PS Rock-Eval Basic/Bulk-Rock vs. Shale Play Methods for Characterization of Unconventional Shale Resource Systems: Application to the Eagle Ford Shale, Texas*

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Abstract

Artificial thermal maturation of rock samples by open-system pyrolysis is the most widely accepted method to evaluate the hydrocarbon content and the petroleum generation potential of source rocks in oil and gas exploration. Traditional pyrolysis methods (e.g. Rock-Eval Basic/Bulk-Rock®) were developed to evaluate conventional petroleum systems where the source and reservoir rocks are not the same. In contrast, for self-contained source-reservoir rocks in unconventional petroleum systems, it has been demonstrated that classical pyrolysis methods underestimate the amount of retained hydrocarbons (free or sorbed). To solve this issue, the Shale Play® method was recently proposed by IFPEN (France). In this method, a new programmed ramp of temperature during both thermovaporization and pyrolysis stages is set to better quantify the amount of producible hydrocarbon. This new program provides three main parameters: a) the Sh0 peak, that corresponds to the available free and sorbed low-to-medium molecular weight aliphatic and aromatic hydrocarbons (20); b) the Sh1, that corresponds to the medium and high-molecular weight hydrocarbons (30 aromatics and saturates); and c) the Sh2 peak, that represents the hydrocarbons released by cracking of sedimentary organic matter. In this work, we compared Rock-Eval pyrolysis results obtained using both the Basic/Bulk-Rock® and the Shale Play® methods. Twelve core samples from Well #1 and Well #2 drilled in the Eagle Ford Shale Play at Gonzales and La Salle counties (Texas) respectively were investigated. We detected that part of the low to medium-molecular weight hydrocarbon (S1 peak) is lost during the Basic/Bulk-Rock® method because the thermovaporization step starts at 300°C. In contrast, the Shale Play® method showed a more accurate quantification of low to high-molecular weight thermovaporized hydrocarbons (Sh0 and Sh1 peaks) because of the new temperature settings, where the starting temperature is 100°C. The increase in hydrocarbon quantification per rock sample with the Shale Play® method ranges between 17.4-40.6 %, averaging 25.7 %. Based on these results, the Shale Play® method allows an improved recovery of hydrocarbons still present in source rocks. The oil crossover effect and potential productive intervals were mainly identified in core samples from the Lower Eagle Ford member. We demonstrated that this method is more adapted to identify potential producing targets in unconventional shale resource systems.

References Cited

Romero-Sarmiento, M-F., D. Pillot, G. Letort, V. Lamoureux-Var, V. Beaumont, A-Y. Huc, and B. Garcia, 2015, New Rock-Eval Method for Characterization of Unconventional Shale Resource Systems: Oil & Gas Science and Technology, v. 71/3, p. 1-9.

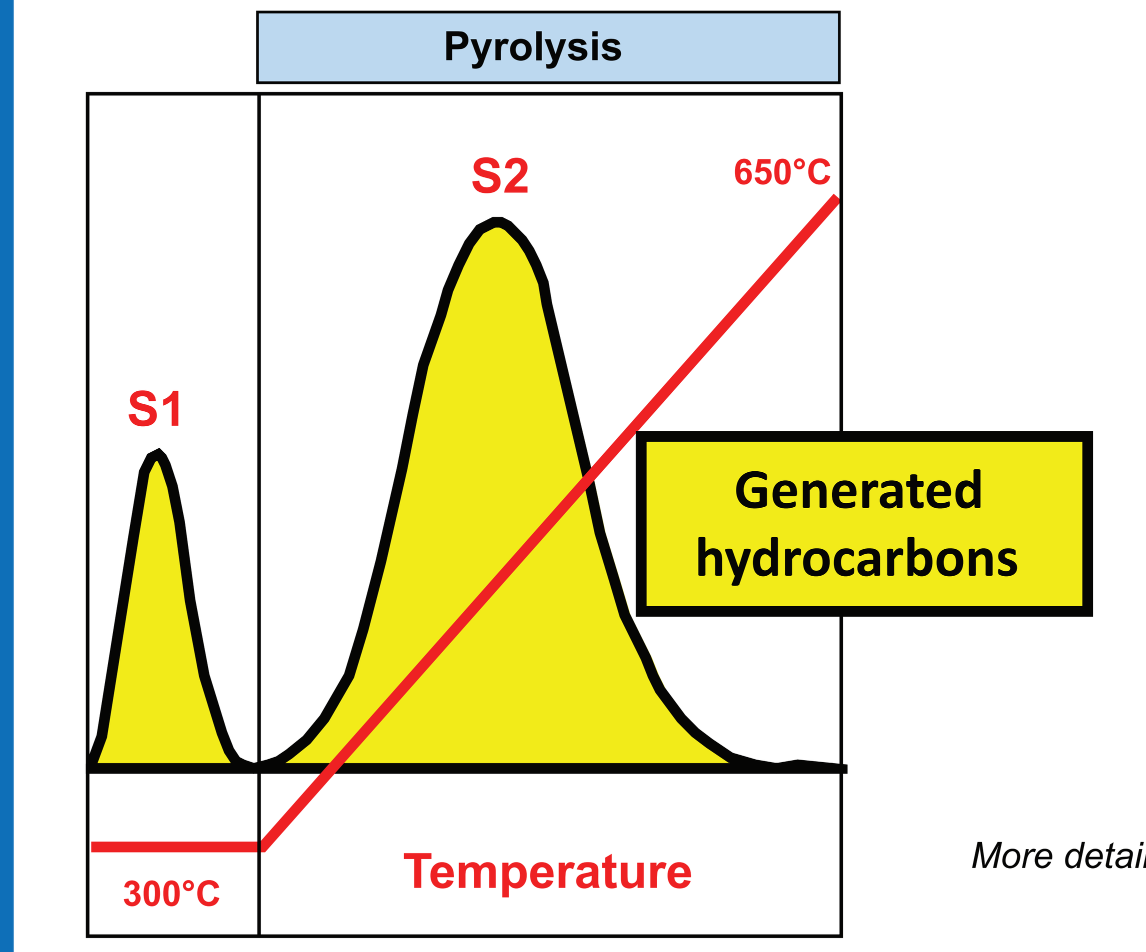
Romero-Sarmiento, M-F., T. Euzen, S. Rohais, C. Jiang, and R. Littke, 2016, Artificial thermal maturation of source rocks at different thermal maturity levels: Application to the Triassic Montney and Doig Formations in the Western Canada Sedimentary Basin: Organic Geochemistry, v. 97, doi: http://dx.doi.org/10.1016/j.orggeochem.2016.05.002

Ramiro-Ramirez, S., 2016, Petrographic and petrophysical characterization of the Eagle Ford Shale in La Salle and Gonzales counties, Gulf Coast Region, Texas: Master's Thesis, Colorado School of Mines, Golden, CO, USA.

IFPEN Rock-Eval Basic/Bulk-Rock versus Shale Play methods

Rock-Eval temperature program

Basic/Bulk-Rock method ®



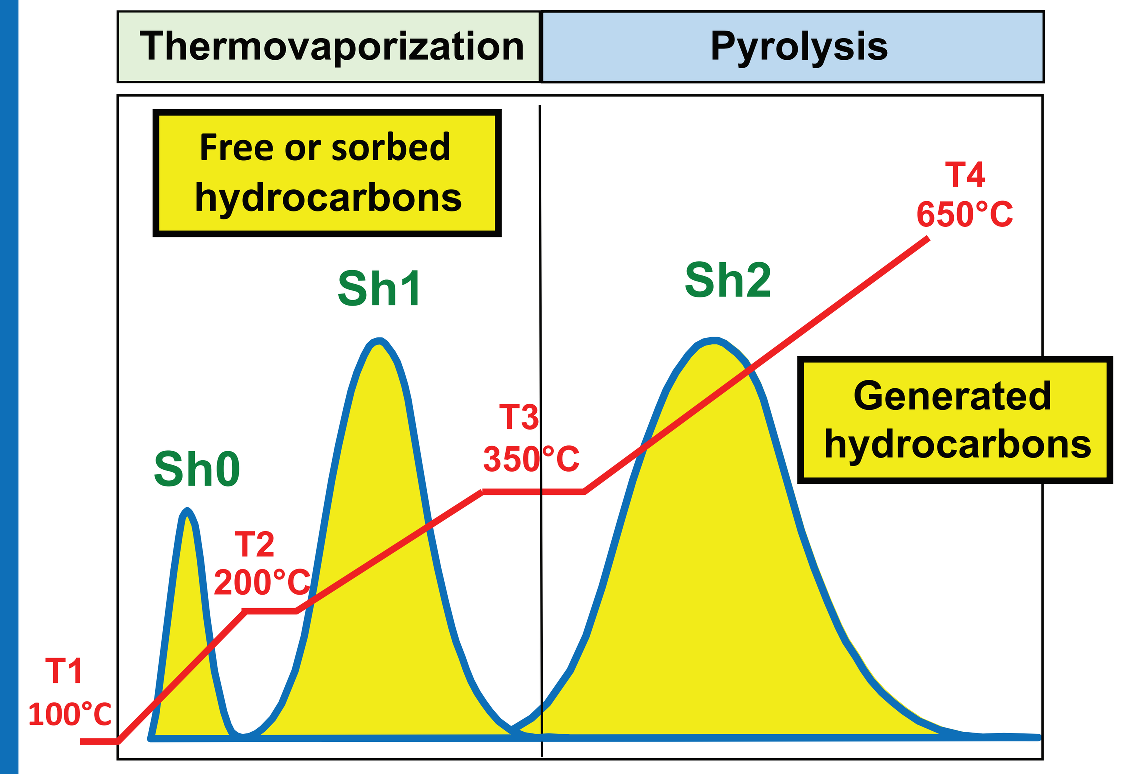
Source rocks

- Initialization at 300 °C during 3 minutes
- Pyrolysis from 300 °C to 650 °C at 25°C/min
- Oxidation from 300 °C to 850 °C at 20°C/min

More details available in Espitalié et al. (1986), Lafargue et al. (1998) & Behar et al. (2001).

Shale Play method ®

Tight, fractured and hybrid shale plays



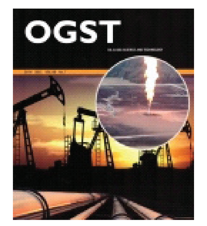
- The pyrolysis step starts at low T1=100 °C
- Pyrolysis from 100 °C to 200 °C (T2) at 25°C/min
  T2 is maintained for 3 minutes
- Pyrolysis from 200 °C to 350 °C (T3) at 25°C/min
  T3 is maintained for 3 minutes
- Pyrolysis from 350 °C to 650 °C (T4) at 25°C/min
- Oxidation from 300 °C to 850 °C at 20°C/min

More details available in Romero-Sarmiento et al. (2015; 2016) & Patent 14/55.009 (2014).

References

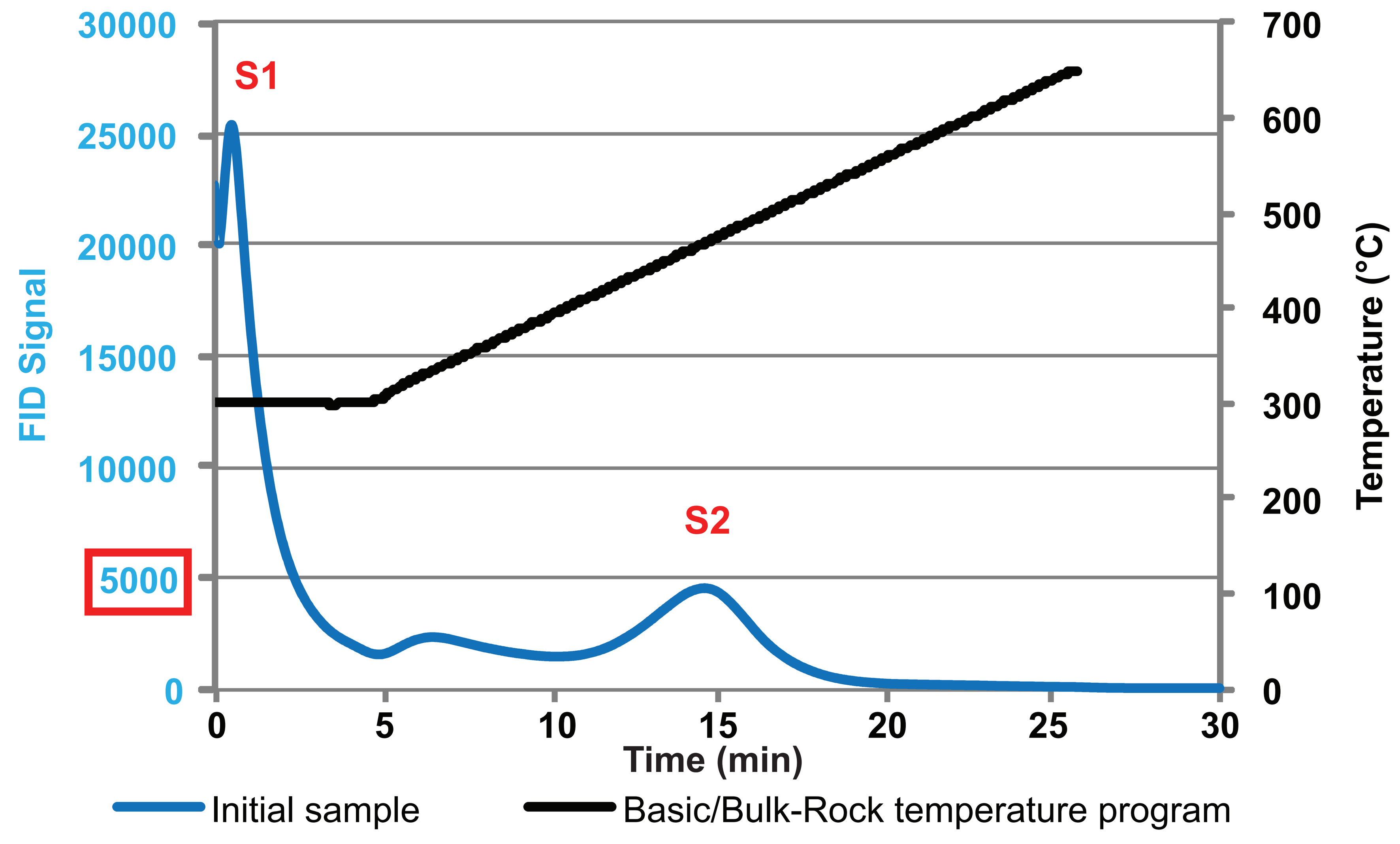
New Rock-Eval method for characterization of unconventional shale resource systems

Romero-Sarmiento et al. (2015). Published in OIL & GAS SCIENCE AND TECHNOLOGY



Rock-Eval pyrogram

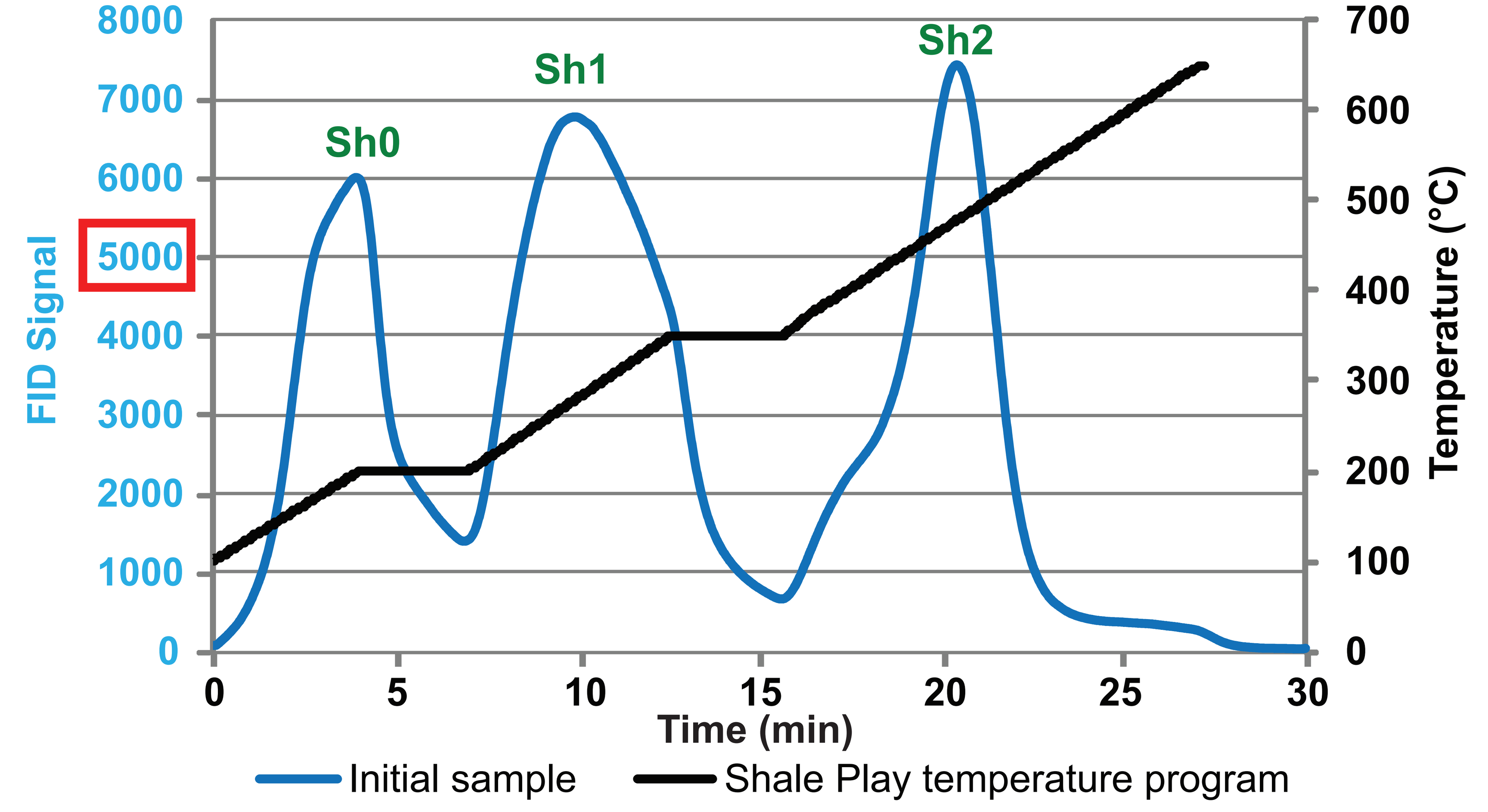
Basic/Bulk-Rock parameters ®



[Sh0 + Sh1] > S_1 peak

HC_{cont} = Sh0 + Sh1

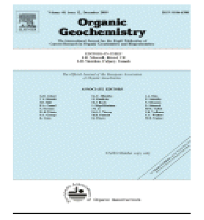
Shale Play parameters ®



Basic/Bulk-Rock vs. Shale Play parameters: Late Jurassic Bazhenov Shale sample (Romero-Sarmiento et al., 2015)

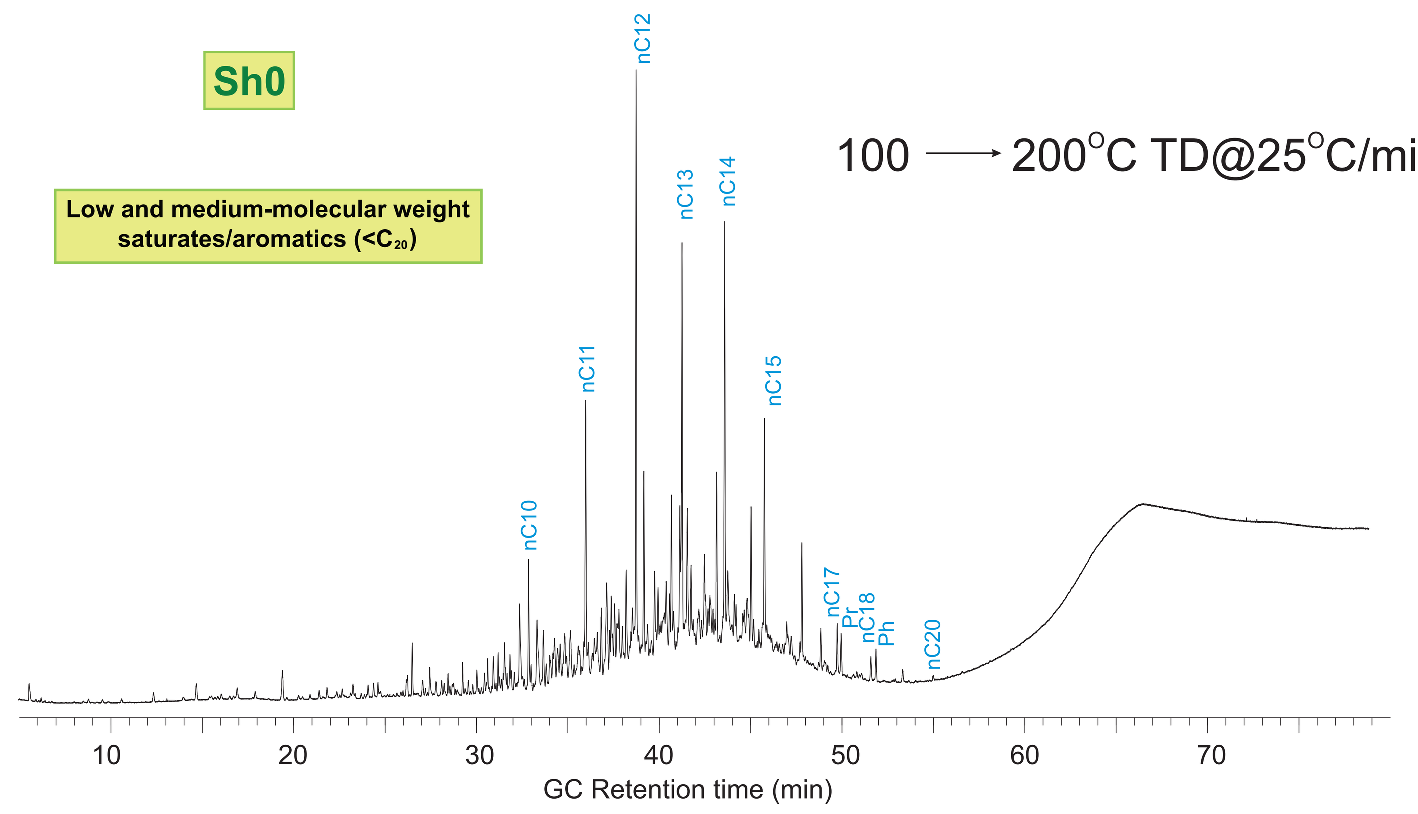
Artificial thermal maturation of source rocks at different thermal maturity levels: Application to the Triassic Montney and Doig Formations in the Western Canada Sedimentary Basin

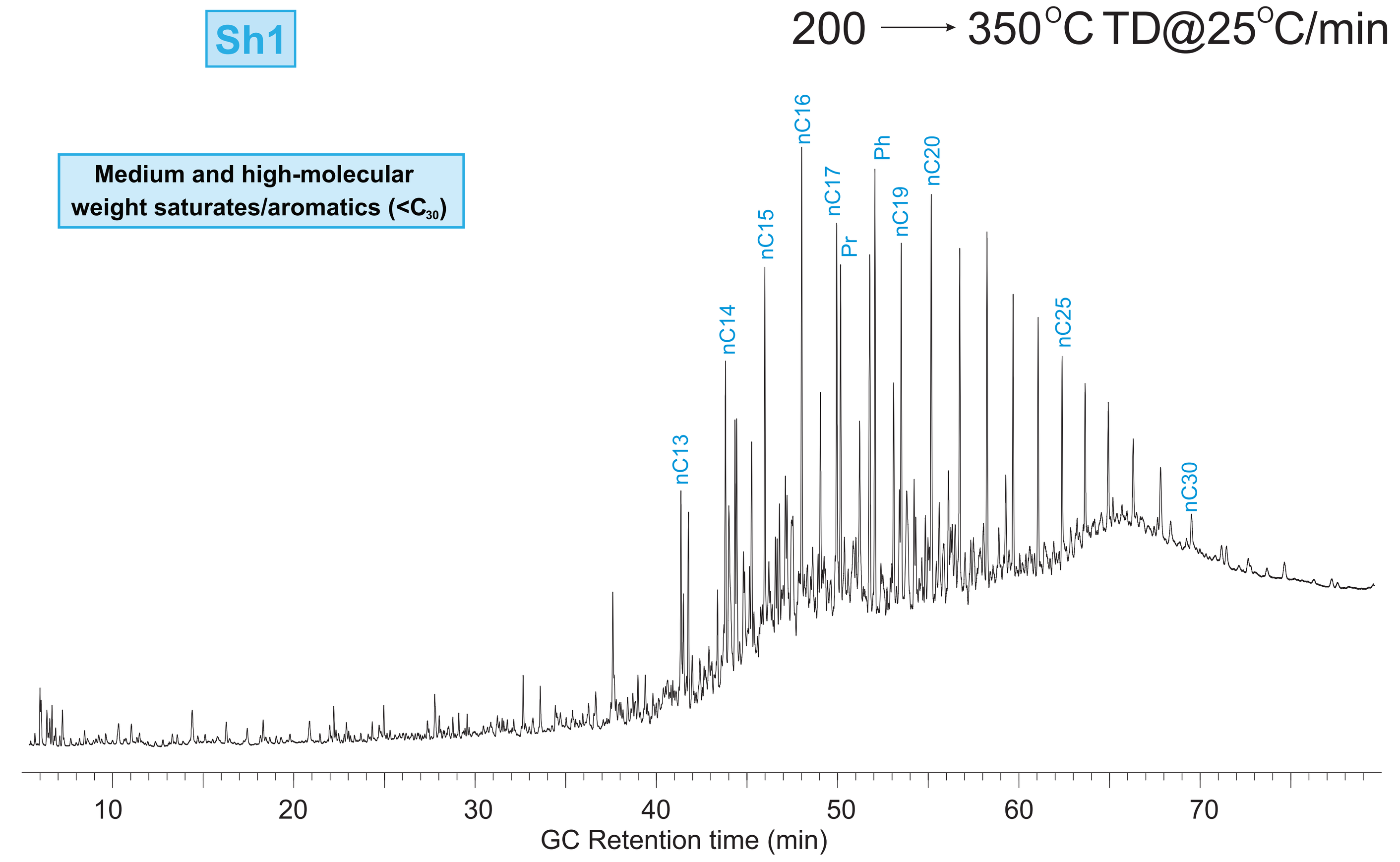
Romero-Sarmiento et al. (2016). Published in ORGANIC GEOCHEMISTRY



Composition of hydrocarbons thermally desorbed

HC detected by Sh0 and Sh1 parameters





GC traces from TD-GC-MS-FID analysis of early mature core sample from Doig Formation - Canada (Romero-Sarmiento et al., 2016)

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Key Points

- New pyrolysis method proposed for evaluation of hydrocarbon content in unconventional shale plays
- Twelve core samples from the Eagle Ford Shale Play were analyzed with the Basic/Bulk-Rock® and Shale Play® methods
- Better quantification of low to high-molecular weight thermovaporized hydrocarbons (Sh0 and Sh1 peaks) with Shale Play® method

Motivation

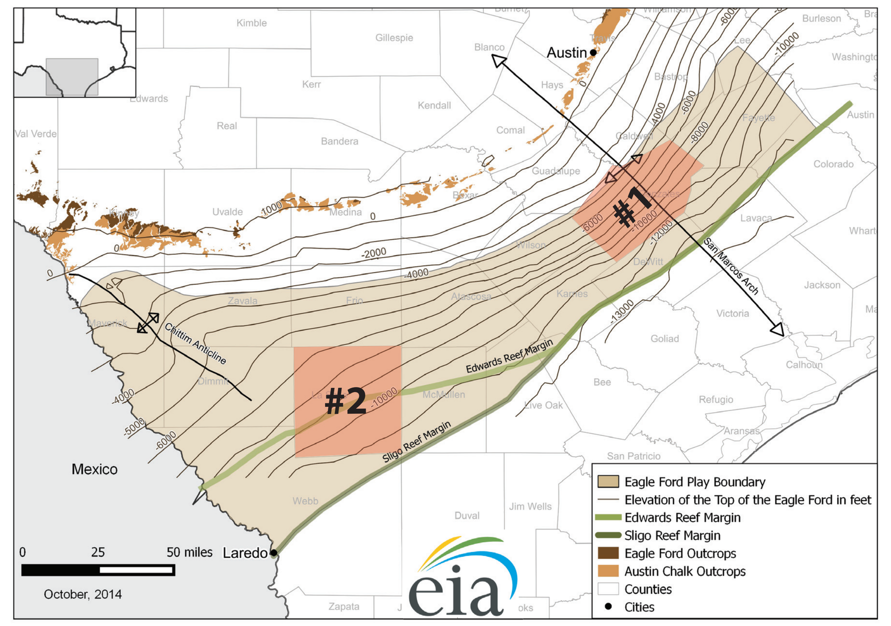
1) Classical pyrolysis methods underestimate the amount of retained hydrocarbons (free or sorbed)

2) Compare Rock-Eval pyrolysis results using both the Basic/Bulk-Rock® and the Shale Play® methods

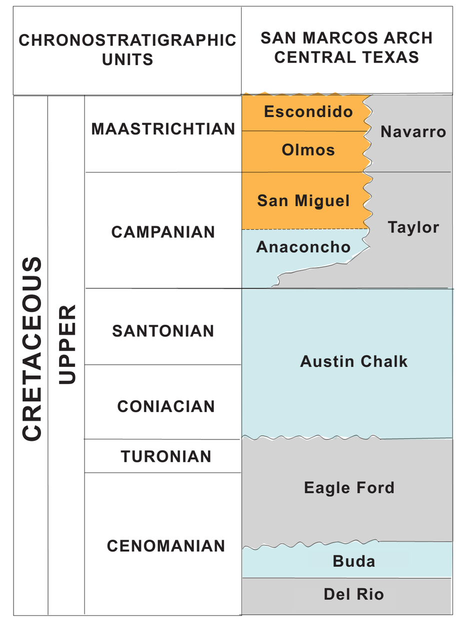
3) Identify potential productive intervals in the lower and upper Eagle Ford Shale members

Study Area

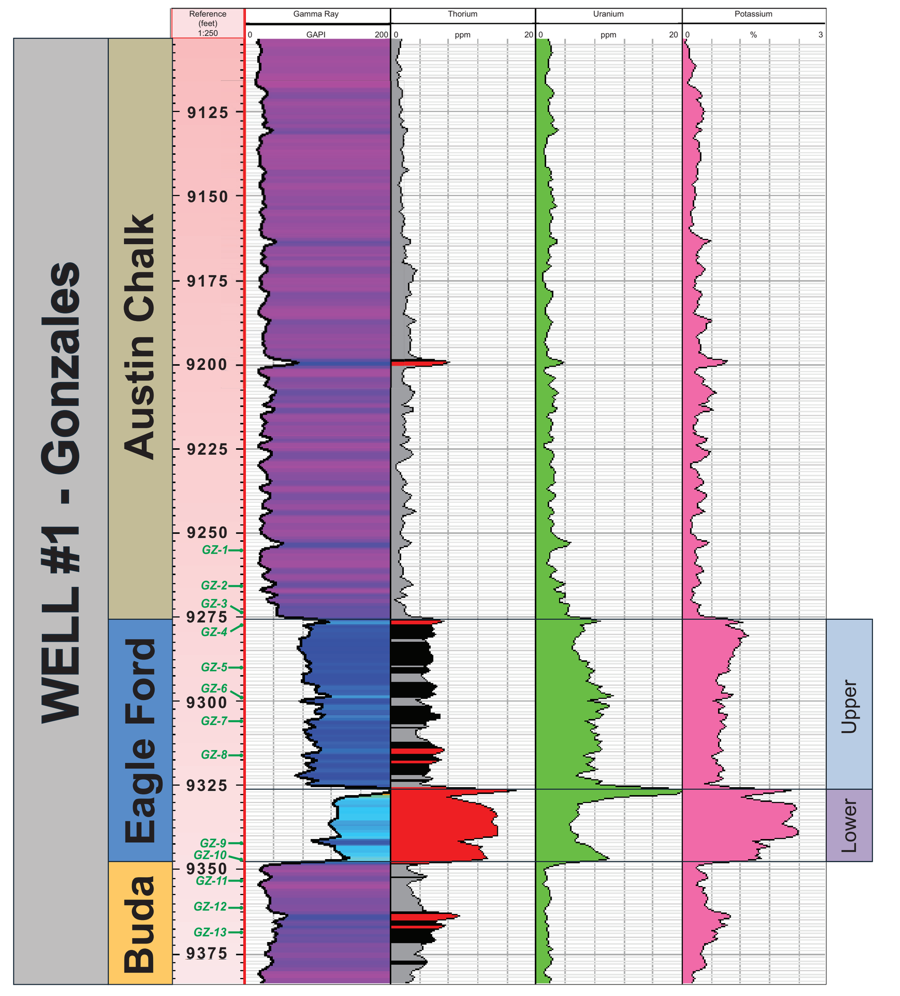
The Eagle Ford Shale is the largest producing formation in the Gulf Coast region, South Texas. As of March 2017, oil and natural gas production surpassed 1.1 MMBOPD and 5.8 BCFPD respectively. These numbers make the Eagle Ford Region the second largest shale and tight oil producing region in the US, behind the Permian Region (2.3 MMBOPD) (EIA, 2017).



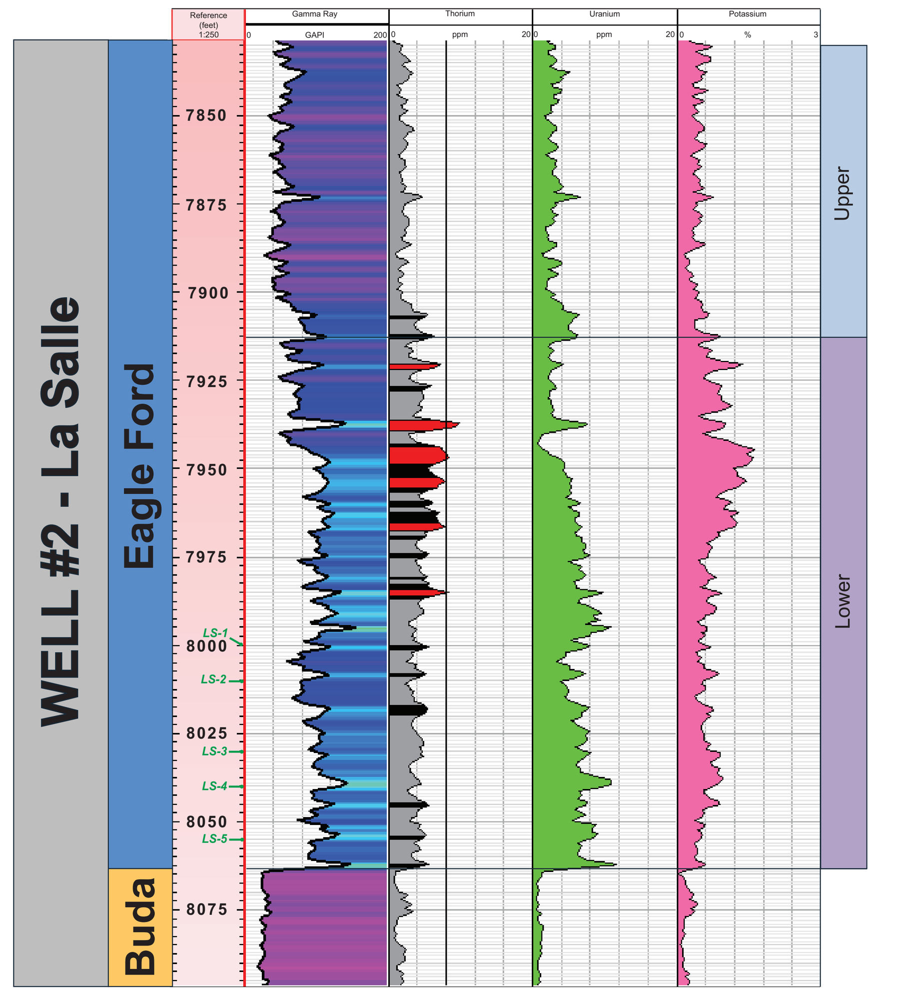
Eagle Ford Shale reagion in West Texas. The wells are located in Gonzales (Well #1) and La Salle (Well #2) counties.



Stratigraphic column for the Upper Cretaceous in Central Texas.

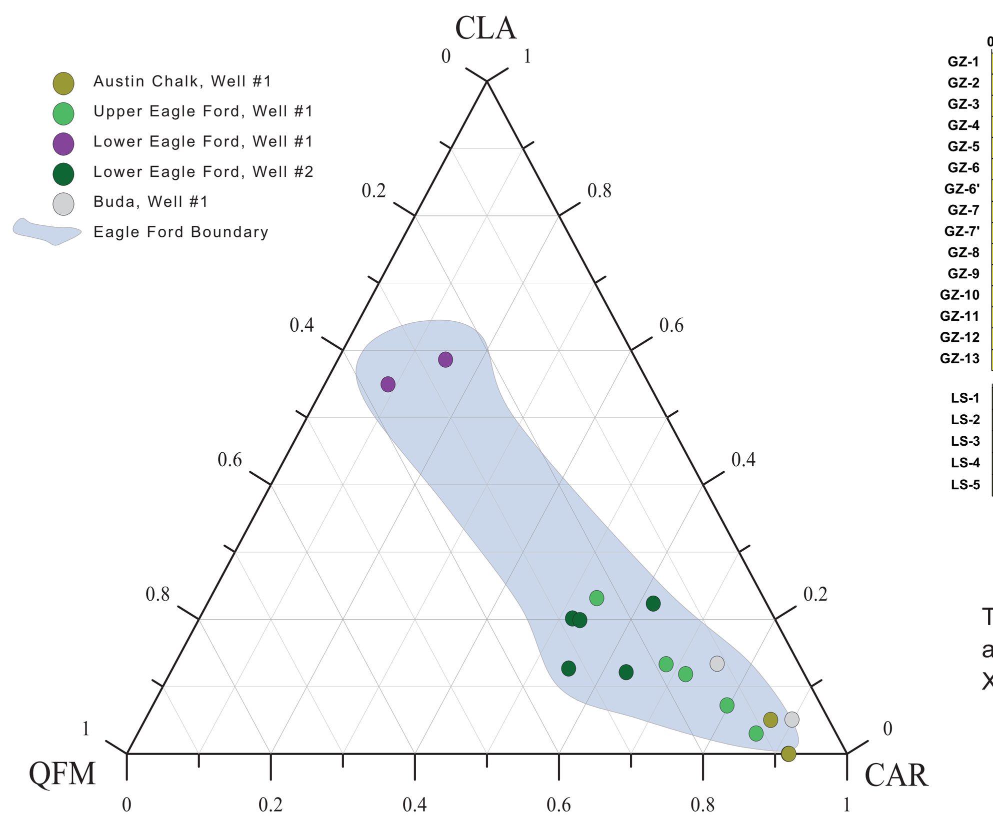


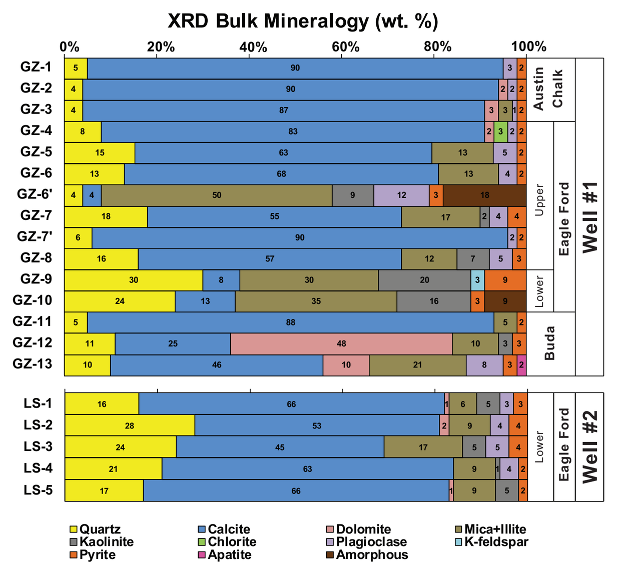
Well #1 log showing part of the Buda Limestone, Eagle Ford Shale, and part of the Austin Chalk. Well depths of analyzed core samples in green.



Well #2 log showing part of the Buda Limestone, lower Eagle Ford, and part of the upper Eagle Ford. Well depths of analyzed core samples in green.

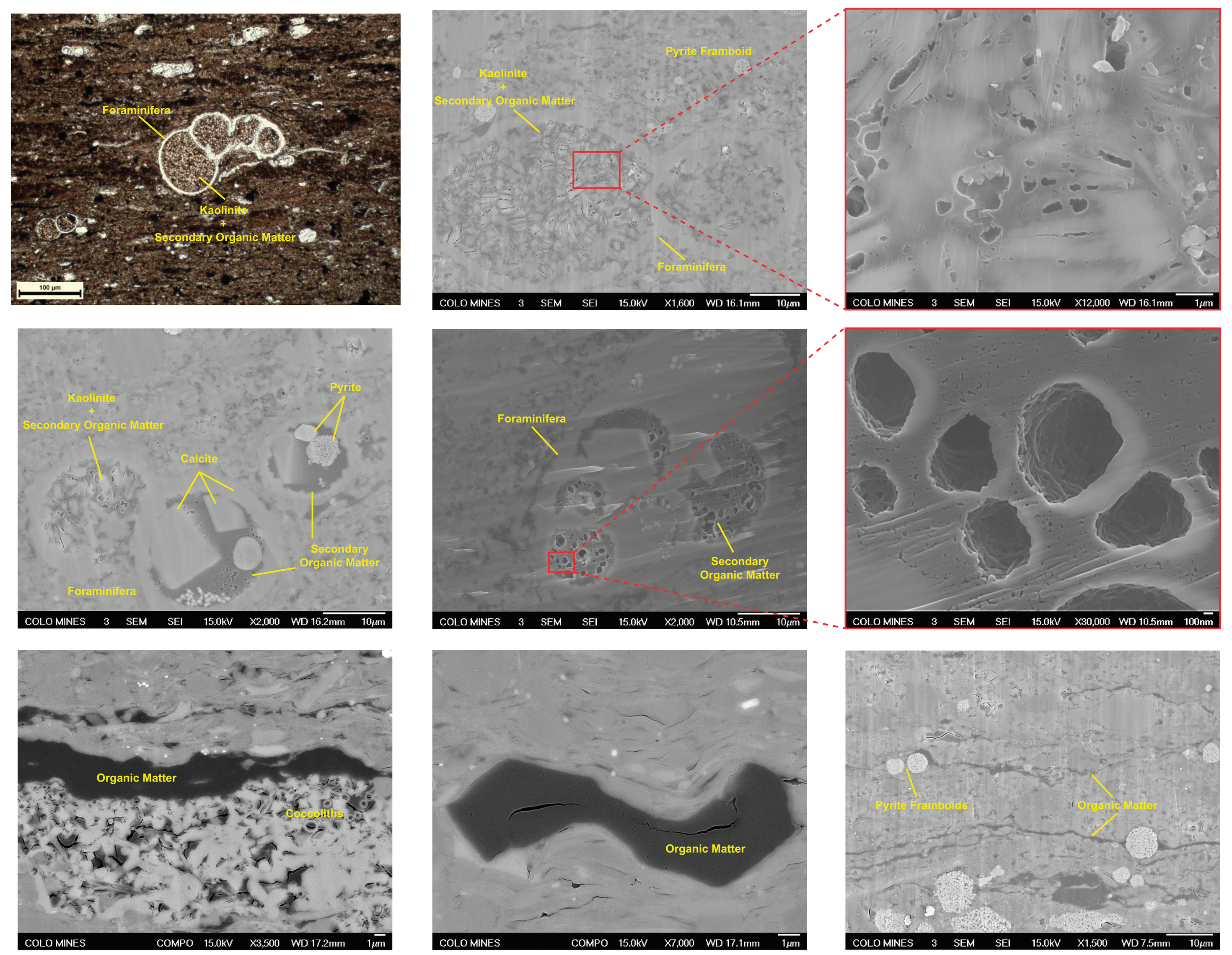
Samples Location and Characteristics



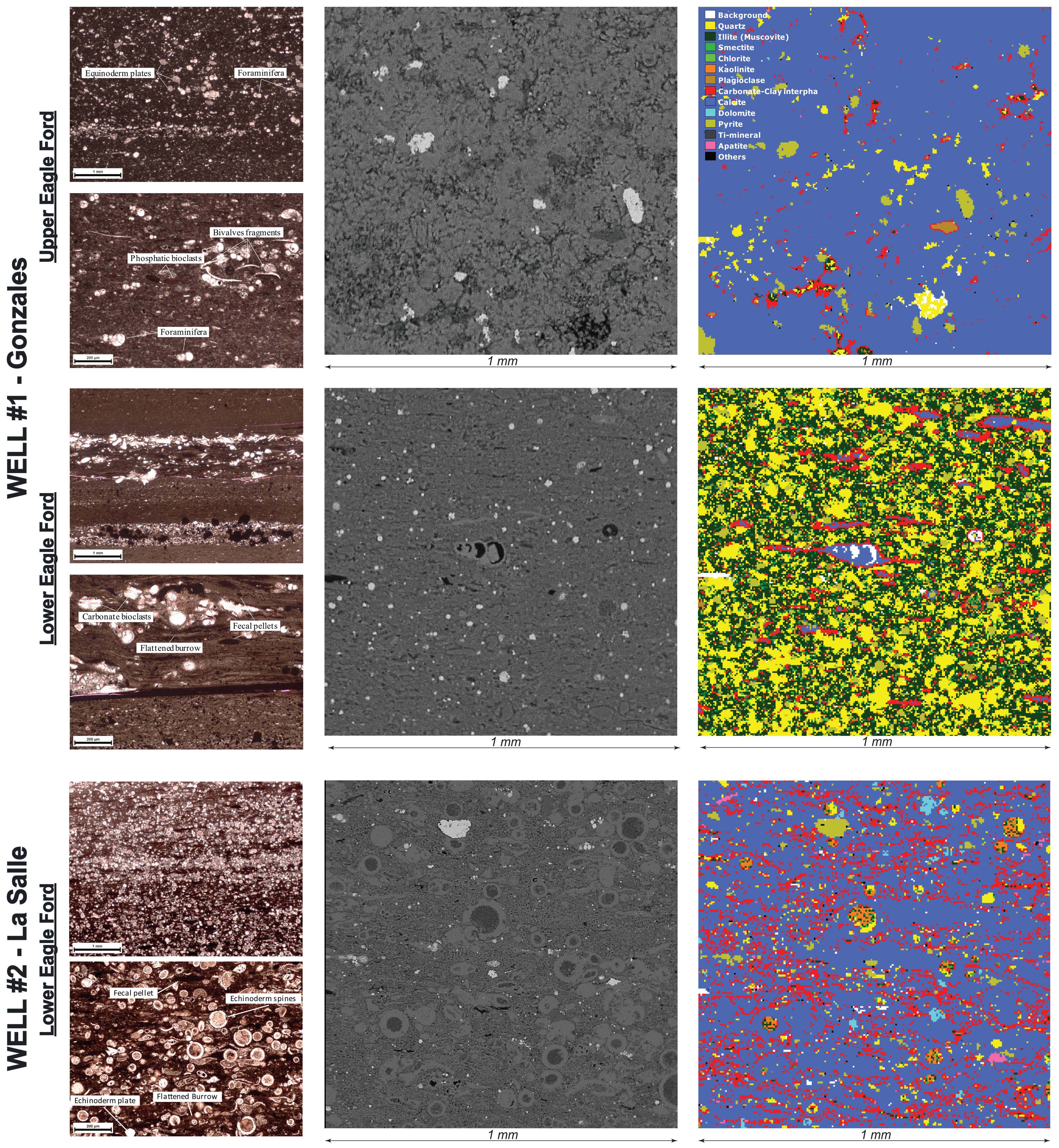


Ternary diagram and chart showing mineralogy of analyzed core samples. Data was obtained from X-Ray Diffraction (XRD).

Organic Matter Distribution



Mineralogy Distribution



Rock-Eval Basic/Bulk-Rock versus Shale Play methods: Application to the Eagle Ford Shale

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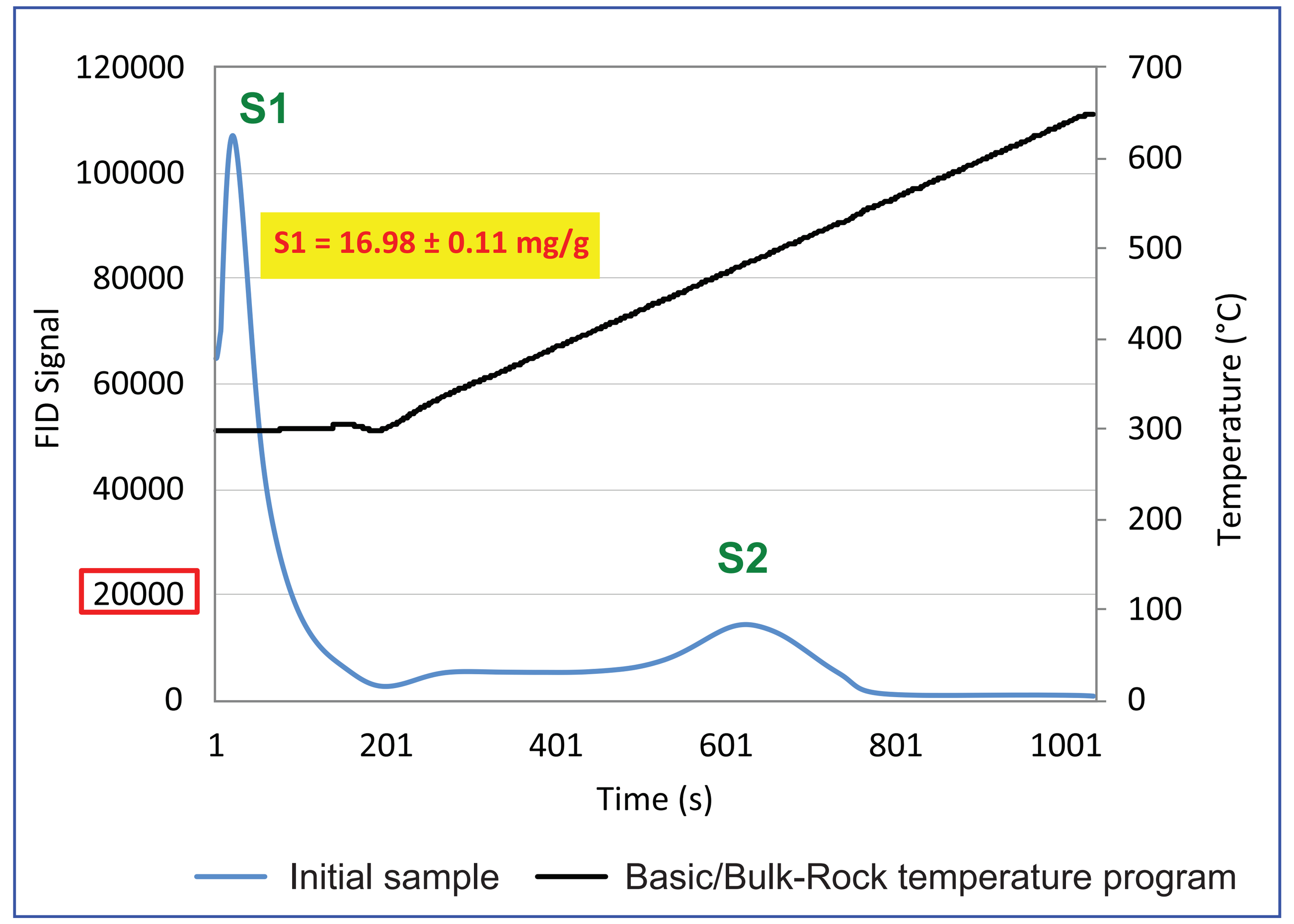
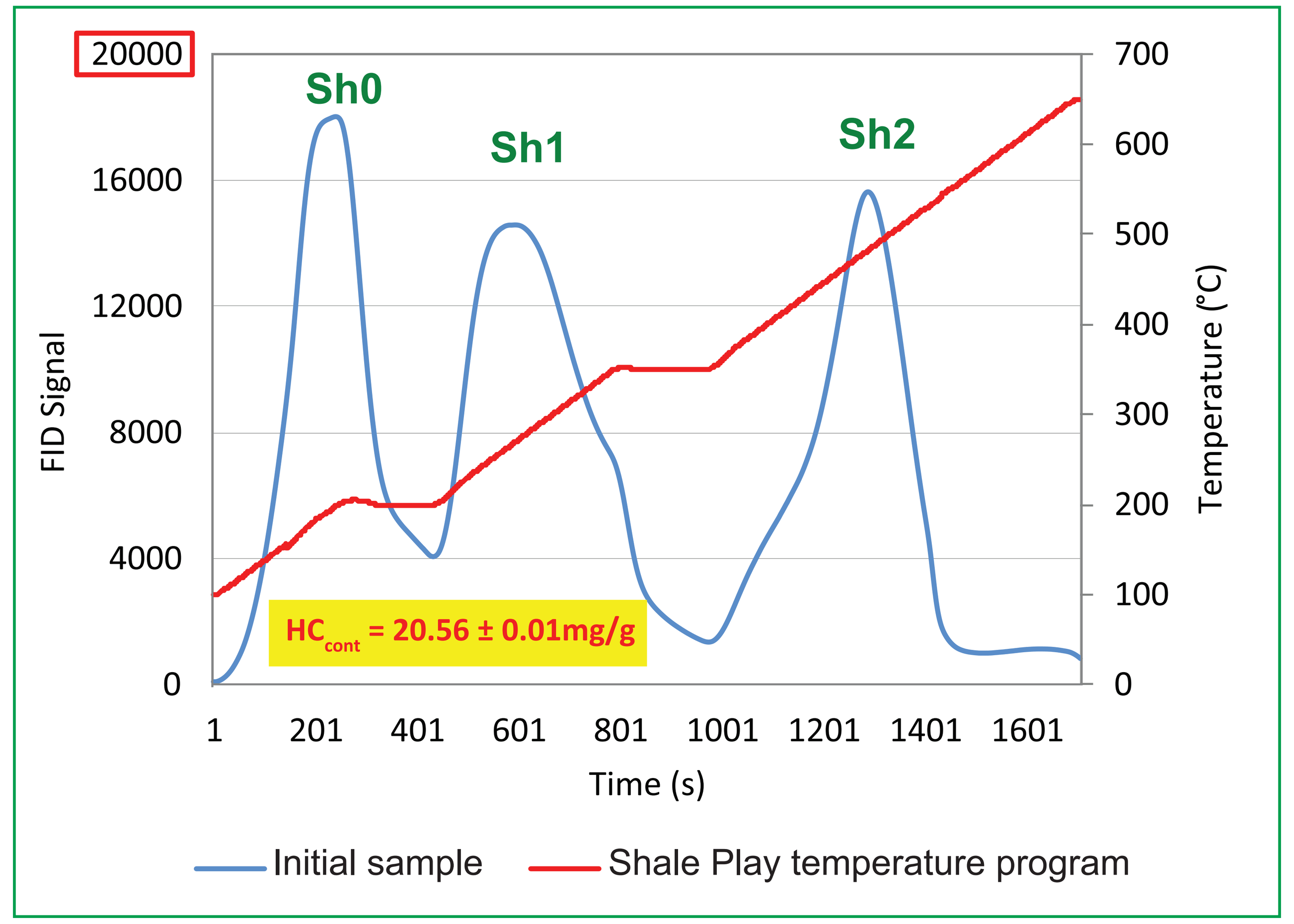
Results

Pyrograms: Basic/Bulk-Rock vs. Shale Play methods ®

S1 and S2 peaks from Basic/Bulk-Rock method



Sh0, Sh1 and Sh2 peaks from Shale Play method



[Sh0 + Sh1] > S_1 peak

Sample LS-1
Lower Eagle Ford Formation
Well #2

HC_{cont} = Sh0 + Sh1

*Romero-Sarmiento et al. (2015)

Rock-Eval results: Basic/Bulk-Rock vs. Shale Play methods ®

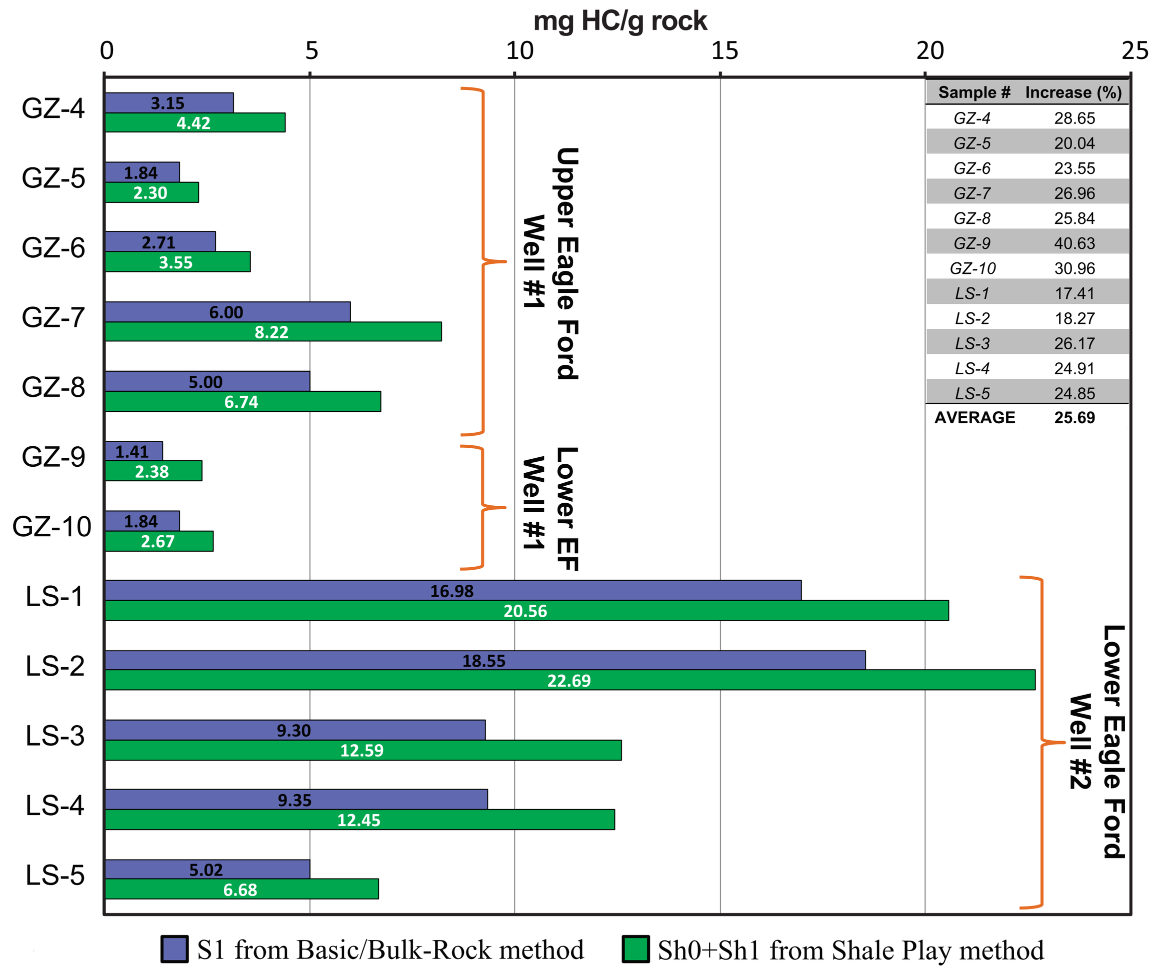
			Basic/Bulk-Rock method	Shale Play method		
Samples	Well	Unit	S1(mg/g)	Sh0(mg/g)	Sh1(mg/g)	HCcont(mg/g)
GZ-4	1	Upper Eagle Ford	3.15 ± 0.30	2.45 ± 0.01	1.97 ± 0.04	4.42 ± 0.05
GZ-5	1	Upper Eagle Ford	1.84 ± 0.04	1.11 ± 0.05	1.19 ± 0.01	2.30 ± 0.06
GZ-6	1	Upper Eagle Ford	2.71 ± 0.03	1.85 ± 0.01	1.70 ± 0.01	3.55 ± 0.02
GZ-7	1	Upper Eagle Ford	6.00 ± 0.00	3.51 ± 0.02	4.71 ± 0.00	8.22 ± 0.02
GZ-8	1	Upper Eagle Ford	5.00 ± 0.11	3.01 ± 0.08	3.73 ± 0.02	6.74 ± 0.11
GZ-9	1	Lower Eagle Ford	1.41 ± 0.01	0.57 ± 0.01	1.81 ± 0.02	2.38 ± 0.01
GZ-10	1	Lower Eagle Ford	1.84 ± 0.00	0.69 ± 0.02	1.98 ± 0.00	2.67 ± 0.02
LS-1	2	Lower Eagle Ford	16.98 ± 0.11	9.38 ± 0.25	11.19 ± 0.26	20.56 ± 0.01
LS-2	2	Lower Eagle Ford	18.55 ± 0.06	10.49 ± 0.28	12.21 ± 0.29	22.69 ± 0.01
LS-3	2	Lower Eagle Ford	9.30 ± 0.05	5.06 ± 0.17	7.53 ± 0.06	12.59 ± 0.11
LS-4	2	Lower Eagle Ford	9.35 ± 0.08	5.17 ± 0.06	7.28 ± 0.06	12.45 ± 0.01
LS-5	2	Lower Eagle Ford	5.02 ± 0.10	2.67 ± 0.05	4.02 ± 0.08	6.68 ± 0.03

Potentially producible oil present in rock samples:
- Lower Eagle Ford (Well 2)

HC_{cont} = Sh0 + Sh1

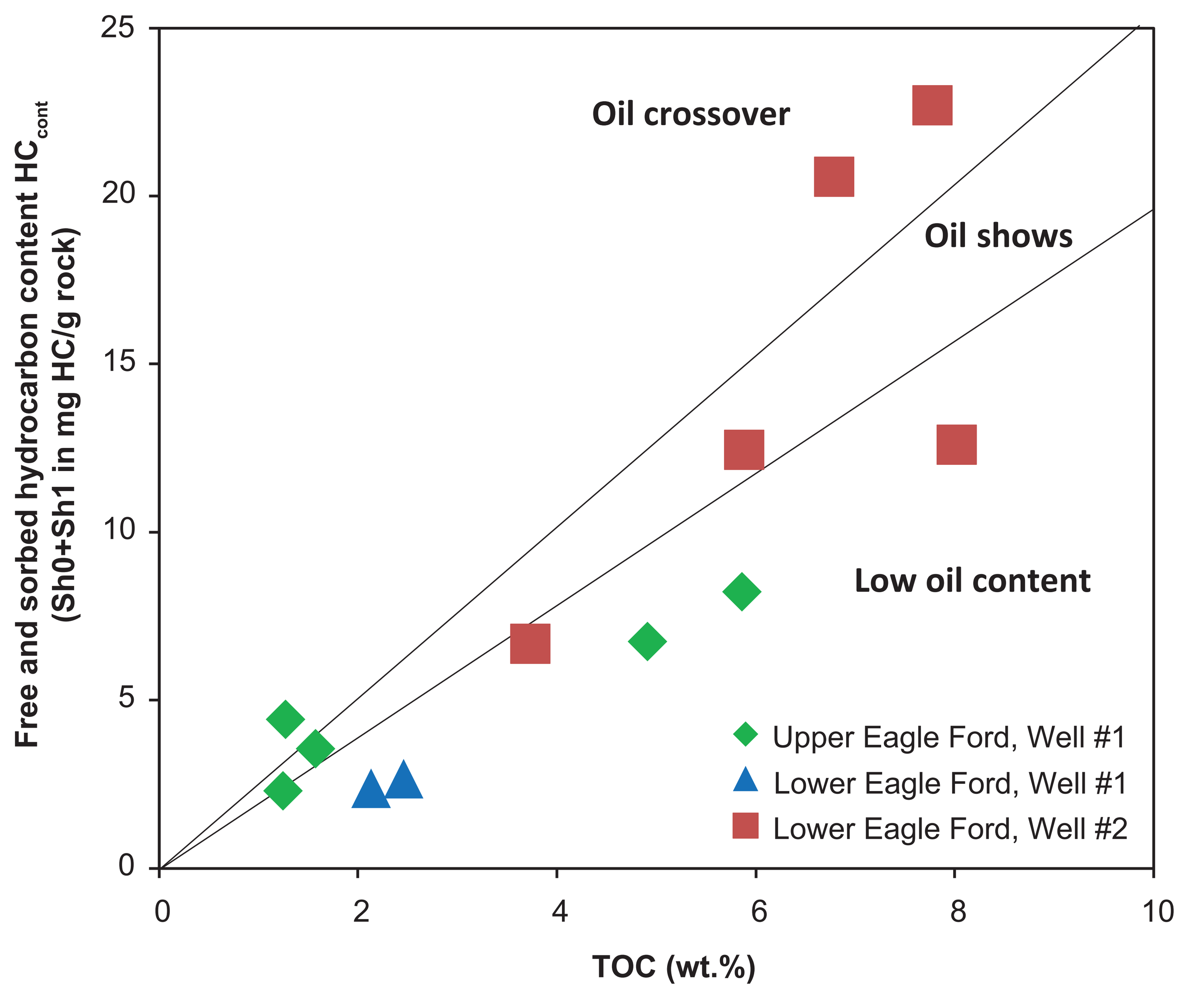
*Romero-Sarmiento et al. (2015)

[Sh0 + Sh1] > S_1 peak



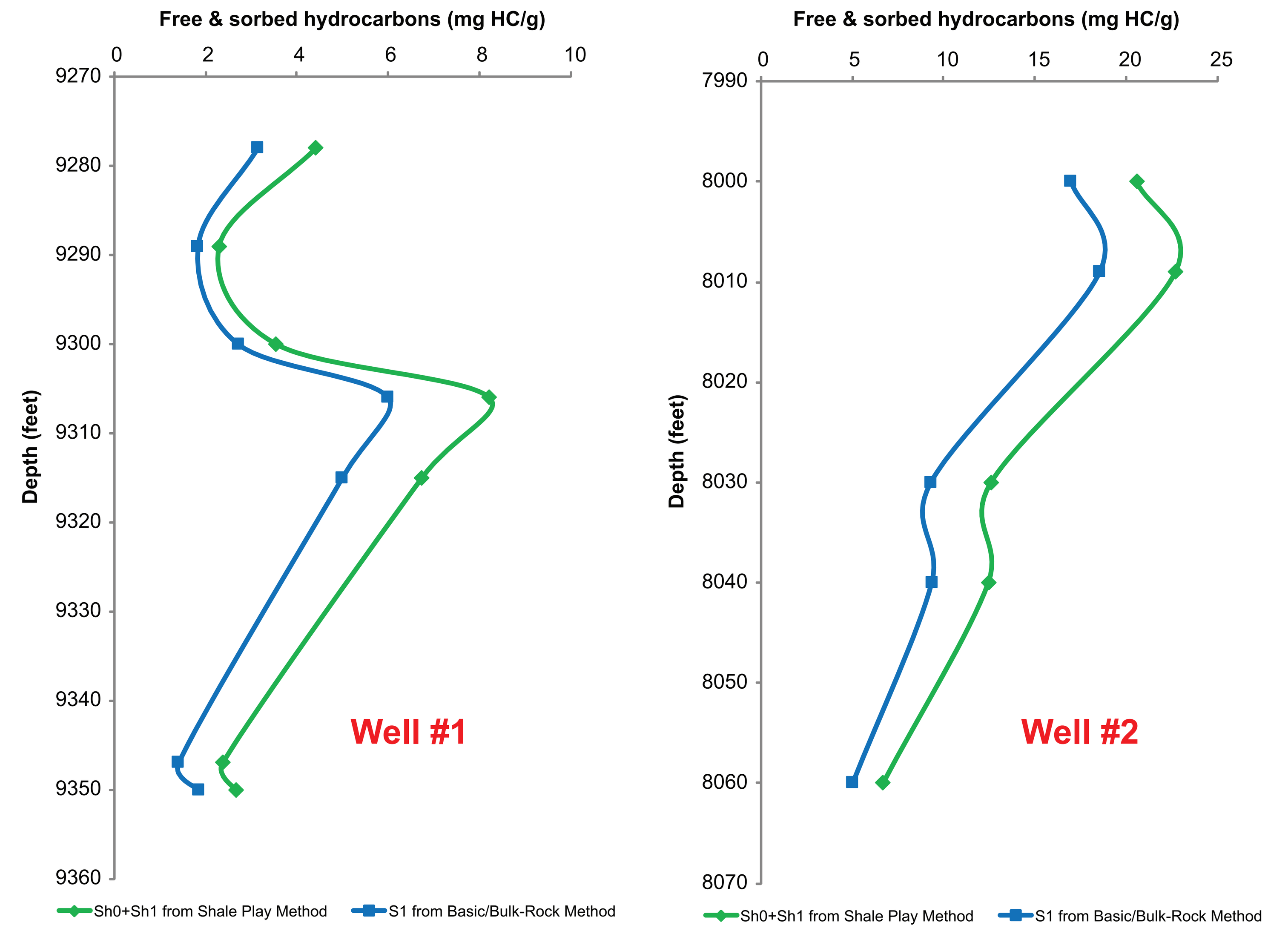
Free & sorbed hydrocarbon content [HCcont] vs. TOC

modified OSI = (Sh0 + Sh1)x100 / TOC



modified OSI proposed by Romero-Sarmiento et al. (2016)

Free & sorbed hydrocarbons vs. depth



Conclusions & References

Conclusions

The Shale Play method allows an improved recovery of hydrocarbons still present in source rocks

The oil crossover effect and potential productive intervals were mainly identified in core samples from the lower Eagle Ford member.

The Shale Play method has been developed to better discriminate the generated fluids (Sh0+Sh1) from the residual kerogen (Sh2)

References

New Rock-Eval method for characterization of unconventional shale resource systems
Romero-Sarmiento et al. (2015). Published in OIL & GAS SCIENCE AND TECHNOLOGY

Artificial thermal maturation of source rocks at different thermal maturity levels: Application to the Triassic Montney and Doig Formations in the Western Canada Sedimentary Basin
Romero-Sarmiento et al. (2016). Published in ORGANIC GEOCHEMISTRY

Petrographic and petrophysical characterization of the Eagle Ford Shale in La Salle and Gonzales counties, Gulf Coast Region, Texas
Ramiro-Ramirez (2016). Master's degree thesis at COLORADO SCHOOL OF MINES

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IFP Energies nouvelles

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