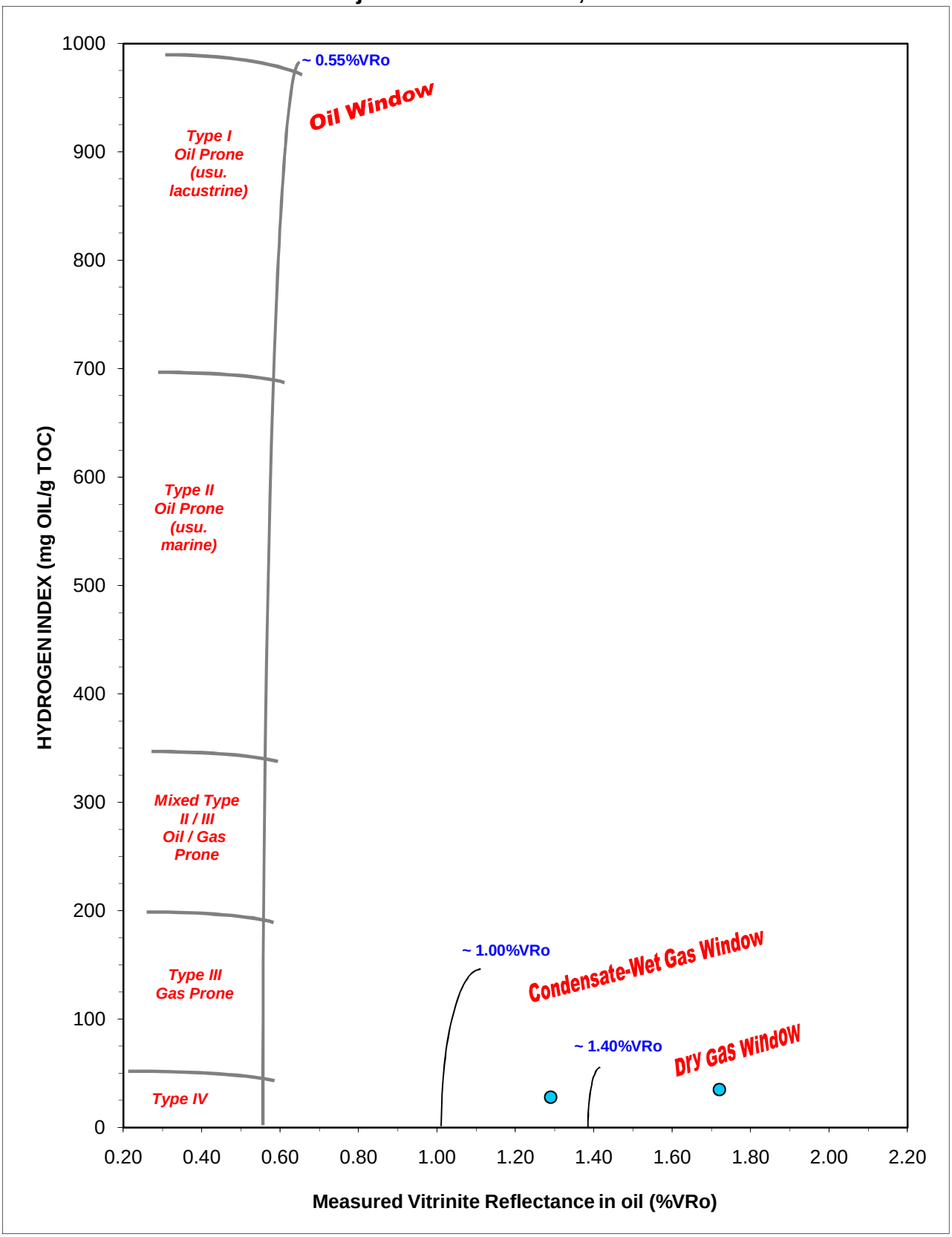

Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

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USA #1 - 10

AGC Project - Arkoma Basin, Arkansas

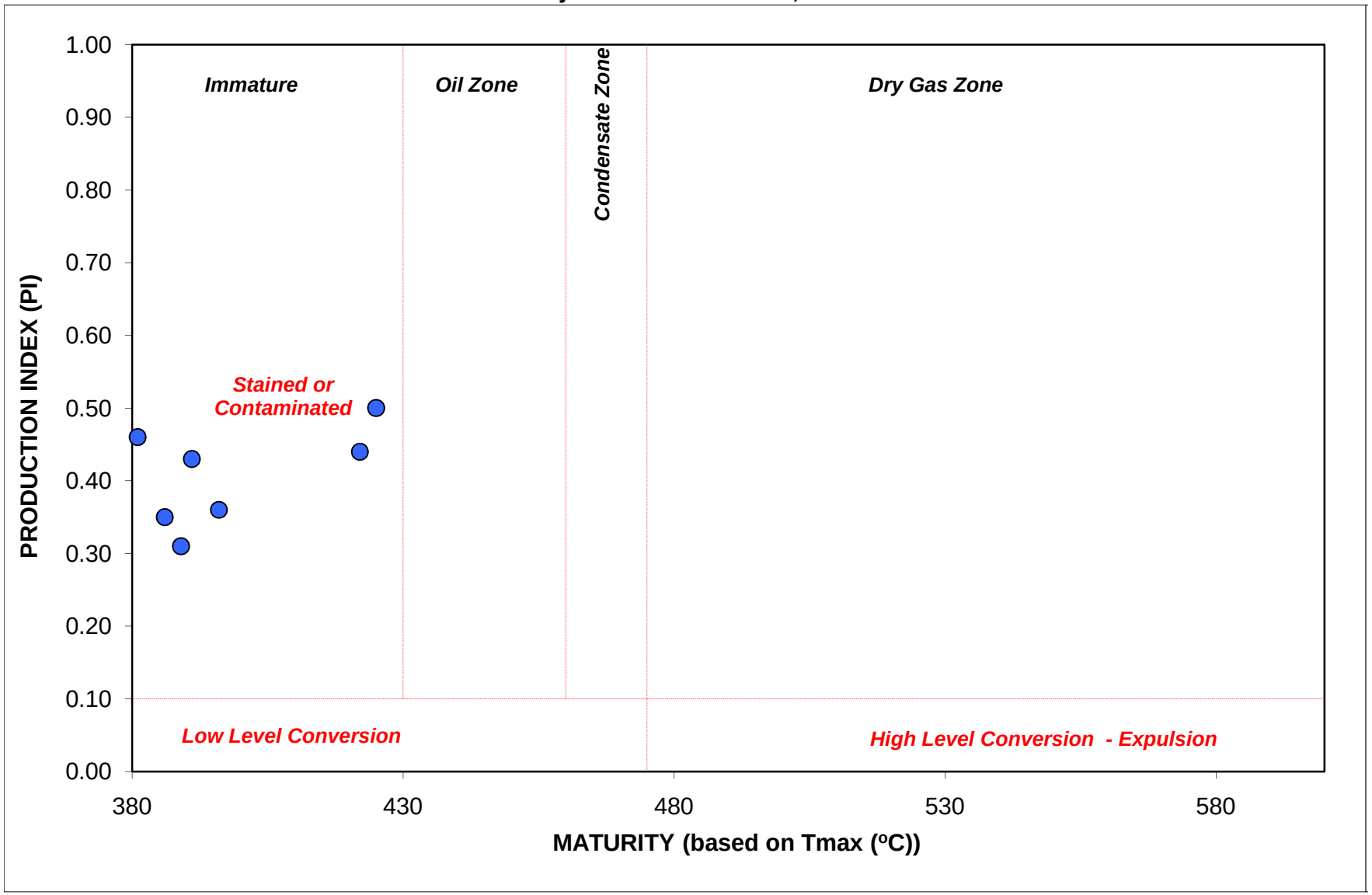


Figure 5a. Kerogen conversion and maturity (based on Tmax).

USA #1 - 10

AGC Project - Arkoma Basin, Arkansas

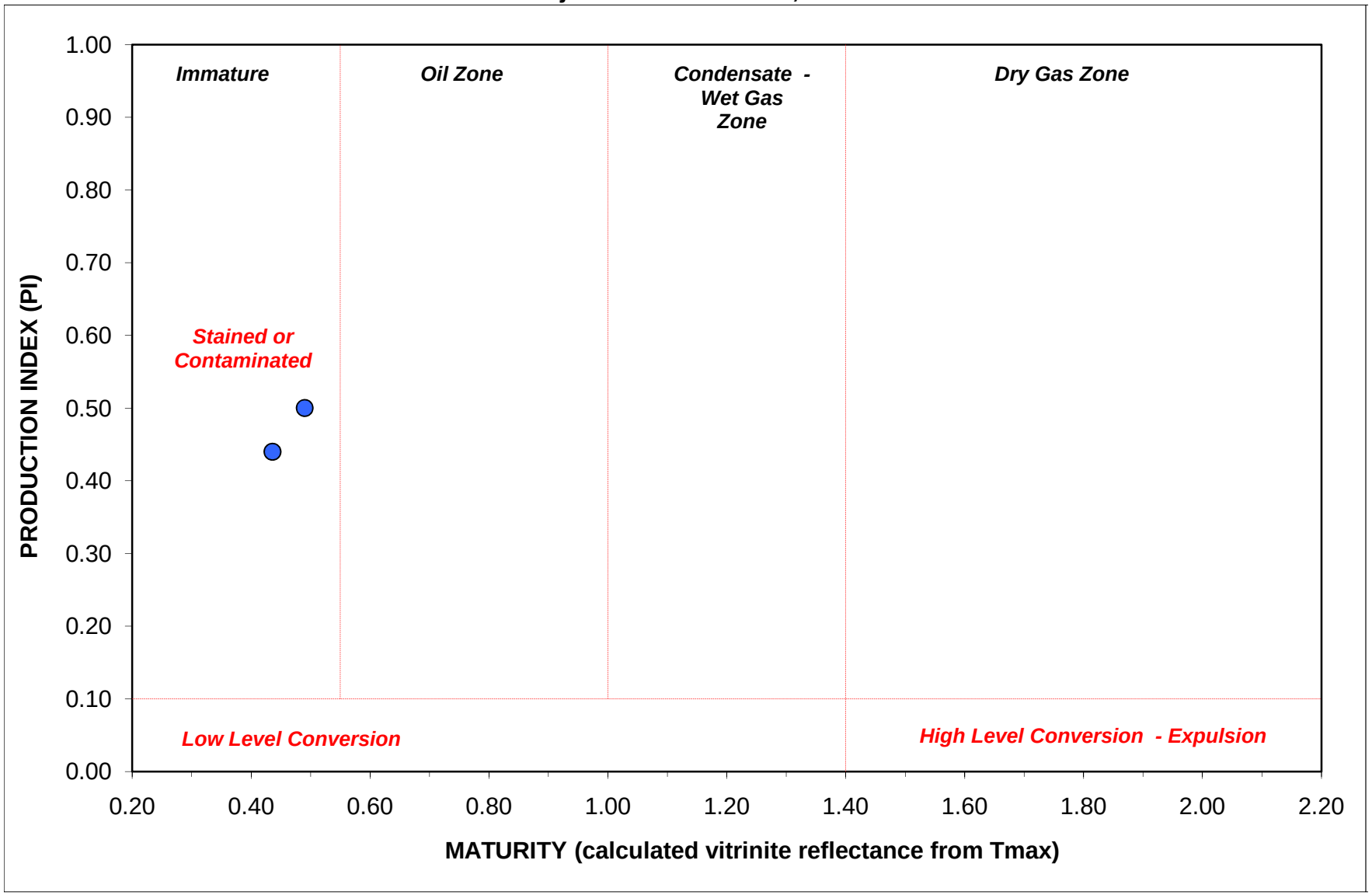


Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

USA #1 - 10

AGC Project - Arkoma Basin, Arkansas

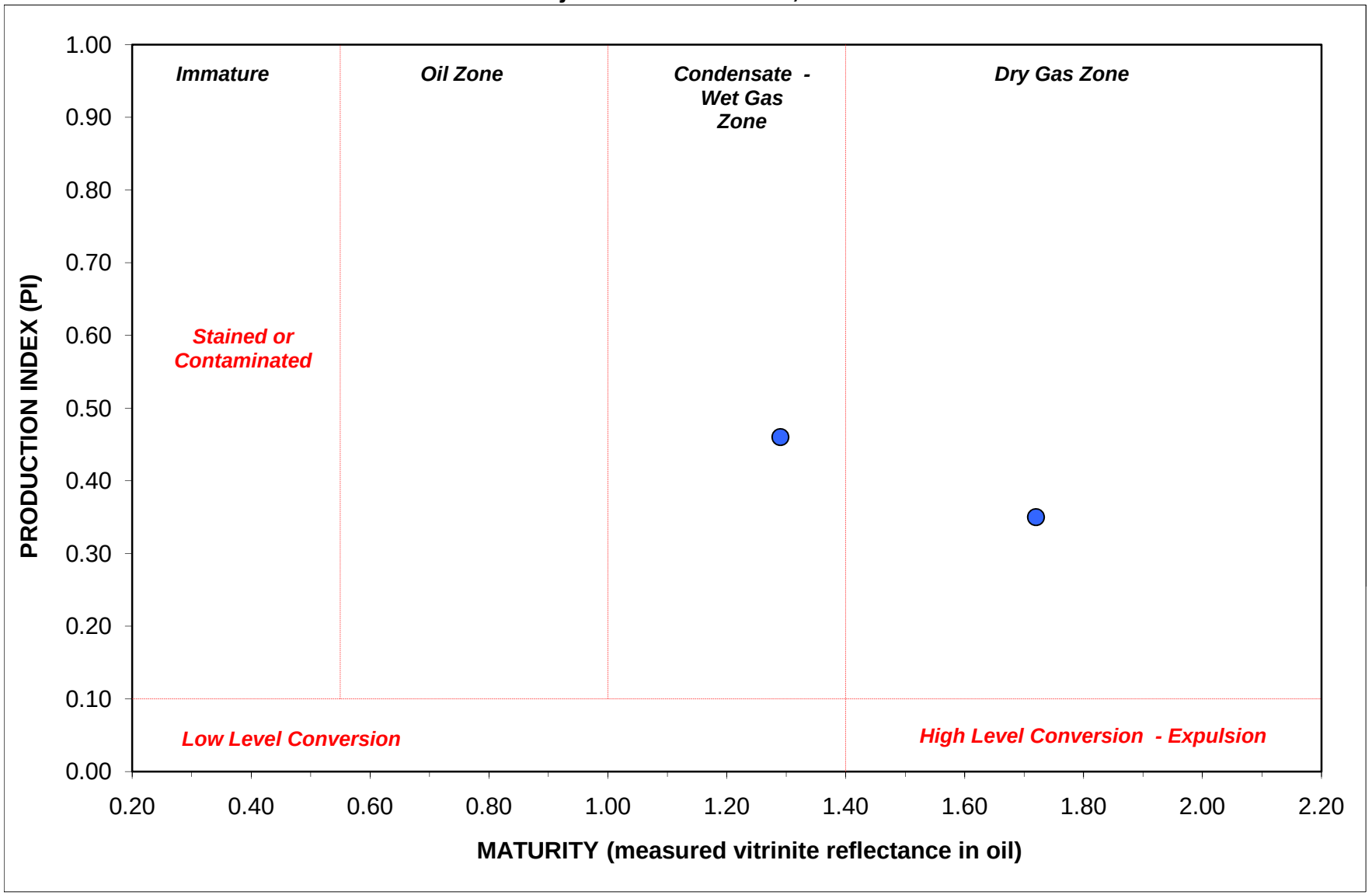


Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

Appendix 14. Geochemical and thermal maturity analyses for the well cutting samples from the Western Coal & Mining #1

WESTERN COAL & MING #1

TOC and ROCK-EVAL DATA REPORT

AGC Project - Arkoma Basin, Arkansas

HGS No.	Basin	API	Operator	Well Name	Well No.	County	State	Top Depth (ft.)	Bottom Depth (ft.)	Median Depth (ft.)	Formation Name	Sample Type	Sample Prep	Leco TOC	Rock-Eval TOC	S1	S2	S3	Tmax (°C)		Cal. %Ro	Meas. %Ro	Conf.	HI	OI	S2/S3	S1/TOC	PI
06-4168-165210	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7390	7400	7395		cuttings	NORM	0.40	0.12	0.05	0.08	0.06	388	*	-1.00			20	15	1	12	0.38
06-4168-165211	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7400	7410	7405	Fayetteville	cuttings	NORM	0.52	0.14	0.07	0.09	0.07	383	*	-1.00			17	13	1	13	0.44
06-4168-165212	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7410	7420	7415	Fayetteville	cuttings	NORM	0.51	0.13	0.07	0.13	0.16	433	*	0.63			25	31	1	14	0.35
06-4168-165213	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7420	7430	7425	Fayetteville	cuttings	NORM	0.95	0.64	0.09	0.20	0.26	344	*	-1.00			21	27	1	9	0.31
06-4168-165214	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7430	7440	7435		cuttings	NORM	1.03	0.63	0.08	0.22	0.19	300	*	-1.00			21	18	1	8	0.27
06-4168-165215	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7440	7450	7445		cuttings	NORM	4.78	5.11	0.91	0.97	0.61	383		-1.00			20	13	2	19	0.48
06-4168-165216	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7450	7460	7455		cuttings	NORM	4.74	4.92	0.70	0.71	0.52	383		-1.00	3.61	D	15	11	1	15	0.50
06-4168-165217	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7460	7470	7465		cuttings	NORM	3.24	3.47	0.48	0.49	0.40	395	*	-1.00			15	12	1	15	0.49
06-4168-165218	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7470	7480	7475		cuttings	NORM	2.33	2.25	0.44	0.44	0.35	362	*	-1.00			19	15	1	19	0.50
06-4168-165219	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7480	7490	7485		cuttings	NORM	2.41	2.32	0.45	0.51	0.38	396		-1.00			21	16	1	19	0.47
06-4168-165220	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7490	7500	7495		cuttings	NORM	1.30	1.04	0.25	0.29	0.29	349	*	-1.00			22	22	1	19	0.46
06-4168-165221	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7500	7510	7505		cuttings	NORM	1.98	2.06	0.38	0.65	0.38	405		0.13			33	19	2	19	0.37
06-4168-165222	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7510	7520	7515		cuttings	NORM	1.77	1.66	0.33	0.40	0.32	398	*	-1.00			23	18	1	19	0.45
06-4168-165223	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7520	7530	7525		cuttings	NORM	1.70	1.56	0.56	0.33	0.27	356	*	-1.00			19	16	1	33	0.63
06-4168-165224	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7690	7700	7695		cuttings	NORM	1.13	0.86	0.12	0.17	0.23	363	*	-1.00			15	20	1	11	0.41
06-4168-165225	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7700	7710	7705		cuttings	NORM	1.13	0.93	0.12	0.20	0.21	350	*	-1.00			18	19	1	11	0.38
06-4168-165226	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7710	7720	7715		cuttings	NORM	1.11	0.85	0.12	0.18	0.21	338	*	-1.00			16	19	1	11	0.40
06-4168-165227	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7720	7730	7725	Chattanooga	cuttings	NORM	1.09	0.87	0.10	0.19	0.33	420	*	0.40			17	30	1	9	0.34
06-4168-165228	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7730	7740	7735	Chattanooga	cuttings	NORM	1.72	1.57	0.36	0.42	0.22	347	*	-1.00			24	13	2	21	0.46
06-4168-165229	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7740	7750	7745	Chattanooga	cuttings	NORM	1.93	1.88	0.34	0.24	0.21	300	*	-1.00			12	11	1	18	0.59
06-4168-165230	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7750	7760	7755	Chattanooga	cuttings	NORM	1.65	1.62	0.22	0.19	0.23	302	*	-1.00			12	14	1	13	0.54
06-4168-165231	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7760	7770	7765	Chattanooga	cuttings	NORM	1.64	1.47	0.19	0.17	0.22	300	*	-1.00			10	13	1	12	0.53
06-4168-165232	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7770	7780	7775	Chattanooga	cuttings	NORM	1.77	1.66	0.17	0.20	0.22	356	*	-1.00			11	12	1	10	0.46
06-4168-165233	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7780	7790	7785	Chattanooga	cuttings	NORM	1.92	1.78	0.21	0.20	0.24	300	*	-1.00			10	12	1	11	0.51
06-4168-165234	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7790	7800	7795	Chattanooga	cuttings	NORM	5.02	4.79	0.25	0.25	0.29	377	*	-1.00			5	6	1	5	0.50
06-4168-165235	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7800	7810	7805	Chattanooga	cuttings	NORM	6.28	4.78	0.32	0.25	0.25	381	*	-1.00	3.71	C	4	4	1	5	0.56
06-4168-165236	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7810	7820	7815		cuttings	NORM	4.27	4.69	0.31	0.39	0.32	383	*	-1.00			9	7	1	7	0.44
06-4168-165238	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7960	7970	7965		cuttings	NORM	1.12	0.76	0.08	0.12	0.16	446	*	0.87			11	14	1	7	0.40
06-4168-165239	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7970	7980	7975		cuttings	NORM	1.25	0.81	0.13	0.23	0.49	363	*	-1.00			18	39	0	10	0.36
06-4168-165240	Arkoma	03131000070000	SHELL OIL CO	WESTERN COAL & MNG	1	SEBASTIAN	AR	7980	7990	7985		cuttings	NORM	1.17	0.94	0.08	0.14	0.36	320	*	-1.00			12	31	0	7	0.36

Note: "-1" indicates not measured or meaningless ratio

* Tmax data not reliable due to poor S2 peak

TOC = weight percent organic carbon in rock
S1, S2 = mg hydrocarbons per gram of rock
S3 = mg carbon dioxide per gram of rock
Tmax = ºC

HI = hydrogen index = S2 x 100 / TOC
OI = oxygen index = S3 x 100 / TOC
S1/TOC = normalized oil content = S1 x 100 / TOC
PI = production index = S1 / (S1+S2)
Cal. %Ro = calculated vitrinite reflectance based on Tmax
Measured %Ro = measured vitrinite reflectance

WESTERN COAL & MINING #1

Geochemical Log

AGC Project - Arkoma Basin, Arkansas

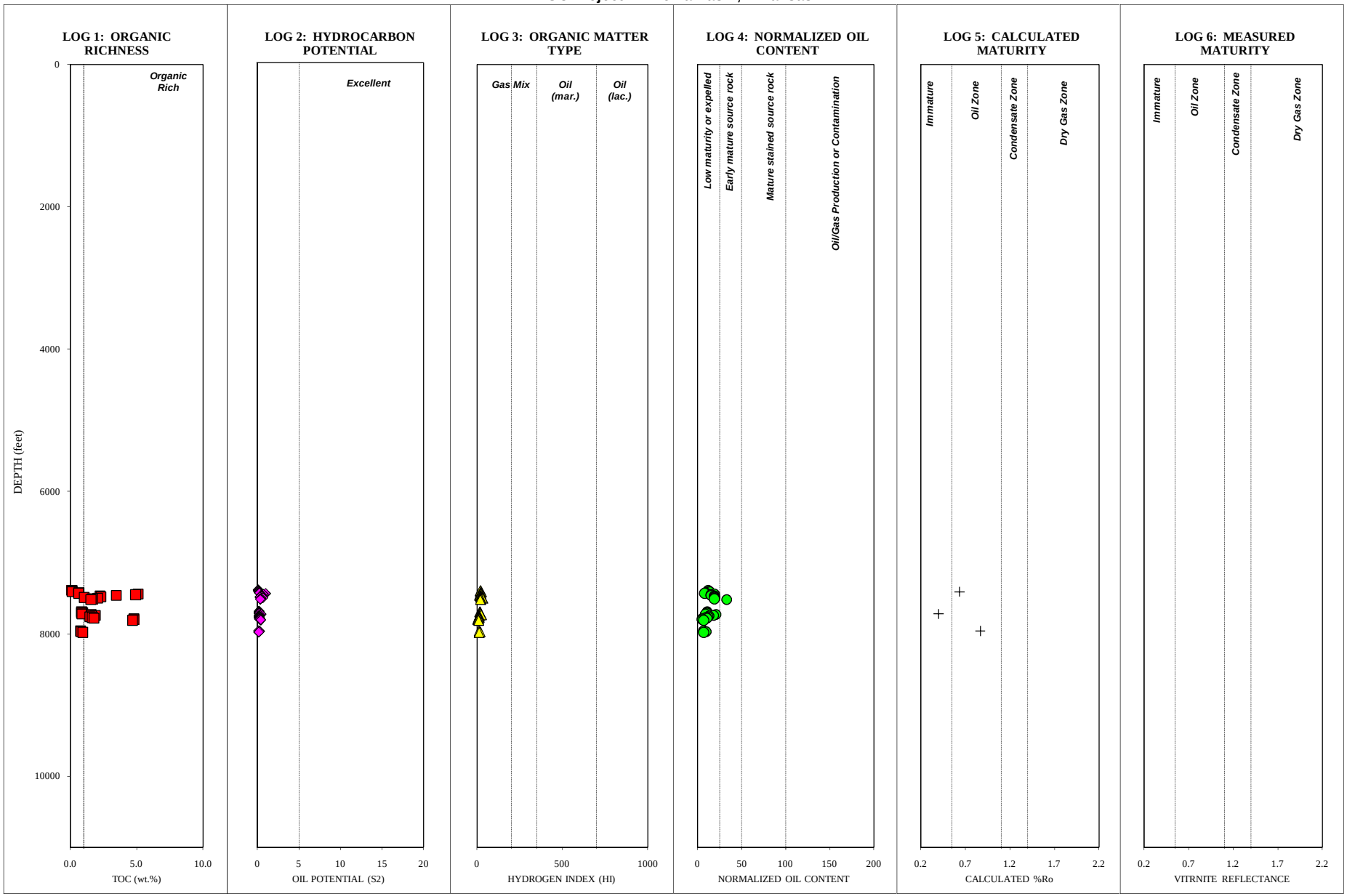


Figure 1. Geochemical log of TOC, remaining potential (S2), kerogen type (HI), normalized oil content, and calculated and measured vitrinite reflectance.

WESTERN COAL & MINING #1

KEROGEN QUALITY

AGC Project - Arkoma Basin, Arkansas

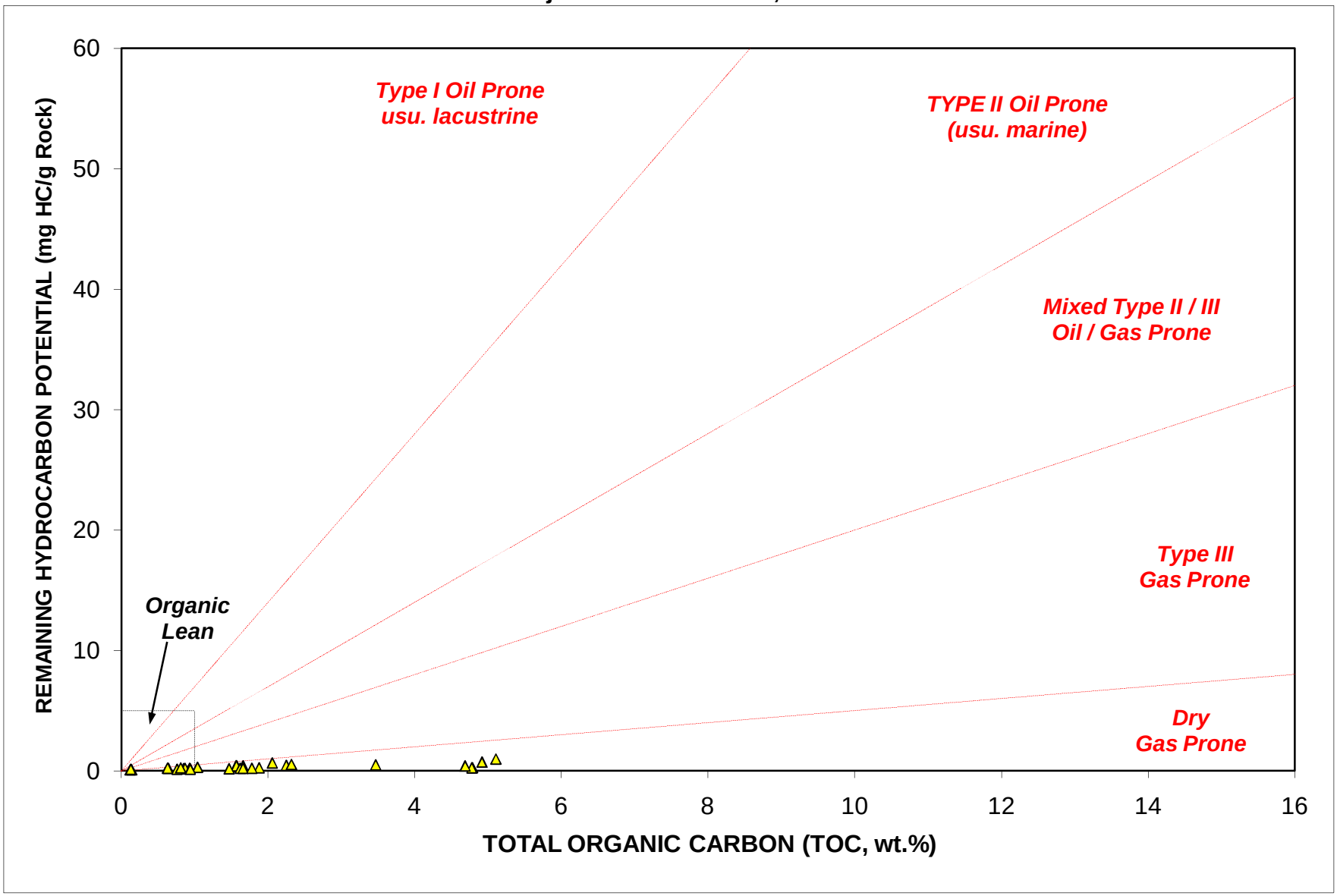


Figure 2. Kerogen Quality

Humble Geochemical Services Division

WESTERN COAL & MINING #1

KEROGEN TYPE
AGC Project - Arkoma Basin, Arkansas

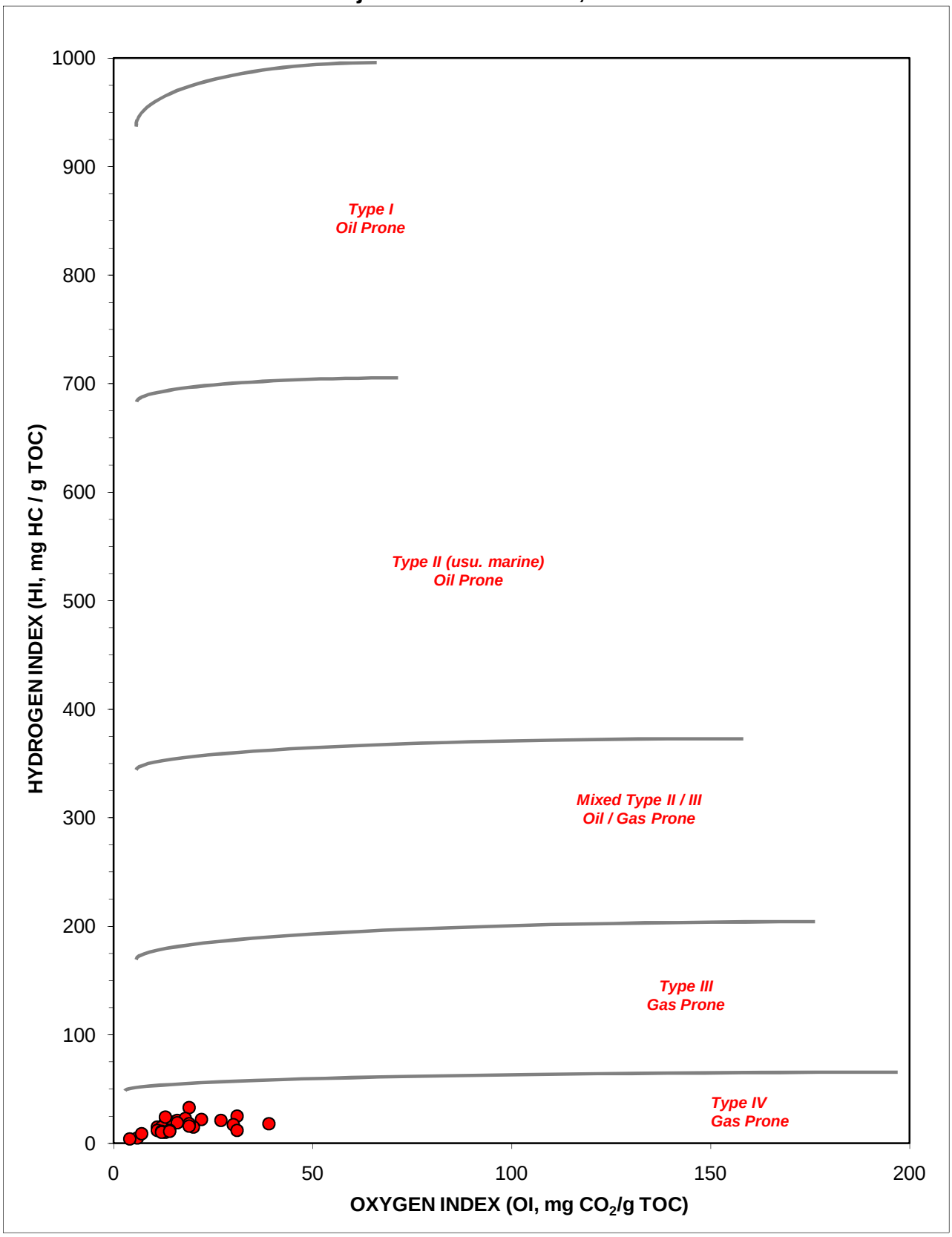


Figure 3. Kerogen type

WESTERN COAL & MINING #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

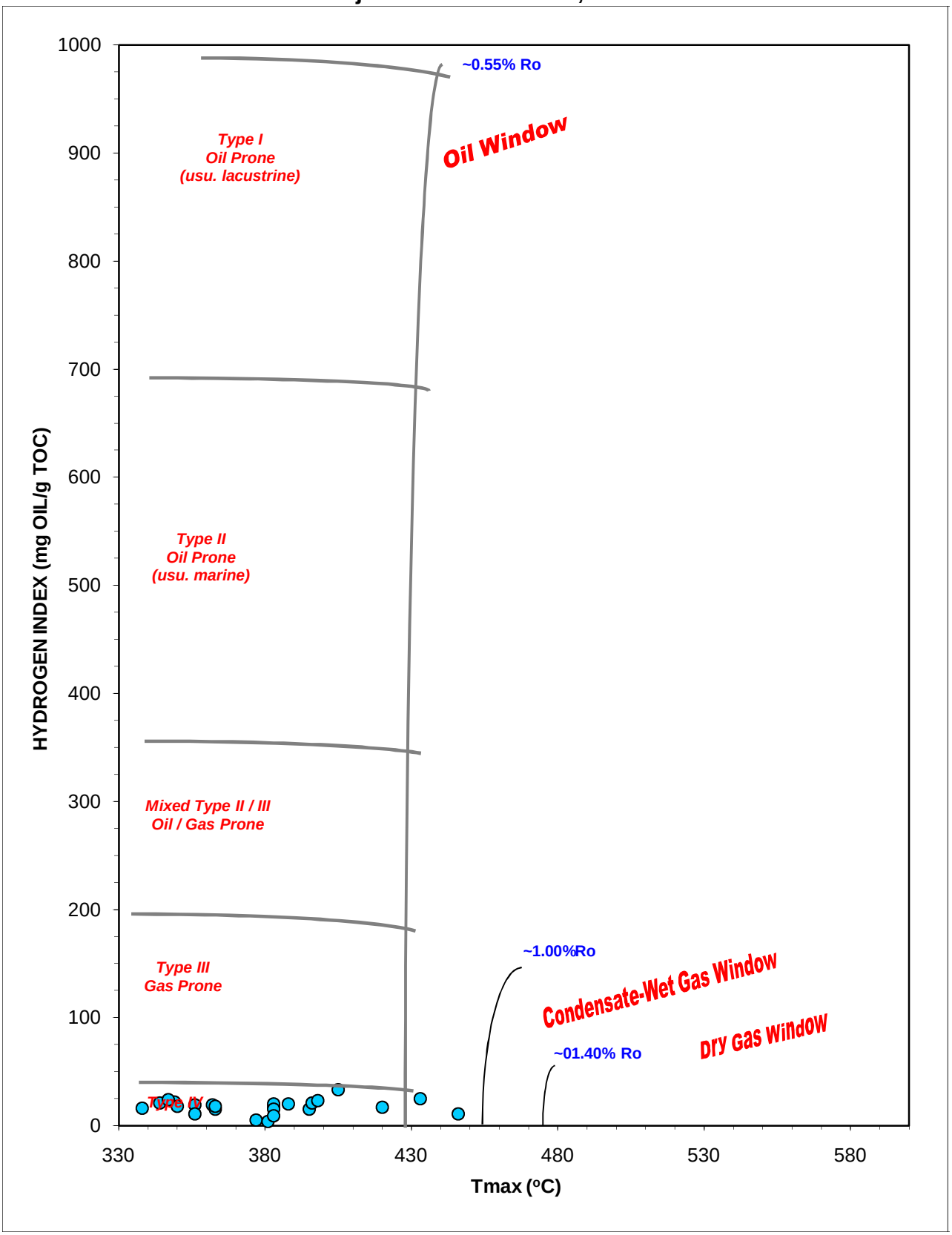


Figure 4a. Kerogen Type and Maturity (Tmax)

Humble Geochemical Services Division

WESTERN COAL & MINING #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

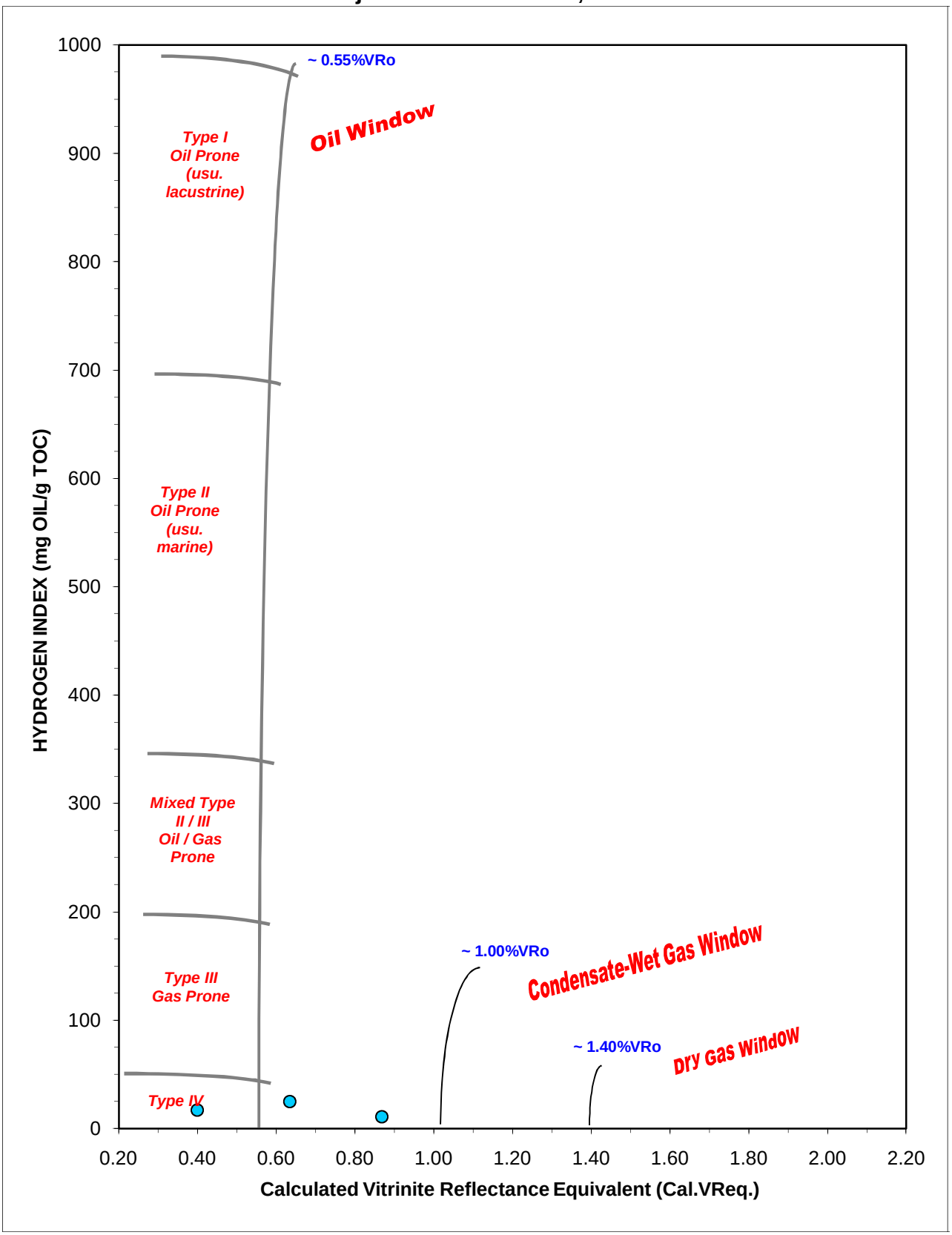


Figure 4b. Kerogen Type and Maturity (Tmax calculated %VRo)

Humble Geochemical Services Division

WESTERN COAL & MINING #1

KEROGEN TYPE and MATURITY

AGC Project - Arkoma Basin, Arkansas

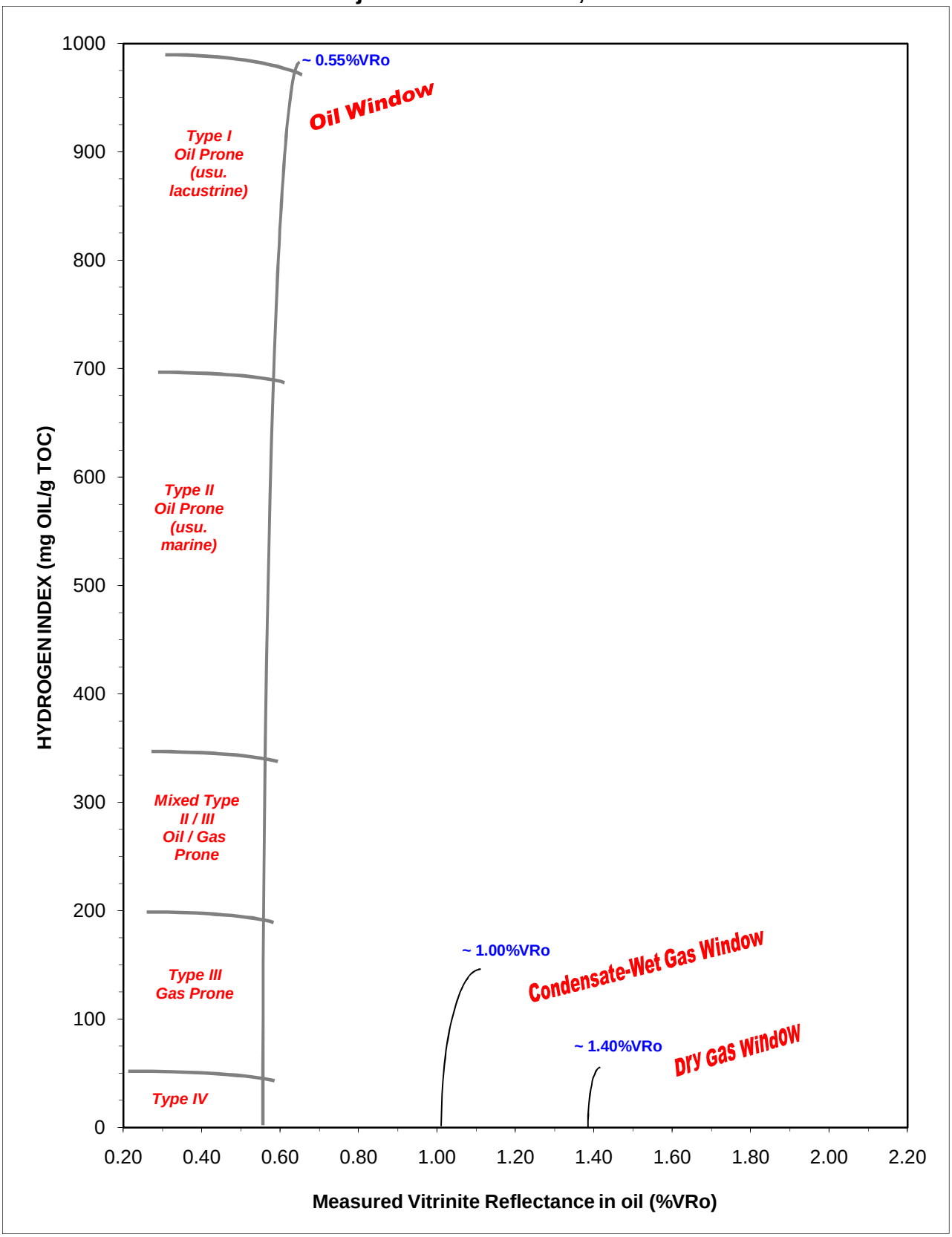


Figure 4c. Kerogen Type and Maturity (Measured vitrinite reflectance)

Humble Geochemical Services Division

WESTERN COAL & MINING #1

AGC Project - Arkoma Basin, Arkansas

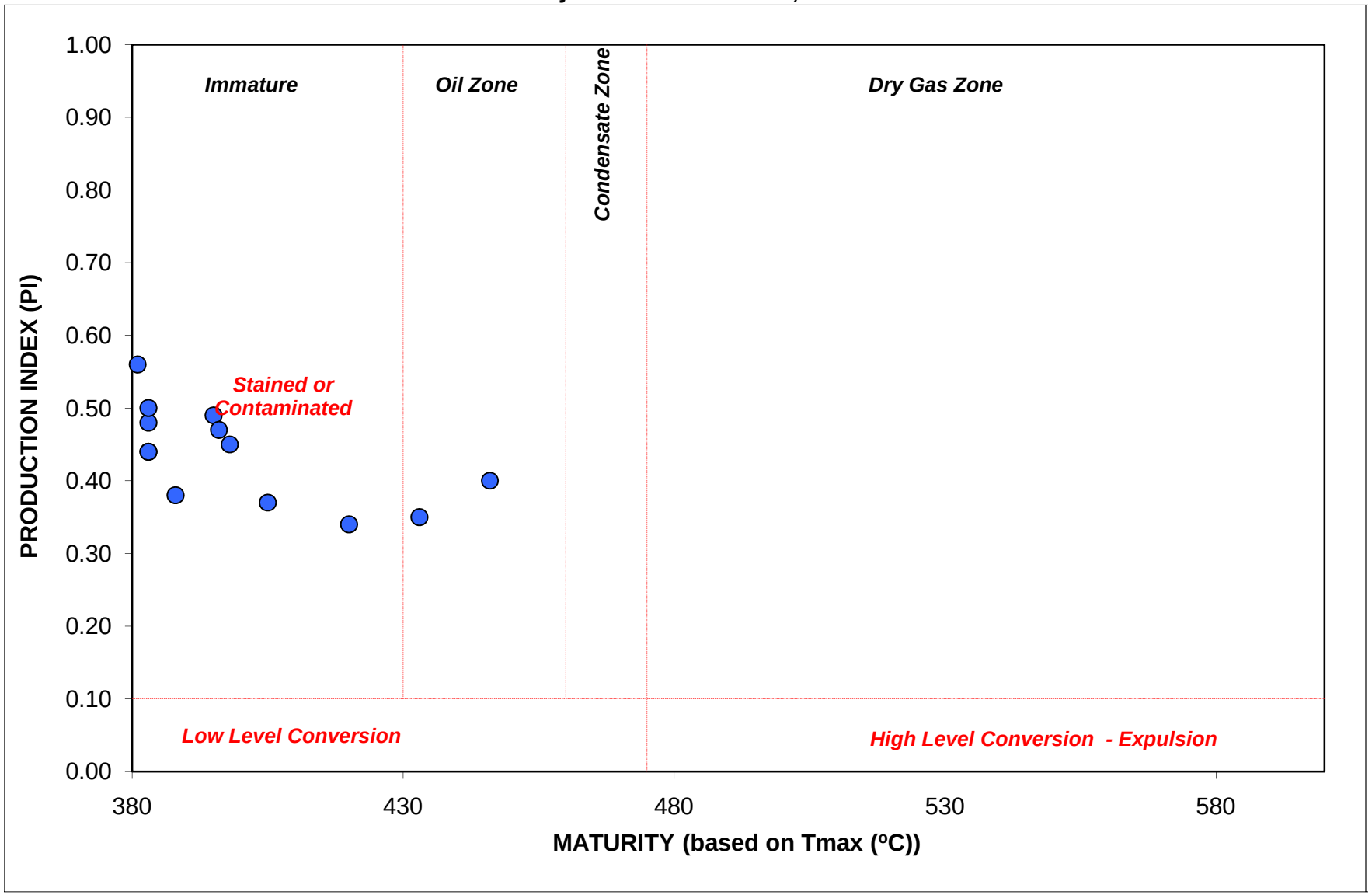


Figure 5a. Kerogen conversion and maturity (based on Tmax).

WESTERN COAL & MINING #1

AGC Project - Arkoma Basin, Arkansas

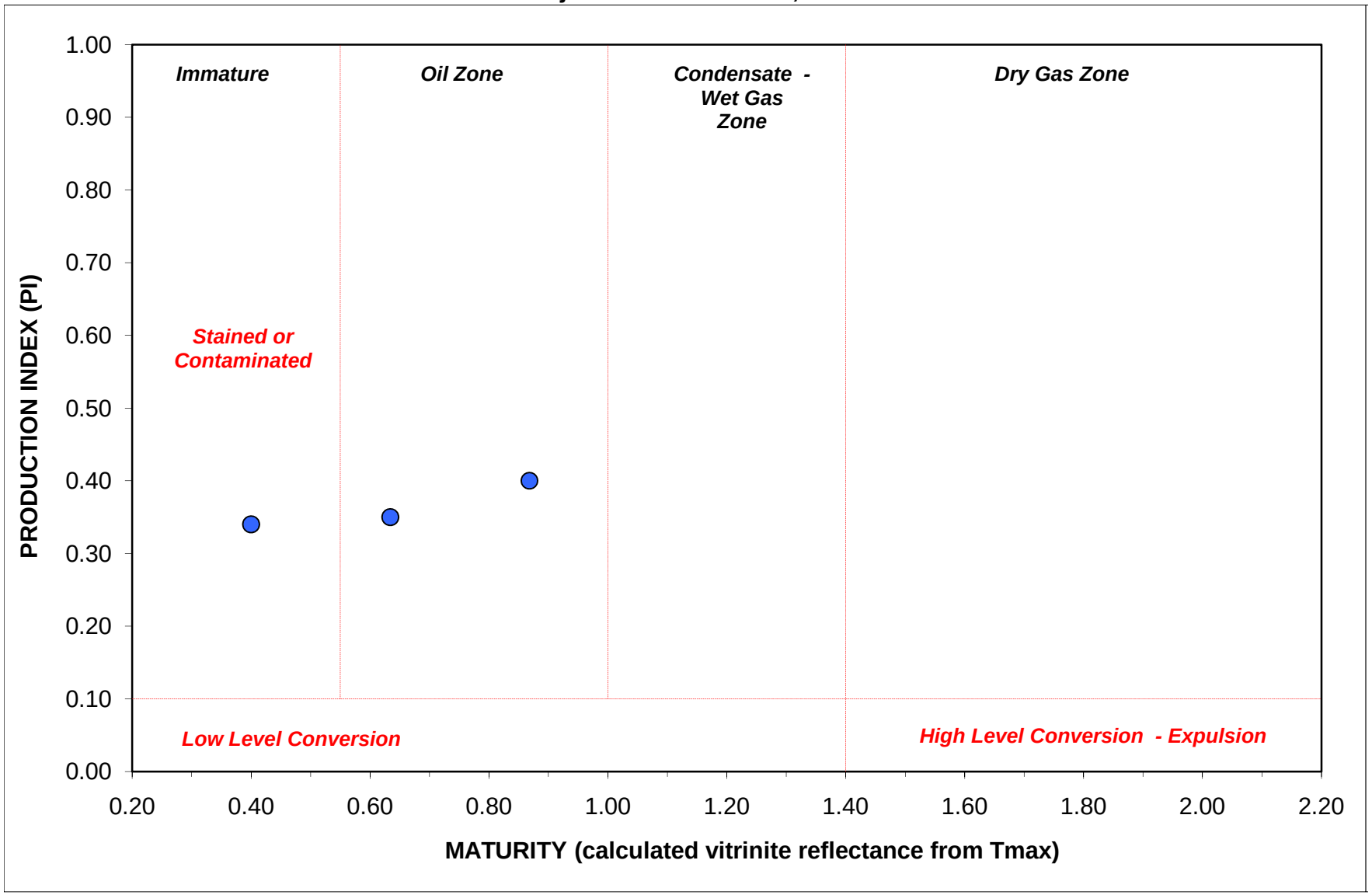


Figure 5b. Kerogen conversion and maturity (calculated %VRo from Tmax).

WESTERN COAL & MINING #1

AGC Project - Arkoma Basin, Arkansas

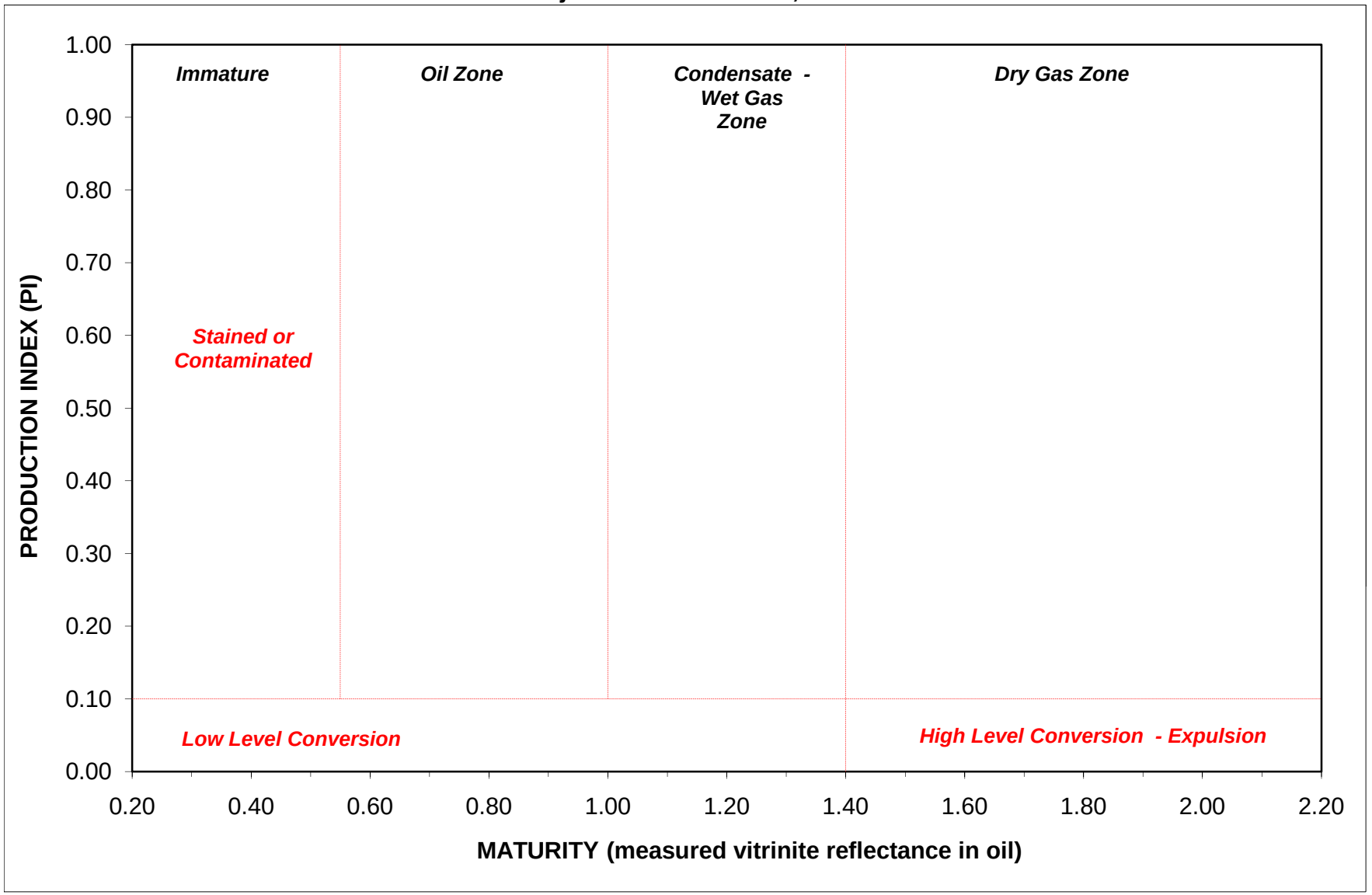


Figure 5c. Kerogen conversion and maturity (measured vitrinite reflectance).

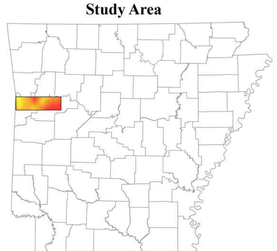
R 32 W R 31 W R 30 W R 29 W R 28 W R 27 W R 26 W R 25 W R 24 W R 23W R 22W

T 9 N T 8 N T 7 N T 6 N T 5 N T 10 N

Van Buren
Kibler
Gordon Fannie I. 1
Crawford
Franklin
Arkansas River
Altus
Hartman
Johnson
Lake Dardanelle
Morrison Bluff
Scranton
Larco 1
USA 1
Fort Smith
Hatfield 1
Barling
Lavaca
Joe Nixon 1
Branch
Charleston
Price 1-11
Caulksville
Paris
Subiaco
Western Coal&Mining 1
Bonanza
Skinner 1
Greenwood
USA 1-10
Arkansas Federal 1
C.E. Isom 1
Hackett
Hales 1-29
Bell 1-25
Sebastian
Magazine
Booneville
Blue Mountain
Yell
Logan
Havana
Johnson-Bedford 1
Midland
Scott

2.0 1.0 2.5 1.5 2.75 3.0 2.5 3.0 1.5 2.0 2.5 3.0 3.75 3.5 3.25 1.5 3.5

Study Area



Arkansas

Miles
5 2.5 0 5 10 15

Kilometers
5 2.5 0 5 10 15

Scale: 1:130,000

Two Component Statistical Interpolation of Total Organic Carbon (TOC) Values and Vitrinite Reflectance Values in the Fayetteville Shale

Symbols

- Gas Well
- Plugged and Abandoned
- Dry Hole
- 3.5 TOC Contour Line
- 2.0 Vitrinite Reflectance Contour Line
- Cities
- County Boundary

TOC Predicted Values

High : 3.68627

Low : 0.912716

N W E S

Data Source: See Appendices 1-14 of the manuscript for the raw geochemical data.

Plate 1 of 6
On the accompanying diskette a manuscript file supplements Plate 1 as a separate .pdf document.

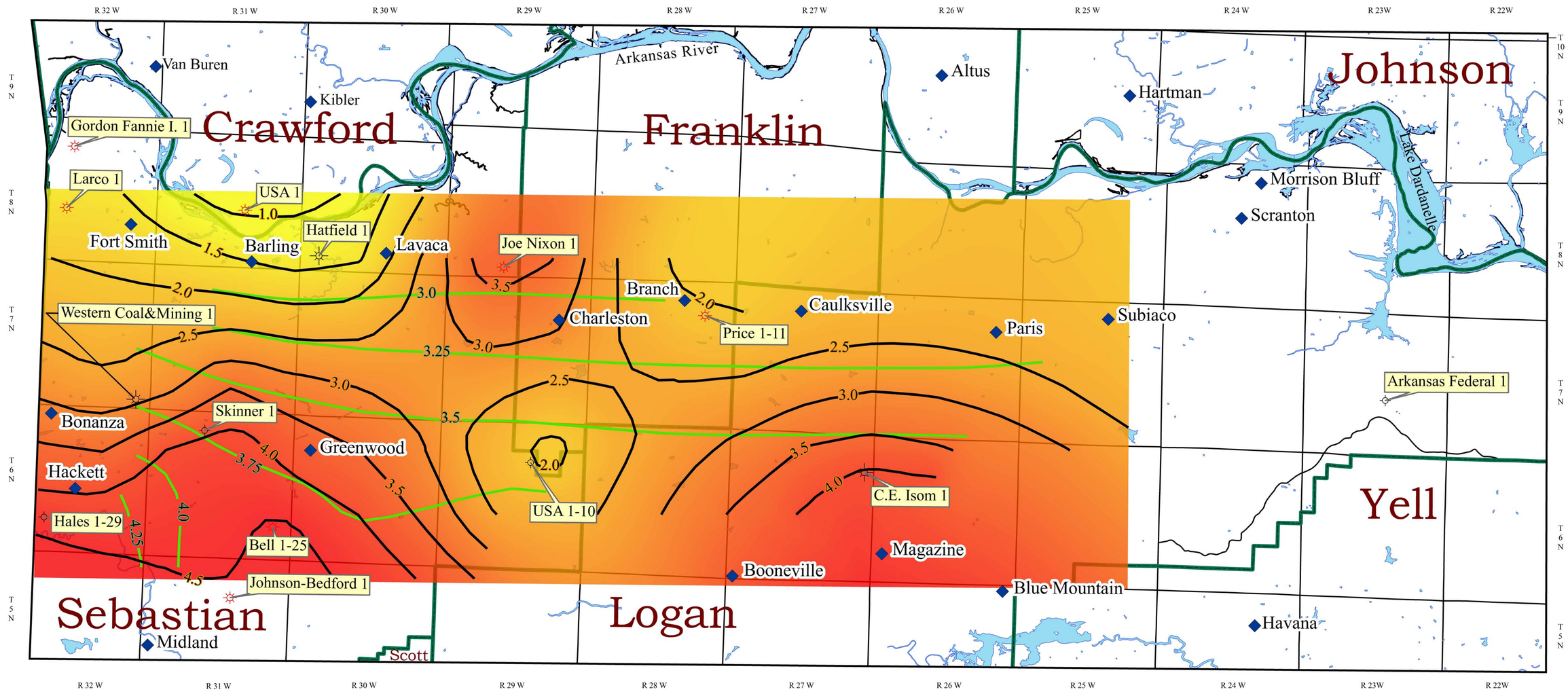
Arkansas Geological Survey
Bekki White, Director and State Geologist
Technical Review by P. Li, M.E. Ratchford and D.M. Jarvie

April 2010

Plate Number

1

Information Circular 40



Study Area

Arkansas

5 2.5 0 5 10 15 Miles

5 2.5 0 5 10 15 Kilometers

Scale: 1:130,000

Two Component Statistical Interpolation of Total Organic Carbon (TOC) Values and Vitrinite Reflectance Values in the Chattanooga Shale

Symbols

- Gas Well
- Plugged and Abandoned
- Dry Hole
- 3.5 — TOC Contour Line
- 3.0 — Vitrinite Reflectance Contour Line
- Cities
- County Boundary

TOC Predicted Values

High : 4.8134

Low : 0.783464

N W E S

Disclaimer: This map was prepared using ESRI software on computers at the Arkansas Geological Survey. The Arkansas Geological Survey does not guarantee the accuracy of this map, especially when used in another system or with other software.

Data Source: See Appendices 1-14 for the raw geochemical data.

Plate 2 of 6
On the accompanying diskette a manuscript file supplements Plate 2 as a separate .pdf document.

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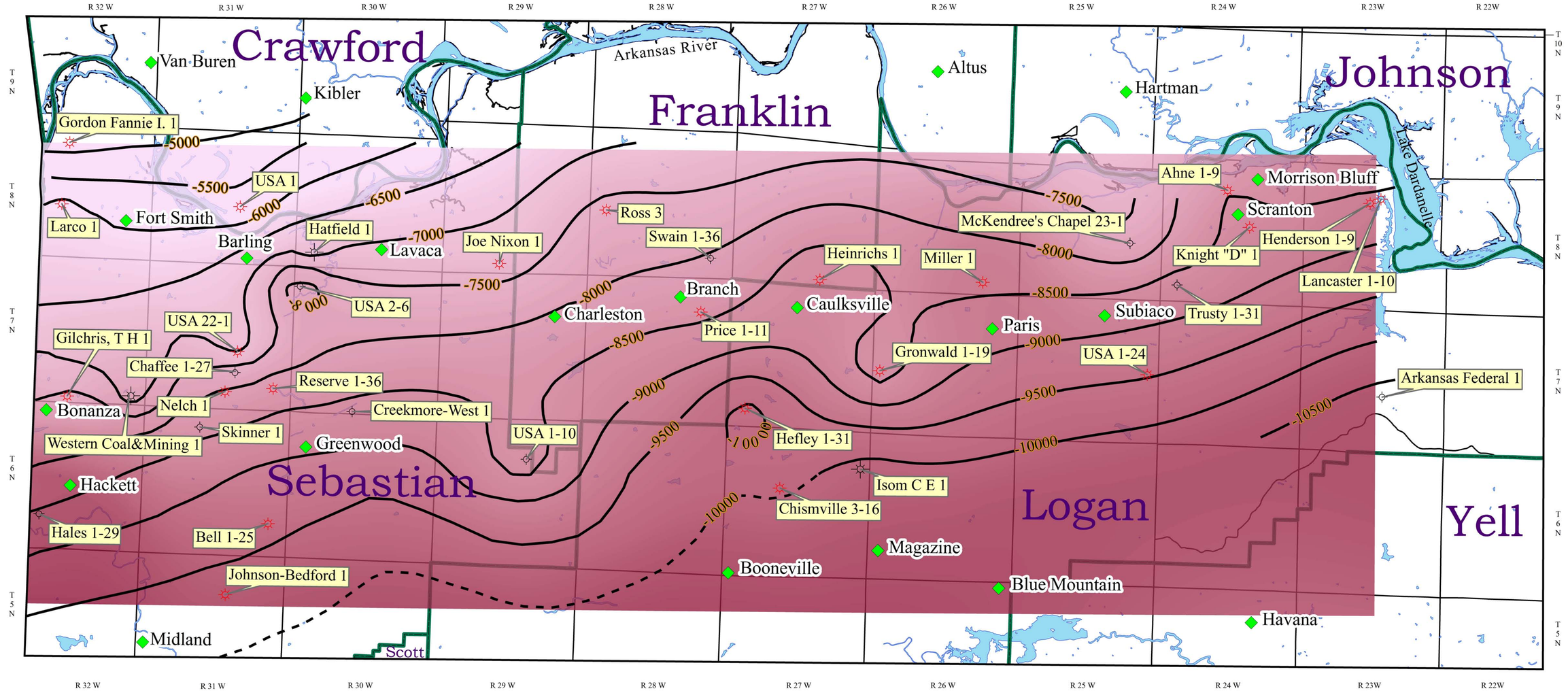
Bekki White, Director and State Geologist
Technical Review by P. Li, M.E. Ratchford and D.M. Jarvie

April 2010

Plate Number

2

Information Circular 40



Study Area

Arkansas

5 2.5 0 5 10 15 Miles

5 2.5 0 5 10 15 Kilometers

Scale: 1:130,000

Structure Contour Map of the Top of the Mississippian Fayetteville Shale

Contour Internal = 500 feet

Symbols

- Gas Well
- Plugged and Abandoned
- Dry Hole
- -5000 Structure Contour Line
- -10000 Inferred Structure Contour Line
- Cities
- County Boundary

Elevation of the Formation Top from Sea Level

High : -5302.91

Low : -11822.4

N W E S

Disclaimer: This map was prepared using ESRI software on computers at the Arkansas Geological Survey. The Arkansas Geological Survey does not guarantee the accuracy of this map, especially when used in another system or with other software.

Data Source: See Table 1 for the raw stratigraphic top data.

Plate 3 of 6
On the accompanying diskette a manuscript file supplements Plate 3 as a separate .pdf document.

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Bekki White, Director and State Geologist
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April 2010

Plate Number

3

Information Circular 40

R 32 W R 31 W R 30 W R 29 W R 28 W R 27 W R 26 W R 25 W R 24 W R 23W R 22W

T 9 N T 8 N T 7 N T 6 N T 5 N

Van Buren
Kibler
Arkansas River
Altus
Hartman
Johnson
Lake Dardanelle
Crawford
Franklin
Logan
Yell
Sebastian
Scott
Fort Smith
Midland
Havana
Bonanza
Greenwood
Hackett
Barling
Lavaca
Charleston
Branch
Caulksville
Paris
Subiaco
Booneville
Magazine
Blue Mountain

Gordon Fannie I. 1
USA 1
Larco 1
Hatfield 1
Ross 3
Swain 1-36
Joe Nixon 1
Heinrichs 1
Miller 1
McKendree's Chapel 23-1
Ahne 1-9
Morrison Bluff
Scranton
Knight "D" 1
Henderson 1-9
Lancaster 1-10
Trusty 1-31
USA 2-6
USA 22-1
Chaffee 1-27
Price 1-11
Gilchrist, T H 1
Reserve 1-36
Nelch 1
Creekmore-West 1
USA 1-10
Western Coal&Mining 1
Skinner 1
Gronwald 1-19
USA 1-24
Arkansas Federal 1
Hefley 1-31
Chismville 3-16
Isom C E 1
Bell 1-25
Hales 1-29
Johnson-Bedford 1

-5500 -6000 -6500 -7000 -7500 -8000 -8500 -9000 -9500 -10000 -10500 -11000

Study Area

Arkansas

5 2.5 0 5 10 15 Miles

5 2.5 0 5 10 15 Kilometers

Scale: 1:130,000

Structure Contour Map of the Top of the Devonian Chattanooga Shale

Contour Internal = 500 feet

Symbols

- Gas Well
- Plugged and Abandoned
- Dry Hole
- -6000 Structure Contour Line
- -11000 Inferred Structure Contour Line
- Cities
- County Boundary

Elevation of Formation Top from Sea Level

High : -5302.91

Low : -11822.4

N W E S

Disclaimer: This map was prepared using ESRI software on computers at the Arkansas Geological Survey. The Arkansas Geological Survey does not guarantee the accuracy of this map, especially when used in another system or with other software.

Data Source: See Table 1 for the raw stratigraphic top data.

Plate 4 of 6
On the accompanying diskette a manuscript file supplements Plate 4 as a separate .pdf document.

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Bekki White, Director and State Geologist
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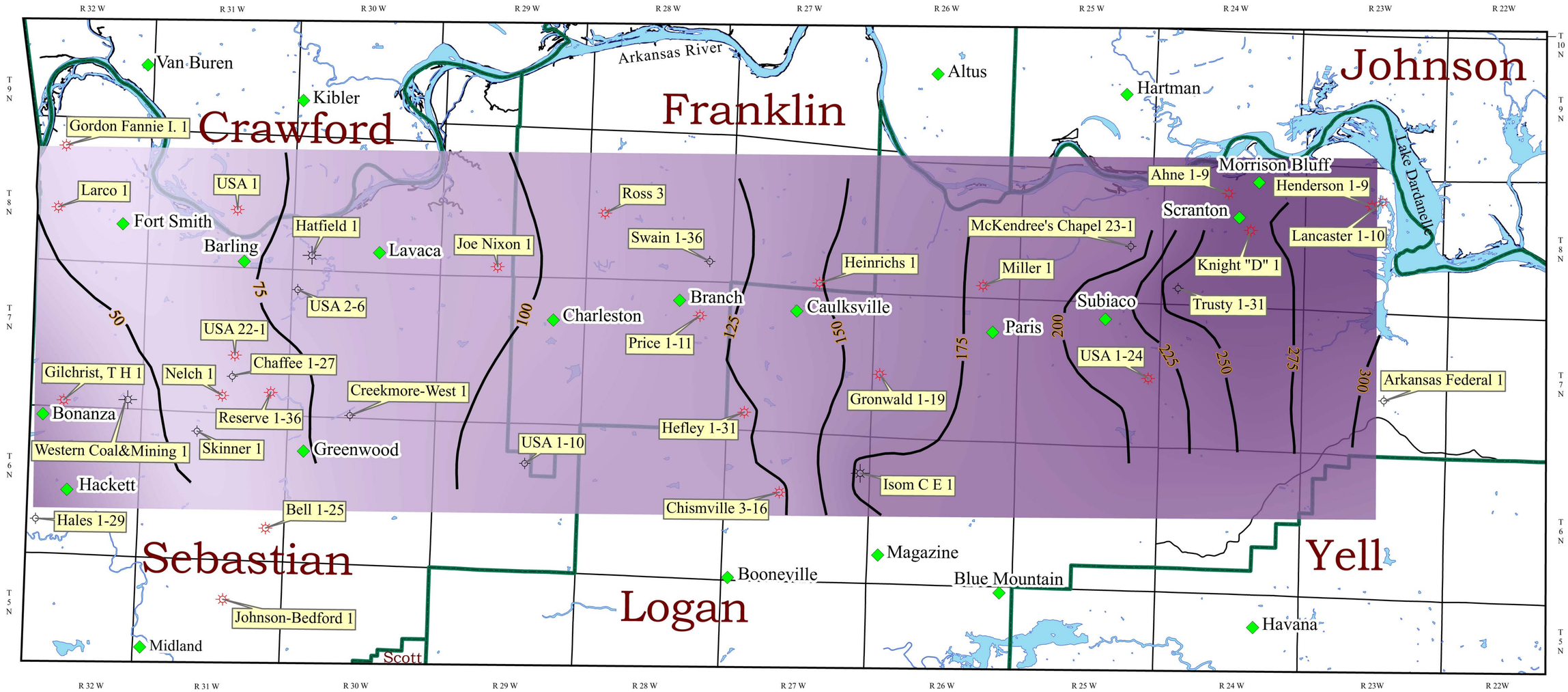
April 2010

Plate Number

4

Information Circular 40



Study Area

Arkansas

Miles
5 2.5 0 5 10 15

Kilometers
5 2.5 0 5 10 15

Scale: 1:130,000

Isopach Map of the Mississippian Fayetteville Shale

Contour Internal = 25 feet

Symbols

- Gas Well
- Plugged and Abandoned
- Dry Hole
- 200 Thickness Contour Line
- Cities
- County Boundary

Thickness of the Fayetteville Shale

High : 297.122

Low : 35.8828

N
W E
S

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Data Source: See Table 1 for the raw stratigraphic top data.

Plate 5 of 6
On the accompanying diskette a manuscript file supplements Plate 5 as a separate .pdf document.

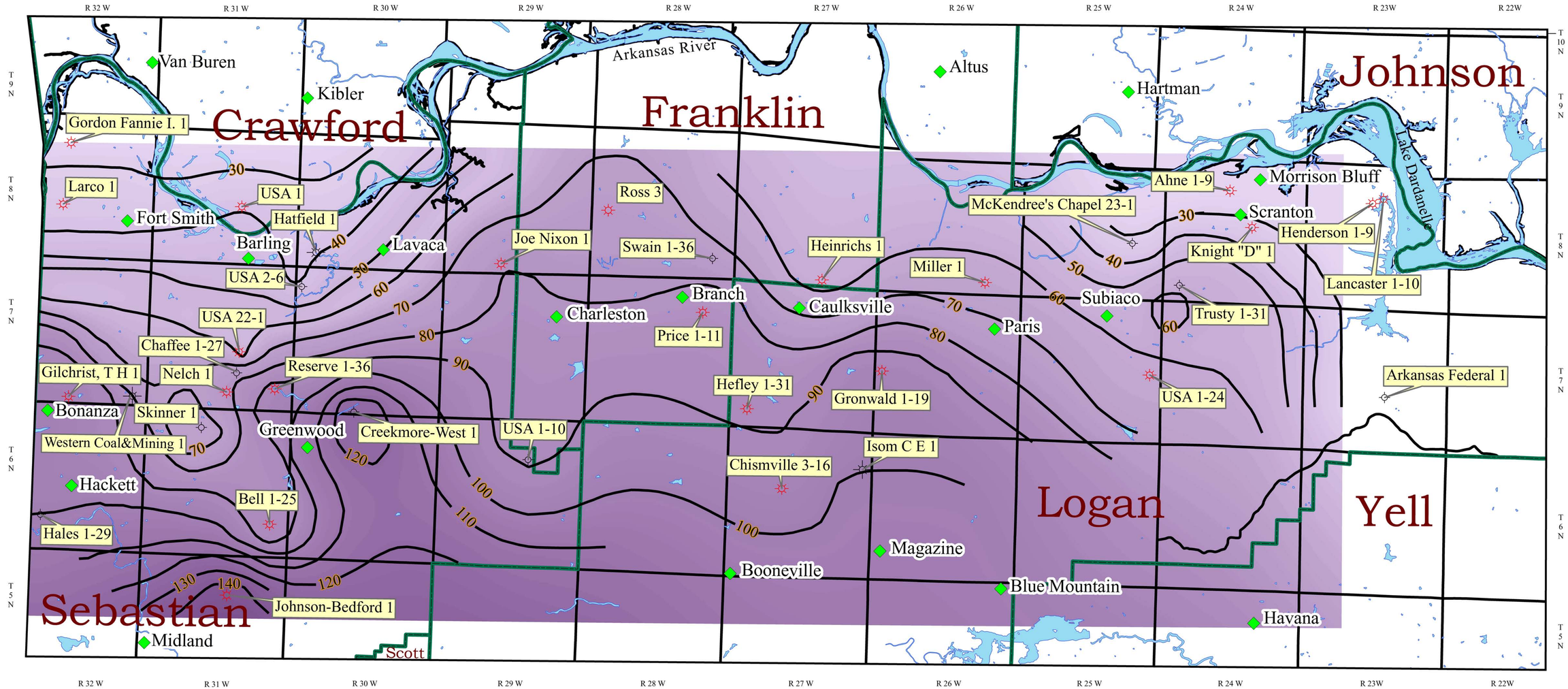
Arkansas Geological Survey
Bekki White, Director and State Geologist
Technical Review by P. Li, M.E. Ratchford and D.M. Jarvie

April 2010

Plate Number

5

Information Circular 40



Study Area

Arkansas

5 2.5 0 5 10 15 Miles

5 2.5 0 5 10 15 Kilometers

Scale: 1:130,000

Isopach Map of the Devonian Chattanooga Shale

Contour Internal = 10 feet

Symbols

- Gas Well
- Plugged and Abandoned
- Dry Hole
- 50 Thickness Contour Line
- Cities
- County Boundary

Thickness of Chattanooga Shale

High : 147.403

Low : 12.2139

N W E S

Disclaimer: This map was prepared using ESRI software on computers at the Arkansas Geological Survey. The Arkansas Geological Survey does not guarantee the accuracy of this map, especially when used in another system or with other software.

Data Source: See Table 1 for the raw stratigraphic top data.

Plate 6 of 6

On the accompanying diskette a manuscript file supplements Plate 6 as a separate .pdf document.

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Bekki White, Director and State Geologist
Technical Review by P. Li, M.E. Ratchford and D.M. Jarvie

April 2010

Plate Number

6

Information Circular 40