Unconventional Upper Jurassic Petroleum Resource System, Tampico-Misantla Basin, East Central Mexico*

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Abstract

Unconventional resource systems are currently being drilled in the Tampico-Misantla Basin (TMB), Mexico. Pemex has drilled multiple wells into the Upper Jurassic source rock system that is the major source of petroleum in the Golden Lane, Deepwater Gulf of Mexico, and onshore in the East Texas, West Louisiana Salt basin. The Tithonian, Kimmeridgian, and Oxfordian are the principal zones of interest for unconventional tight oil development. Hydraulic stimulation and lateral drilling have been used for decades to extract oil from the tight oil sands in the Chicontepec Formation, so such application of such technology is not new to Mexico.

Drilling results have proven the resource potential of the Upper Jurassic in Mexico. The Pemex Corralillo-157 was drilled with a short lateral yielding an initial flow rate of about 650 barrels of 38° API oil per day with a gas-to-oil ratio (GOR) of about 1000 scf/stb. In the Burgos Basin the Tithonian interval has flowed 10 to 12 million cubic feet of gas per day proving the high retention of oil that was cracked to gas under the higher thermal maturity in that northern Mexico basin.

The Upper Jurassic source rock system is a thick (200+ m), carbonate hybrid with various juxtaposed intervals charged with petroleum. As such it is akin to the carbonate-rich Eagle Ford system in south Texas with a hybrid nature and thickness of the Wolfcamp Formation in the Permian Basin, West Texas-New Mexico. Such analogs provide additional support for a prolific tight oil resource system.

Geochemical assessment of archived cuttings and core permit the calculation of the resource potential as well as the windows of optimum petroleum production. The goal for such analysis is to predict accurately the light oil window with high gasoline content. Using highly reproducible quantitative aromatic hydrocarbon maturity data with correlation to production enables prediction of the optimum areas and intervals for favorable economic results. Combined with specialized pyrolysis conditions and fingerprinting data, prediction of petroleum saturations, API gravity, and GOR may be achieved. Secondary charges or other alteration effects can affect such predictions so such effects must be included in the assessment.

Successful drilling results require good targeting of prospective intervals in the thick Upper Jurassic section including determination of zones with the highest mobility petroleum, but also the presence of stimulation barriers or baffles.

Selected References

Guzman, A.E., 2019, The Tampico - Misantla Super Basin, Look Alike to the Permian Basin?: AAPG Global Super Basins, The Permian Conference Sugarland, Texas, 11 p.

Guzmán, A.E., 2018, The Upstream in México Under the New Energy Reform: AAPG 2018 Southwest Section Annual Convention, El Paso, Texas, April 7-10, 2018, Search and Discovery Article #70344 (2018). Website accessed December 2019.

Maende, A., 2015, Wildcat Compositional Analysis for Conventional and Unconventional Reservoir Assessments: HAWK Petroleum Assessment Method (HAWK-PAM), Wildcat Technologies Application Note (052016-1).

Unconventional
Upper Jurassic Resource System,
Tampico Misantla Basin,
East-central Mexico

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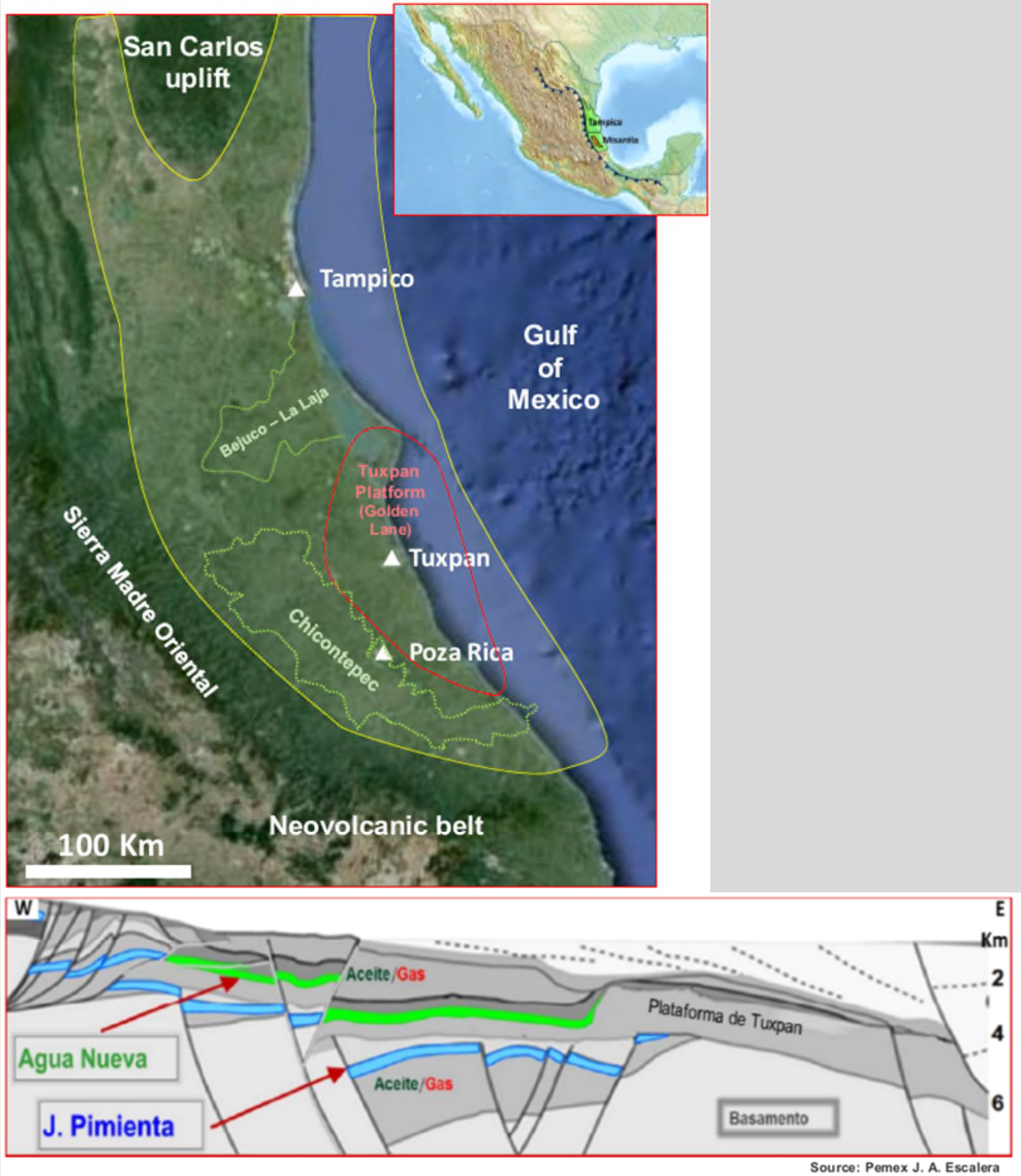
Outline

- Introduction
- Background
- U. Jurassic Unconventional Petroleum Systems
  - Organic richness and petroleum generation potential
  - Thermal maturity
  - Petroleum generation
  - Oil content as measured
  - Oil content and properties as restored
- Synopsis

Introduction

Tampico-Misantla Super Basin



Permian Basin (Pioneer / EIA / USGS)	Tampico – Misantla Basin (Pemex / CNH)	
Original Oil and Gas in Place > 150 Bboe	Original Oil and Gas in Place > 107	
Daily Production 3.6 MMbo	Daily Production .08 MMbo	
Cumulative Production > 37 Bboe	Cumulative Production 7.4 Bboe	
Recoverable > 122 Bboe	Recoverable (Reserves) 6.9 Bboe	> 44 Bboe
	Conventional and Unconventional Recoverable (Resources) 37.2 Bboe	
Midland Sub basin	**Chicontepec Sub Basin**	
Daily Production > 2 MMbo	Daily Production 0.04 MMbo	
Cumulative Production > 2 Bboe	Cumulative Production < .300 Bboe	
Active Rigs ~ 500	Active Rigs 3	
Total wells > 130,000	Total wells < 3,000	

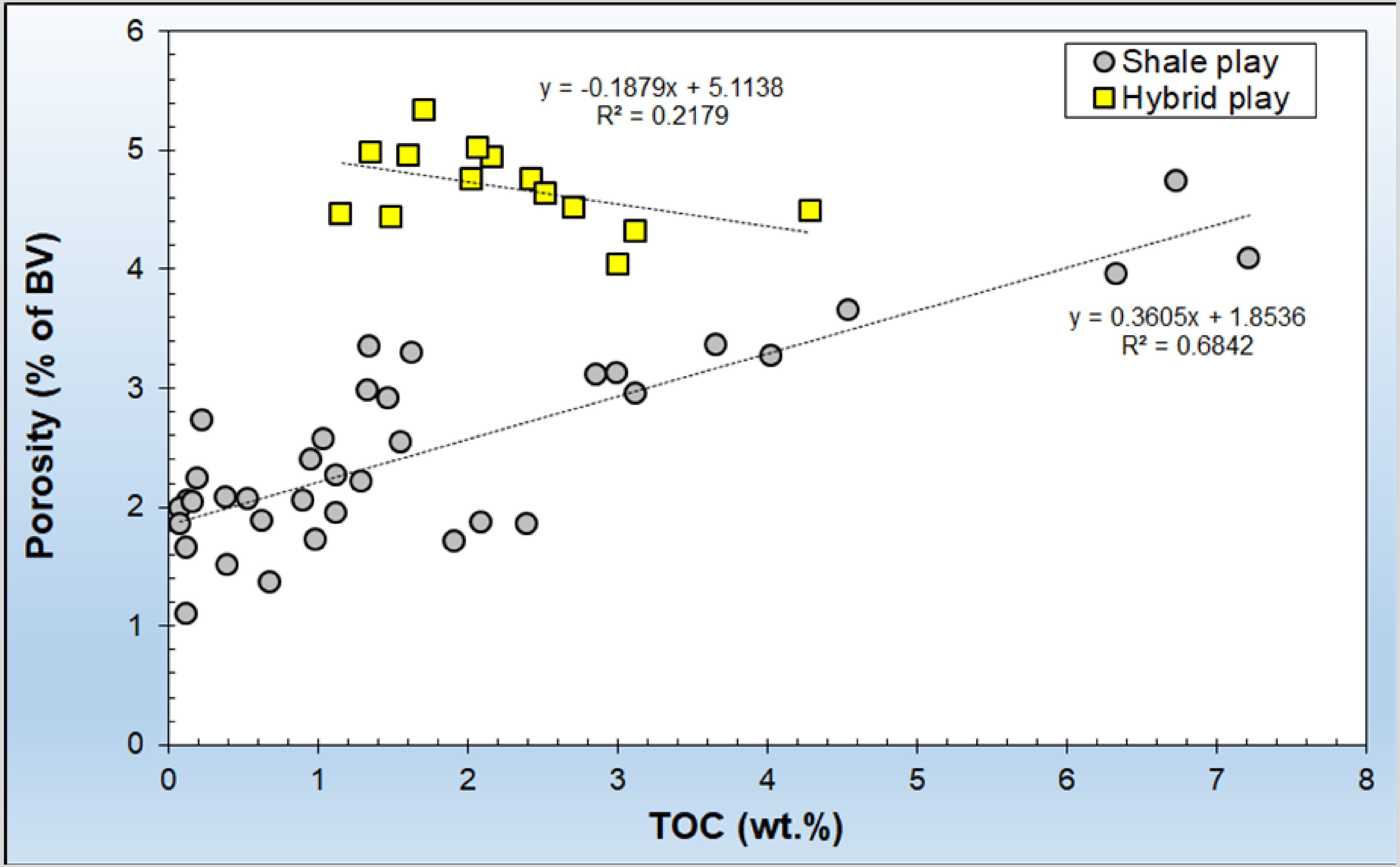
- Hydrocarbon resources:
  - 107 Bboe discovered
  - 2.4 Bboe conventional YTF
  - 34.8 Bboe shale

  } **144.3 Bboe**

Guzman (2018, 2019)

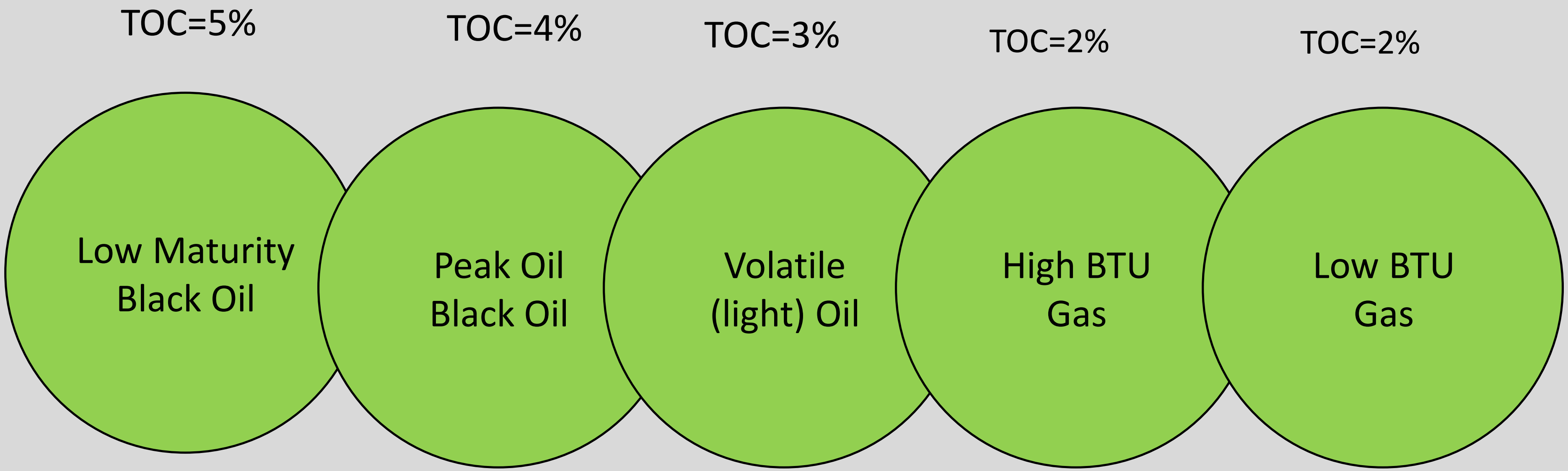
Comparison of Play Types in terms of Porosity

Organic-rich system often shows positive slope of porosity to TOC



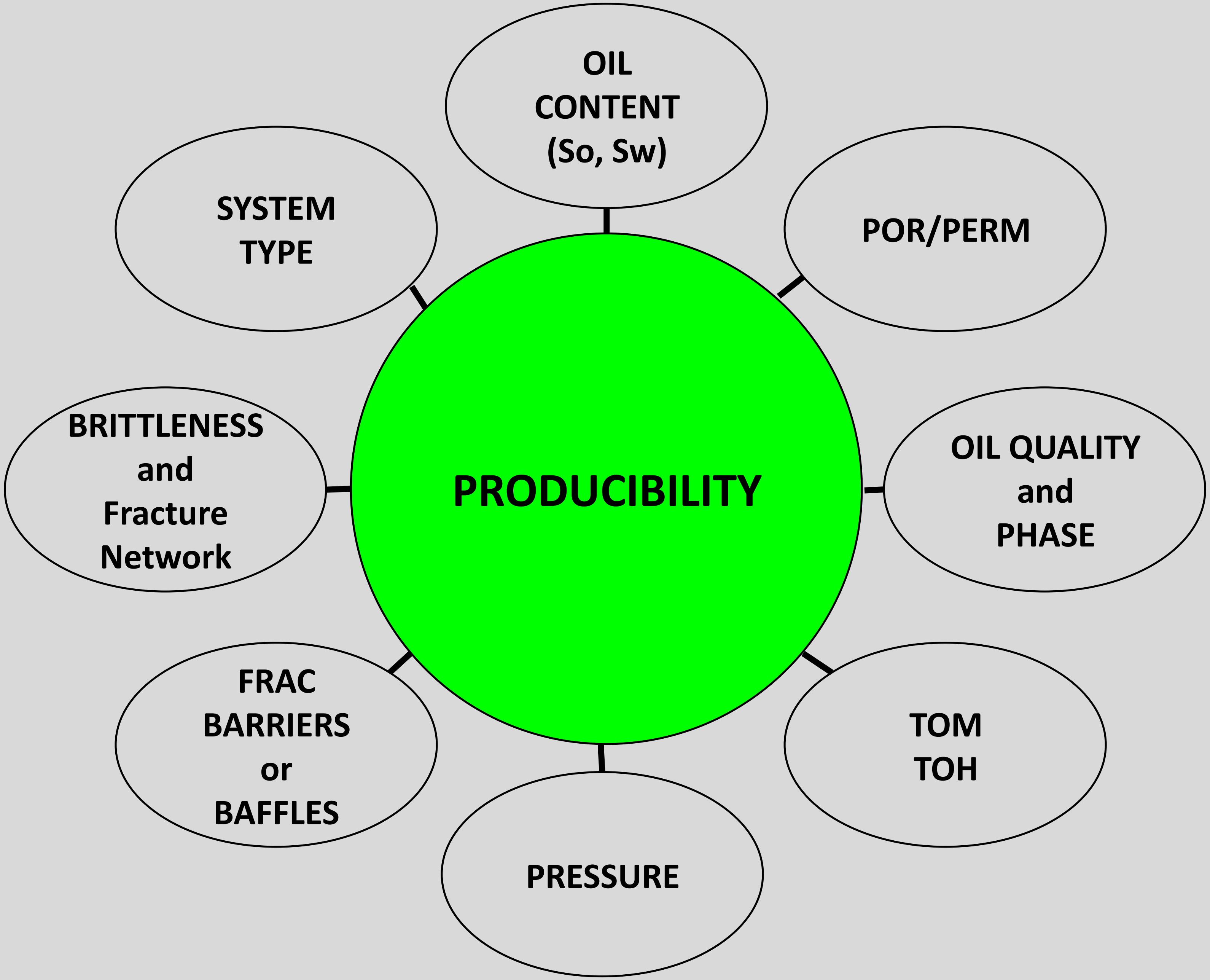
Organic-rich hybrid system often shows negative slope of porosity to TOC

Change in Original TOC and Petroleum Characteristics with increasing thermal maturity

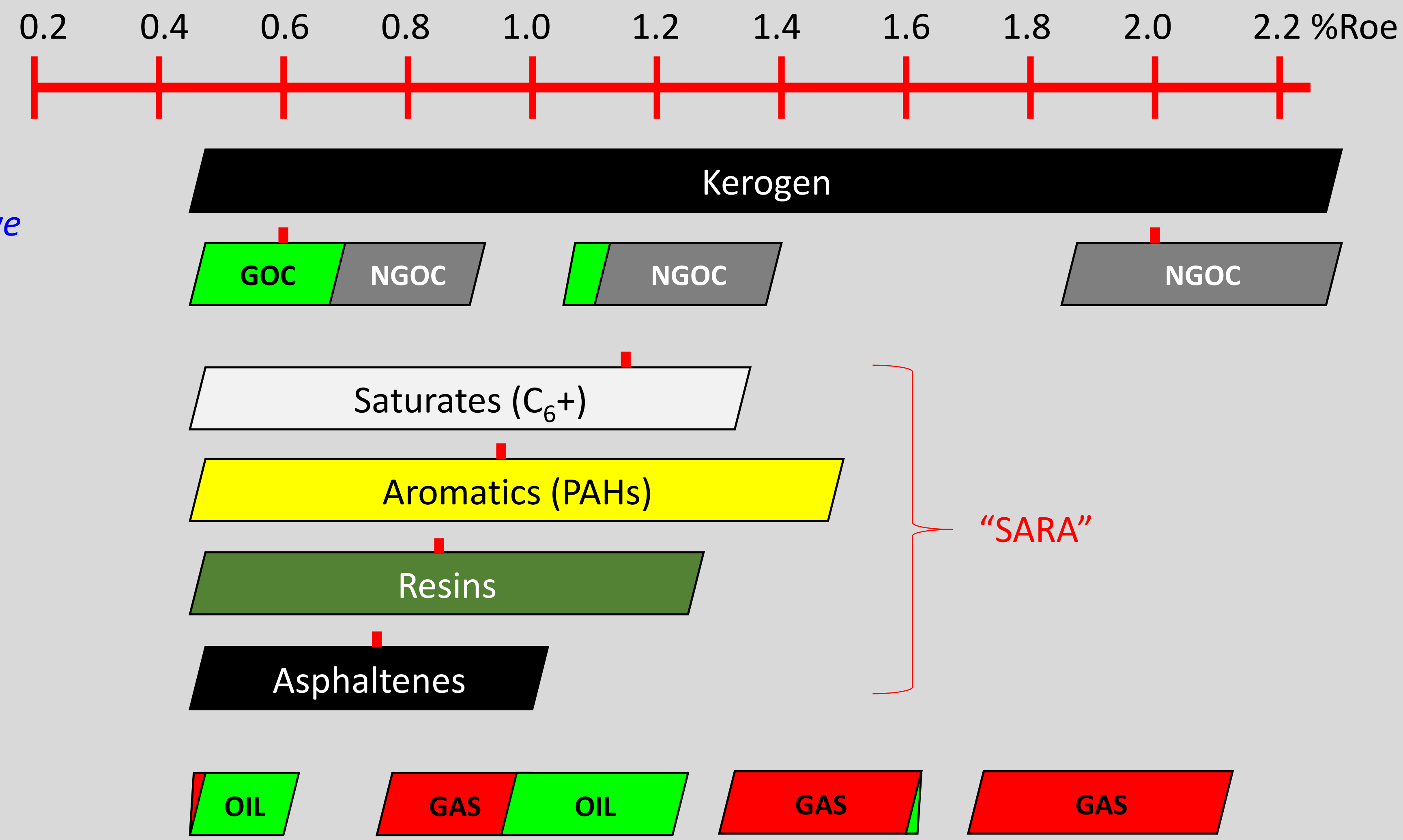


API Gravity:	25	35	45	50+	
GOR:	500	1000	2500	20000	50,000+
Maturity:	0.70	0.85	0.95-1.20	1.20-1.30	>1.4

Select Factors to Consider in a Tight Oil System

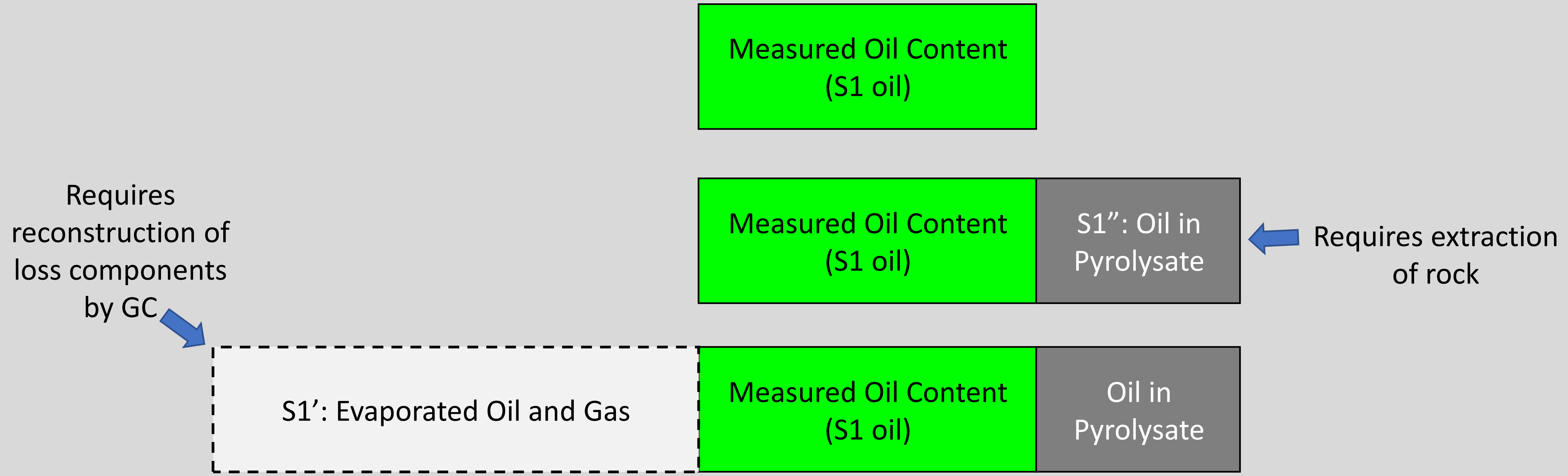


Change in Petroleum Composition with maturation



- *GOC is Generative Organic Carbon portion of TOC*
- *NGOC is Non-Generative Organic Carbon portion of TOC*

Distribution of Petroleum in Reservoir



Total Petroleum = S1 measured + (S2 whole rock – S2 extracted rock) + Evaporative Loss

Evaporative losses of oil can range from 5 to 90% depending on oil phase, por/perm, sampling/handling, pressure

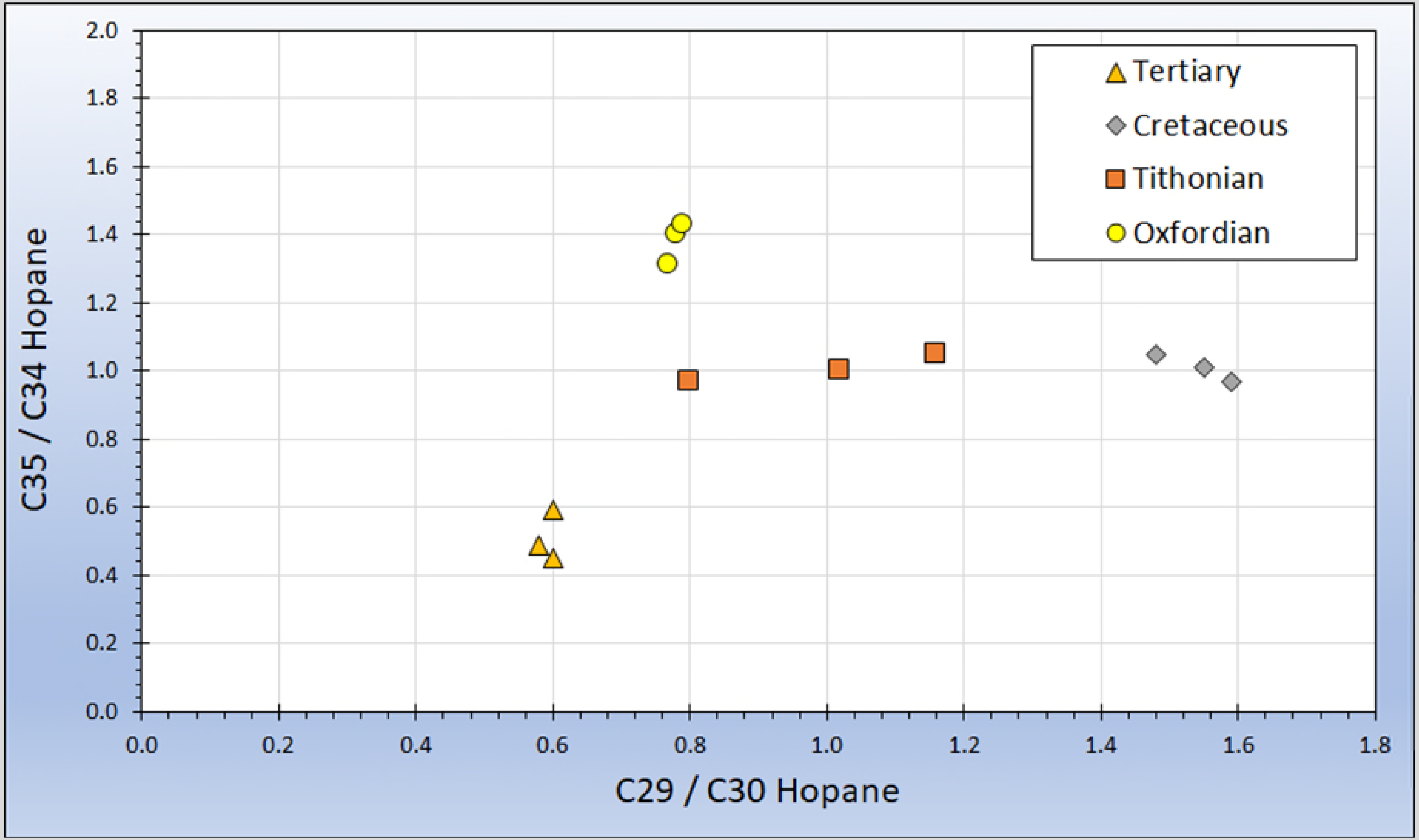
Background

Oil Types in Mexico

Unconventional Objective

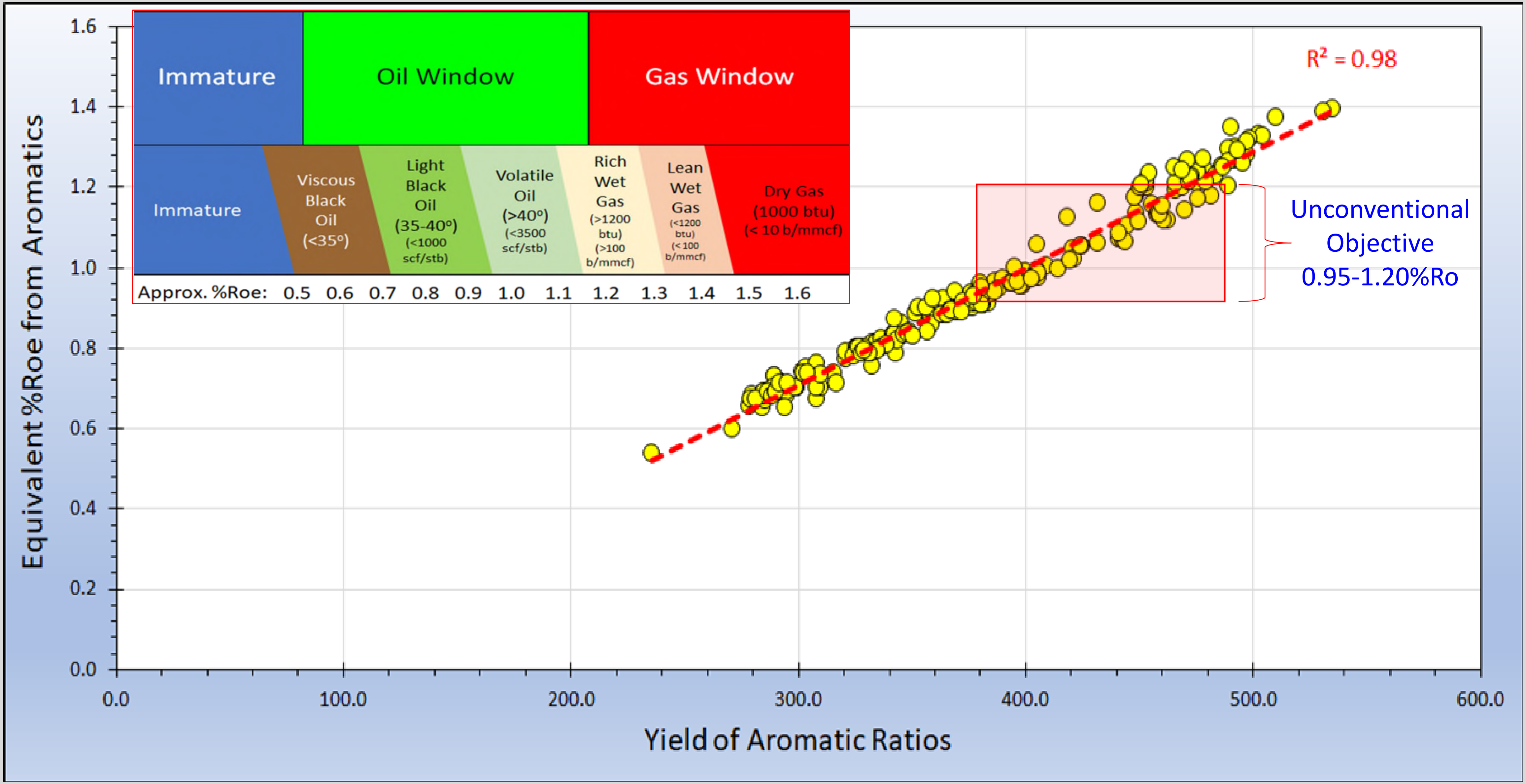
	Heavy	Light	Volatile	Very Heavy
Crude-Oil Type	Maya	Isthmus	Olmeca	Altamira
°API (Gravity)	21.0-22.0	32.0-33.0	38.0-39.0	15.5-16.5
VISCOSITY (SSU 100 °F)	320	60	38	1280-1750
WATER AND SEDIMENTS (% vol.)	0.5	0.5	0.5	1.0
SULPHUR (% weight)	3.4-3.8	1.8	0.73-0.95	5.5-6.0
Reid Vapor Pressure (lb/in2)	6.0	6.0	6.2	3.0
POUR POINT (°F)	-25	-35	-55	32

Differences in Biomarkers among various oils by period or age

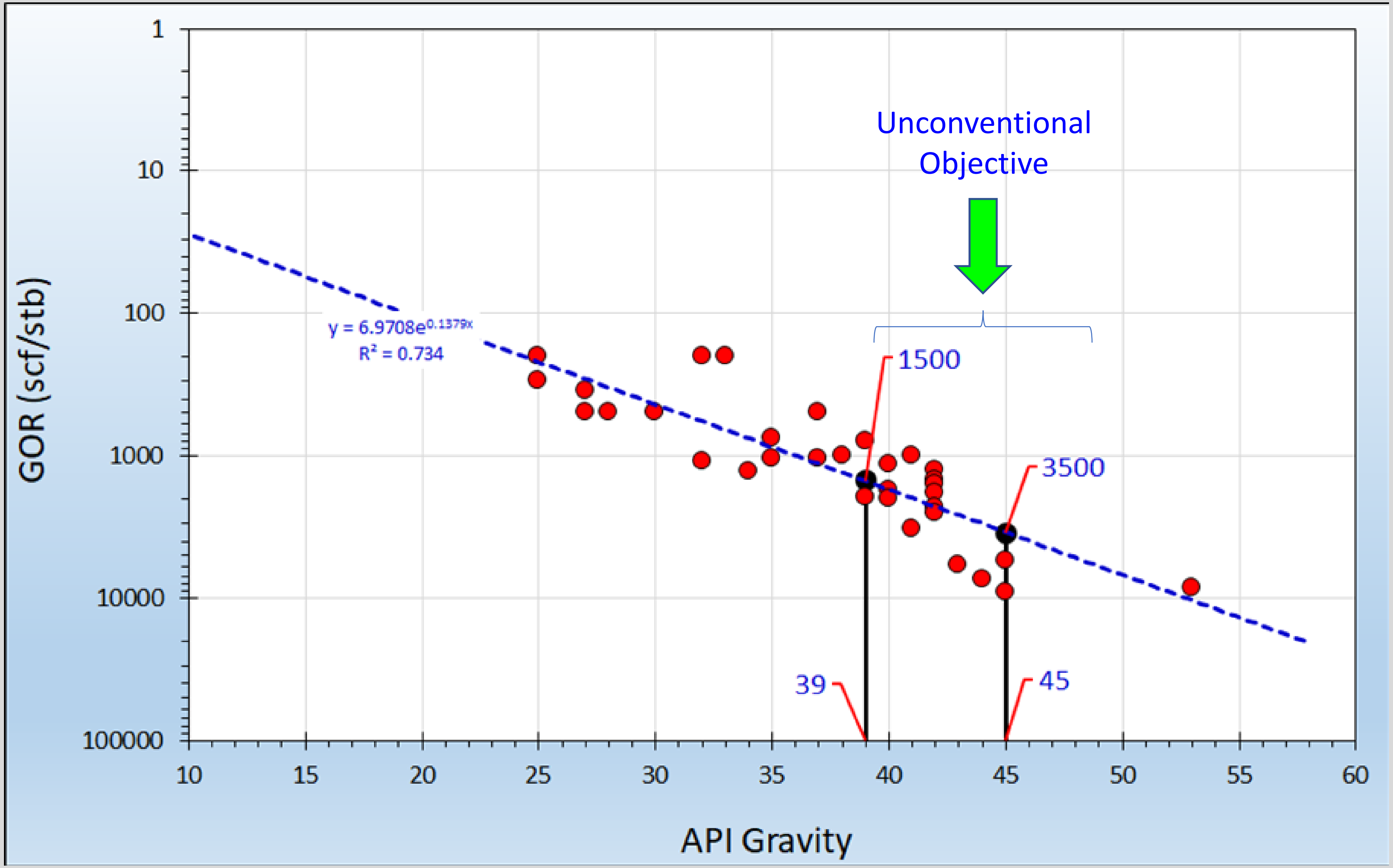


Tithonian data and other fields from Guzman-Vega and Mello, 1999

Thermal Maturity:
Quantitative Aromatic Hydrocarbons



Relationship of GOR to API Gravity, Sureste Basin, Mexico

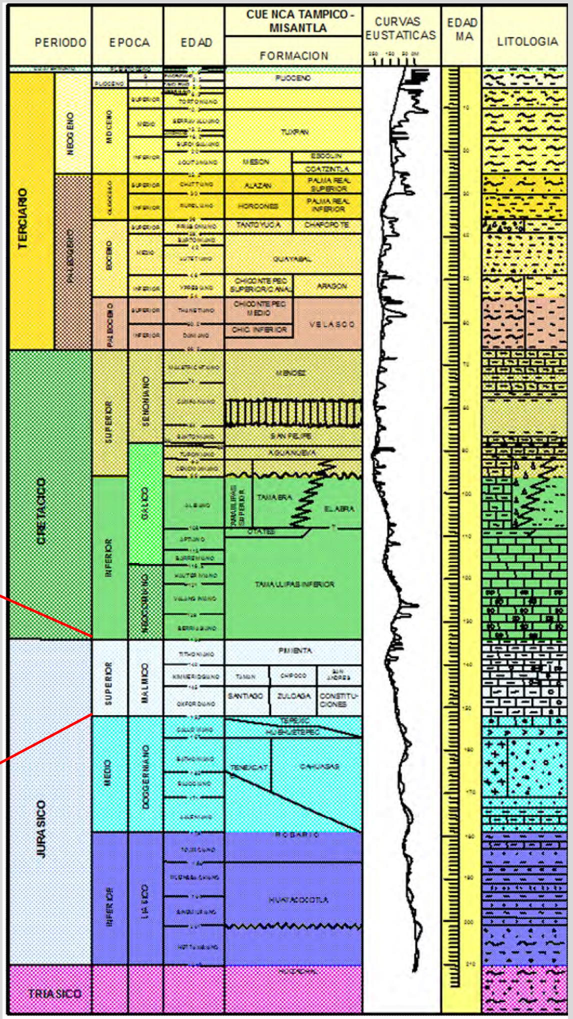


Data from Magoon, 1995

Upper Jurassic Tight Oil Systems, Tampico-Misantla Basin, Onshore, Mexico

Location Map and Generalized Stratigraphic Column

Conventional
Production
Intervals

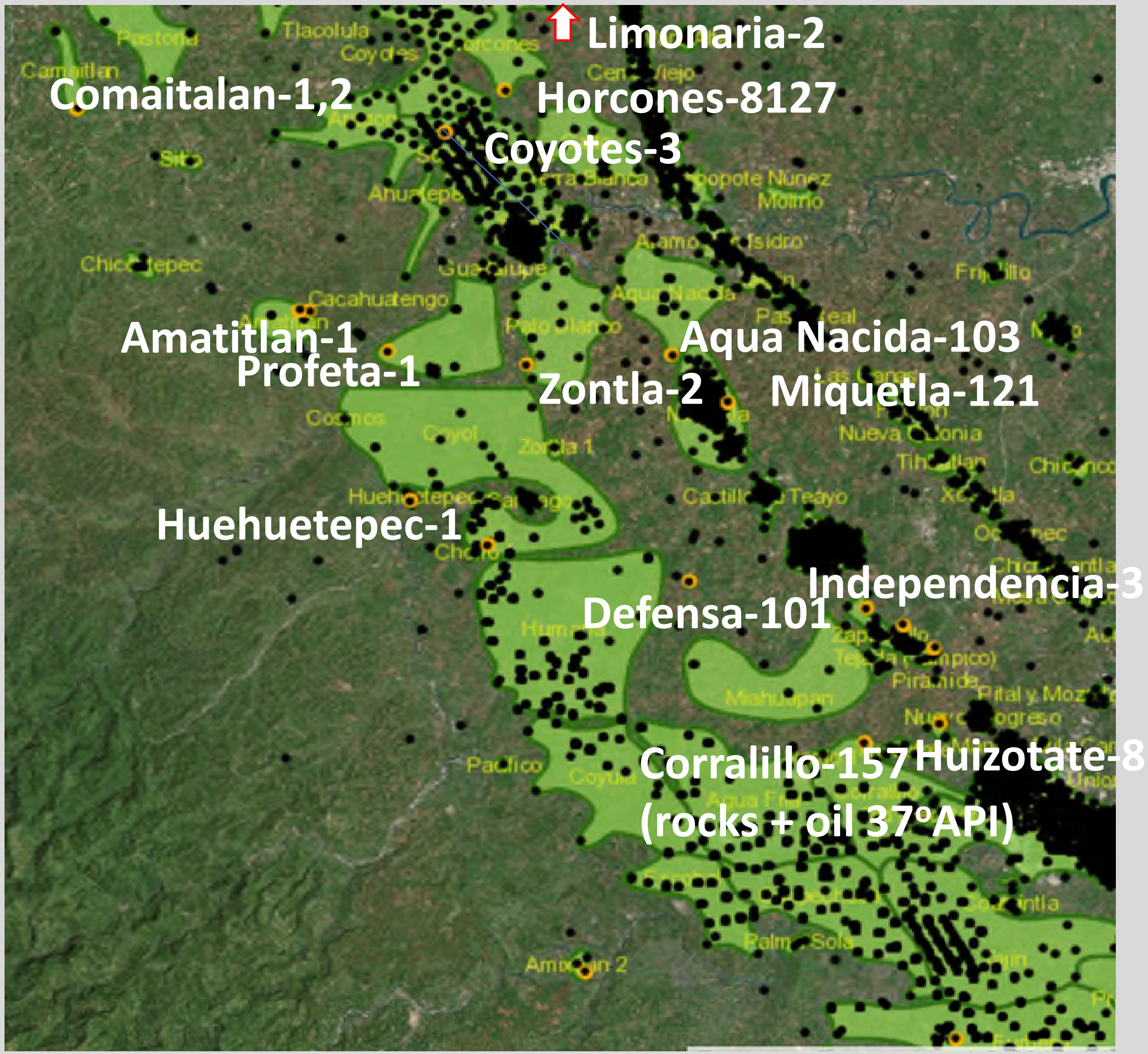


U. Jurassic	Tithonian	Pimienta		
	Kimmeridgian	Taman	Chipoco	San Andres
	Oxfordian	Santiago	Zuloaga	Constitu-ciones

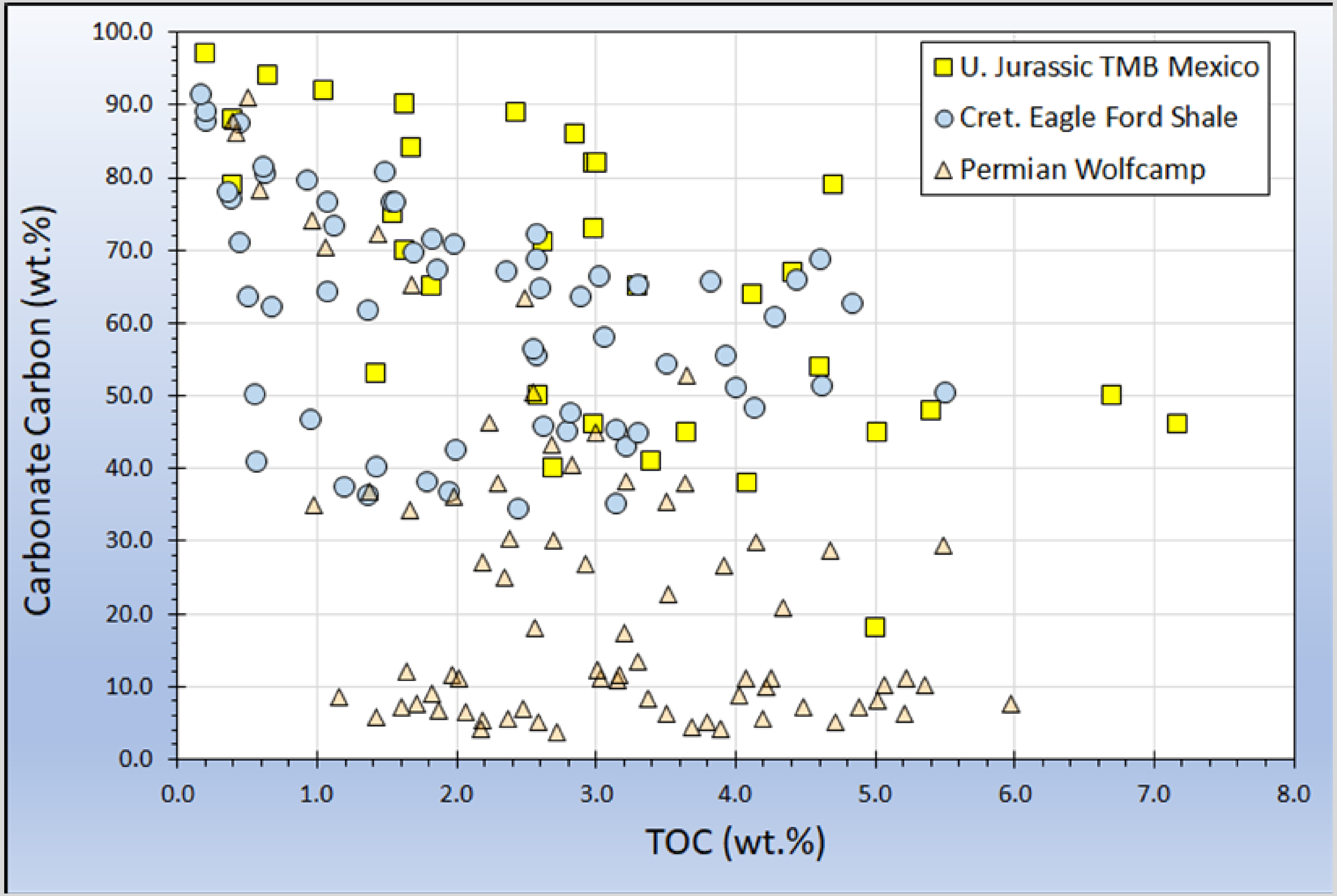
60 billion boe
J.A. Escalera, Pemex

- Bossier, Haynesville, Smackover age equivalents onshore USA
- Also these age are major source rocks in Deepwater Gulf of Mexico

Well Locations for Geochemical Study



Comparison of U. Jurassic, Tampico-Misantla Basin, Mexico to Eagle Ford Shale and Wolfcamp Shale

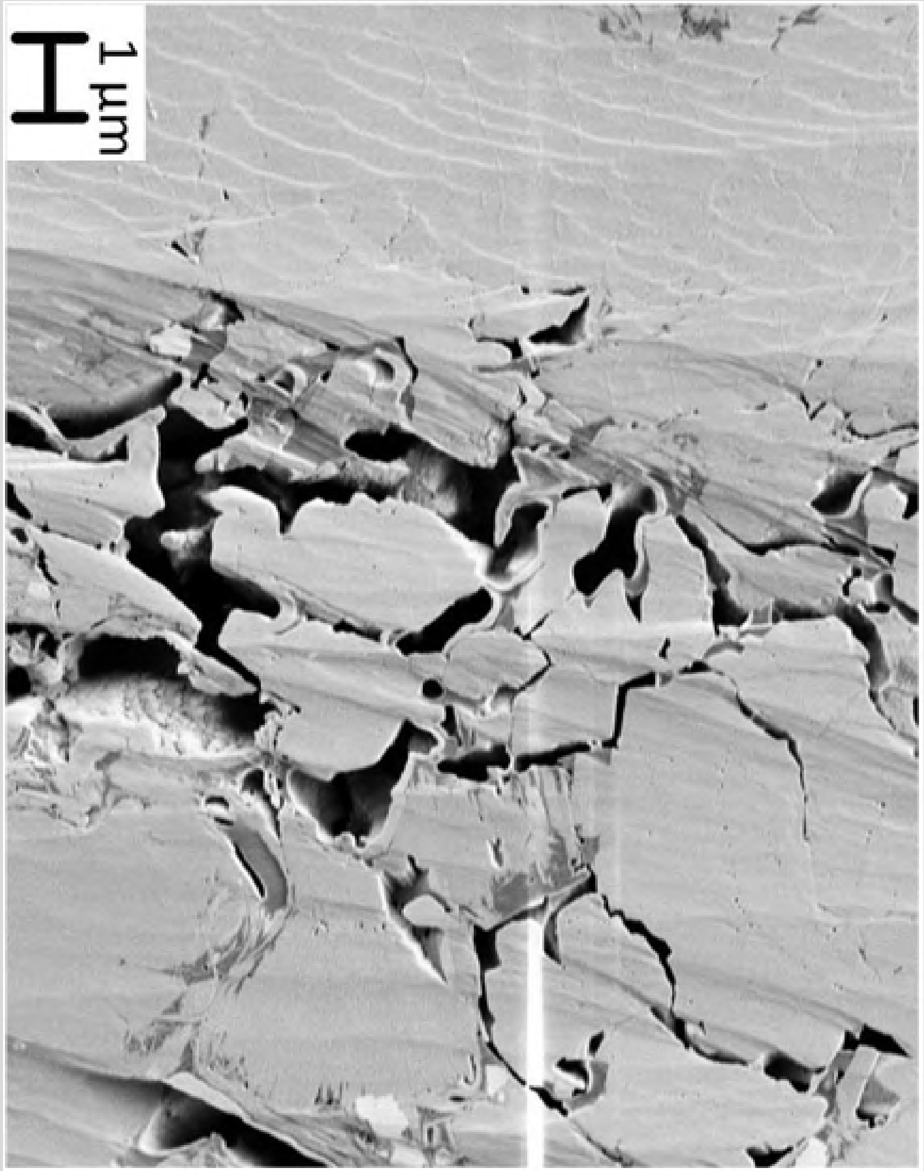


U. Jurassic, TMB, Mexico is similar to Eagle Ford shale lithofacies and TOC

Wolfcamp Shale is much lower carbonate content, i.e., more siliciclastic

Marine carbonate/marly shale source rock affected by carbonic and other organic acids

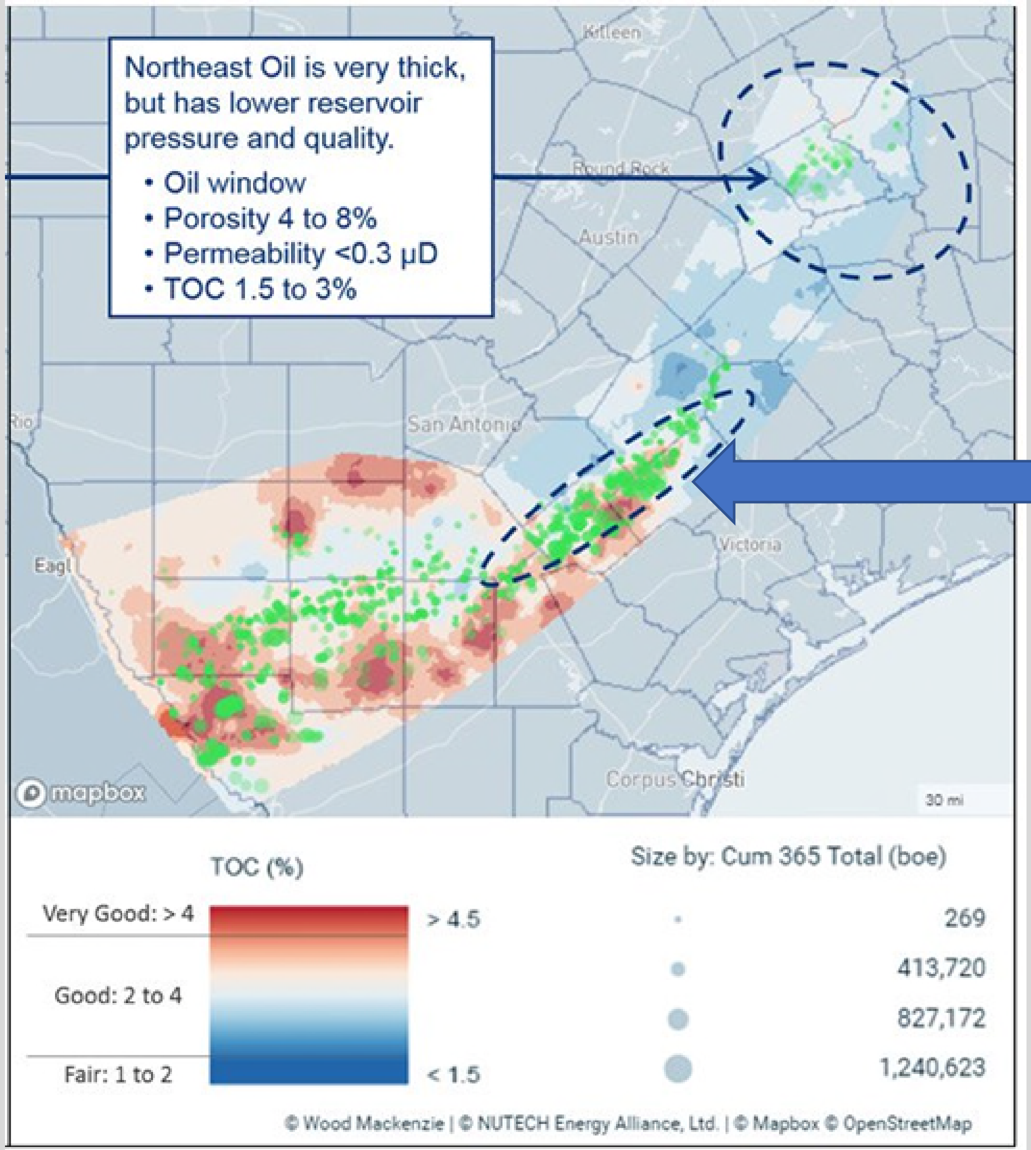
CO_2 and water released from kerogen forming carbonic acid that can cause partial dissolution of carbonate matrix, i.e., 'etching'



Organic acids are also released from kerogen that can also cause partial dissolution of carbonate matrix

Potential for secondary porosity creation in matrix

Best Area in Eagle Ford Shale is modest TOC (2-4 wt.%)



Best producing area of Eagle Ford Shale (mudstone) has modest TOC, good pressure, and good por/perm

Litho- and Organofacies Comparison to the Eagle Ford

Pimienta, Taman, Santiago
Tampico-Misantla Basin
Mexico

- Marine carbonate
- Sulfur wt% 0.50 – 4.00%
- Original TOC ca. 5%
- Original HI ca. 600 mg/g
- Porosity: ca 7%

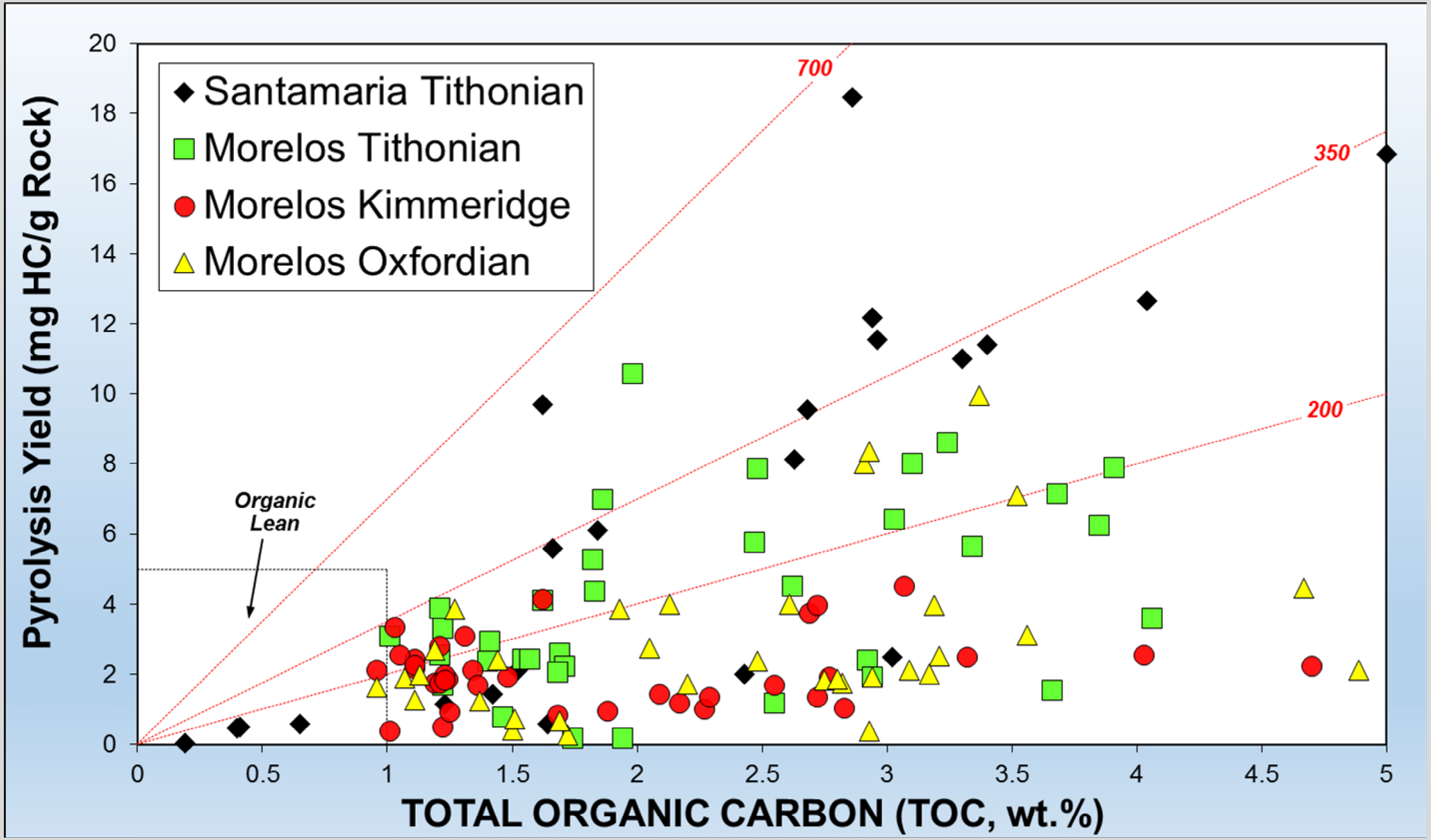
- U. Jurassic
- Thickness: <u>**500-1000 ft**</u>

Eagle Ford
Gulf Coast Basin
South Texas

- Marine carbonate
- Sulfur wt% 0.50 – 4.00%
- Original TOC ca. 5%
- Original HI ca. 600 mg/g
- Porosity: ca 7%

- Cretaceous
- Thickness: 200-250 ft

U. Jurassic Tight Oil System, TMB: Present-day S2-kerogen and TOC Yields

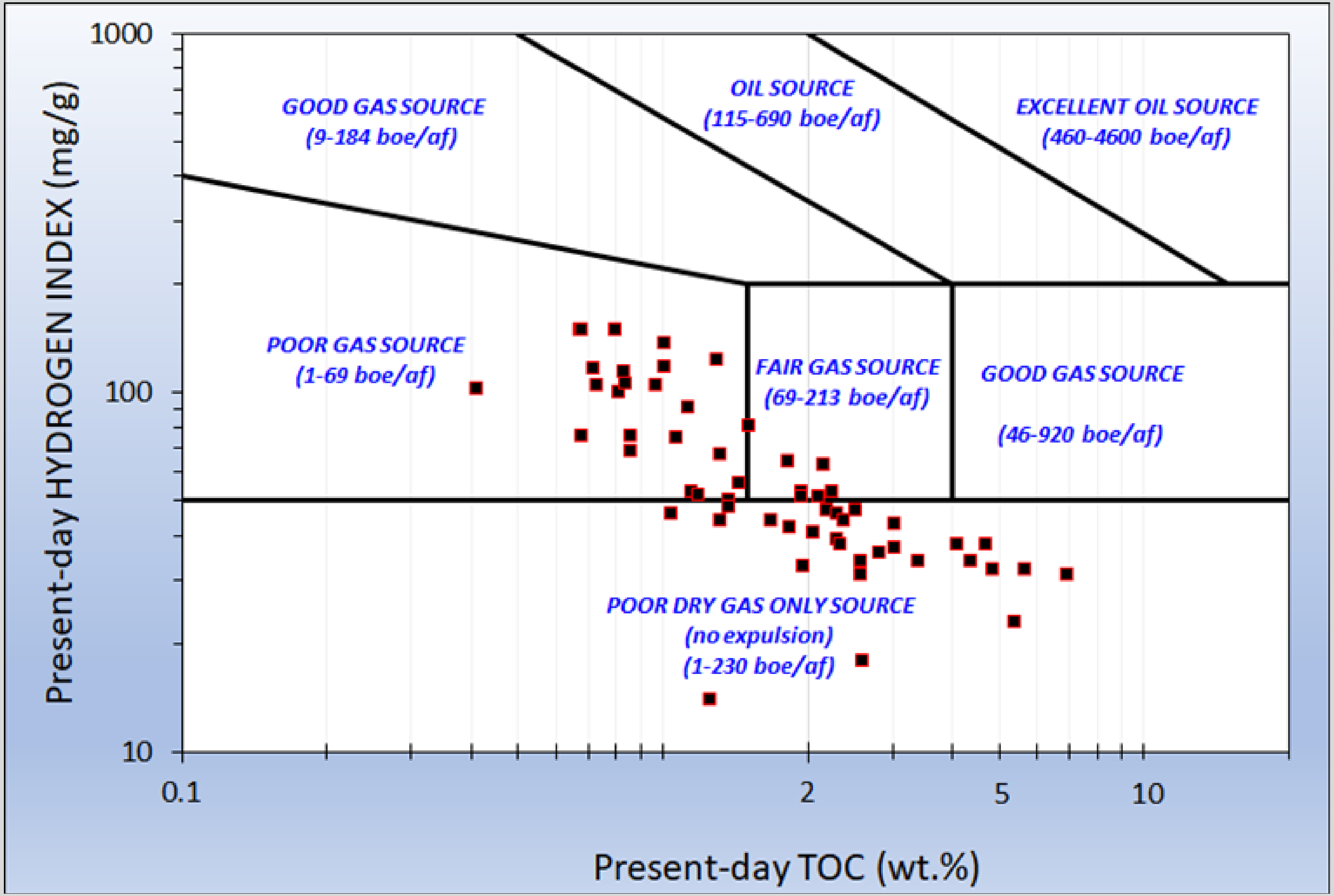


Data from Morelos, 1992; Santamaria, 1996

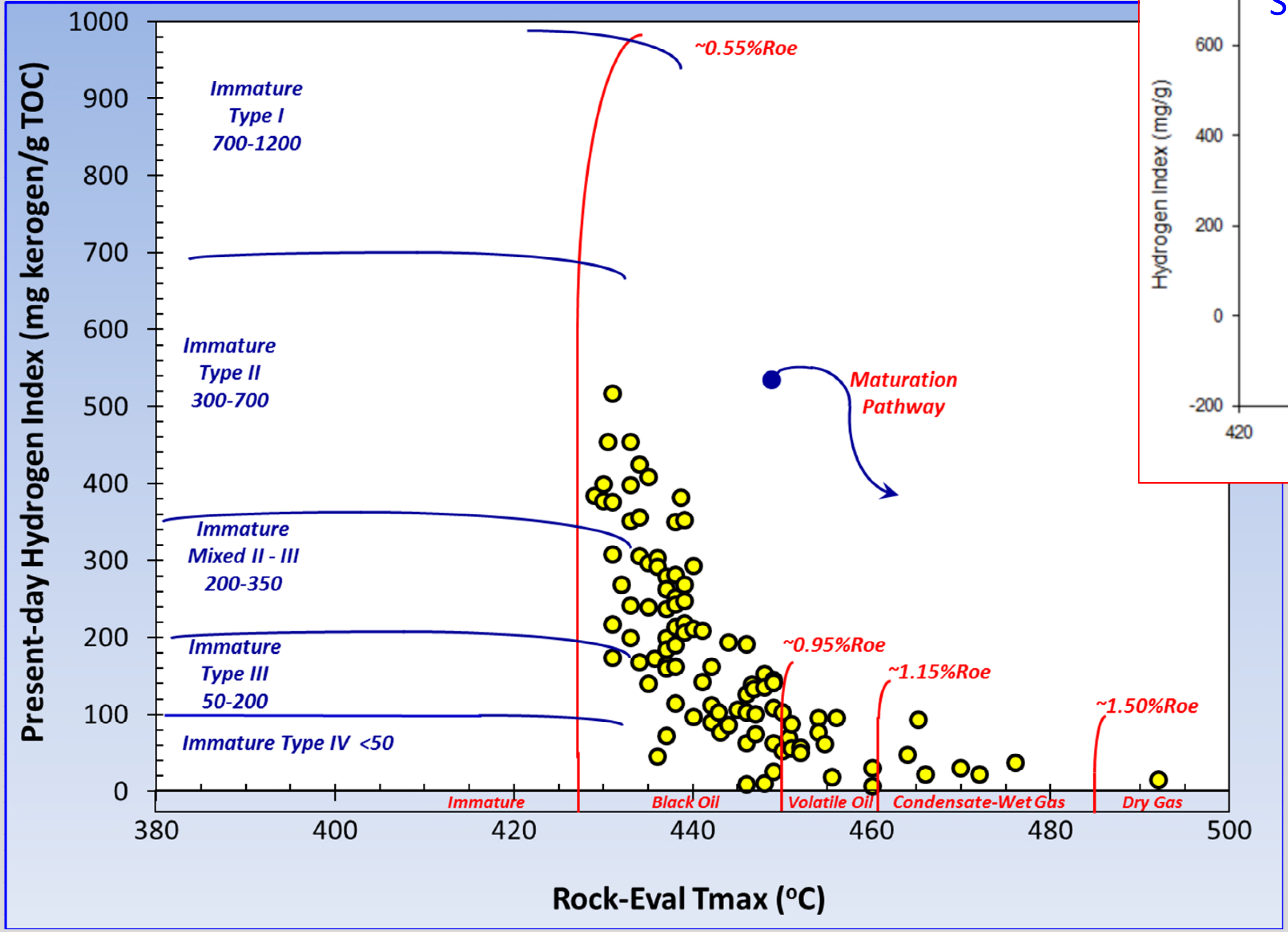
Present-day Source Potential U. Jurassic reduced by level of maturation

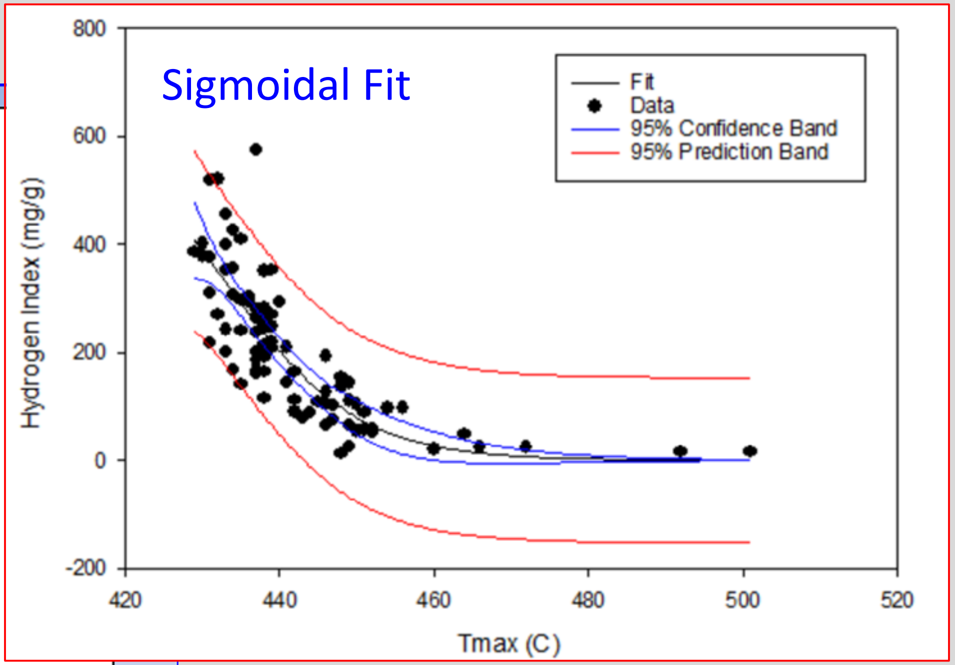
Note: Petroleum Generation Potential is a combination of HI and TOC

1.00% TOC with HI = 600 Total Yield is only: ~ 138 boe/af (sub-commercial)



Geochemical Data used to Restore Original U. Jurassic Petroleum Potential



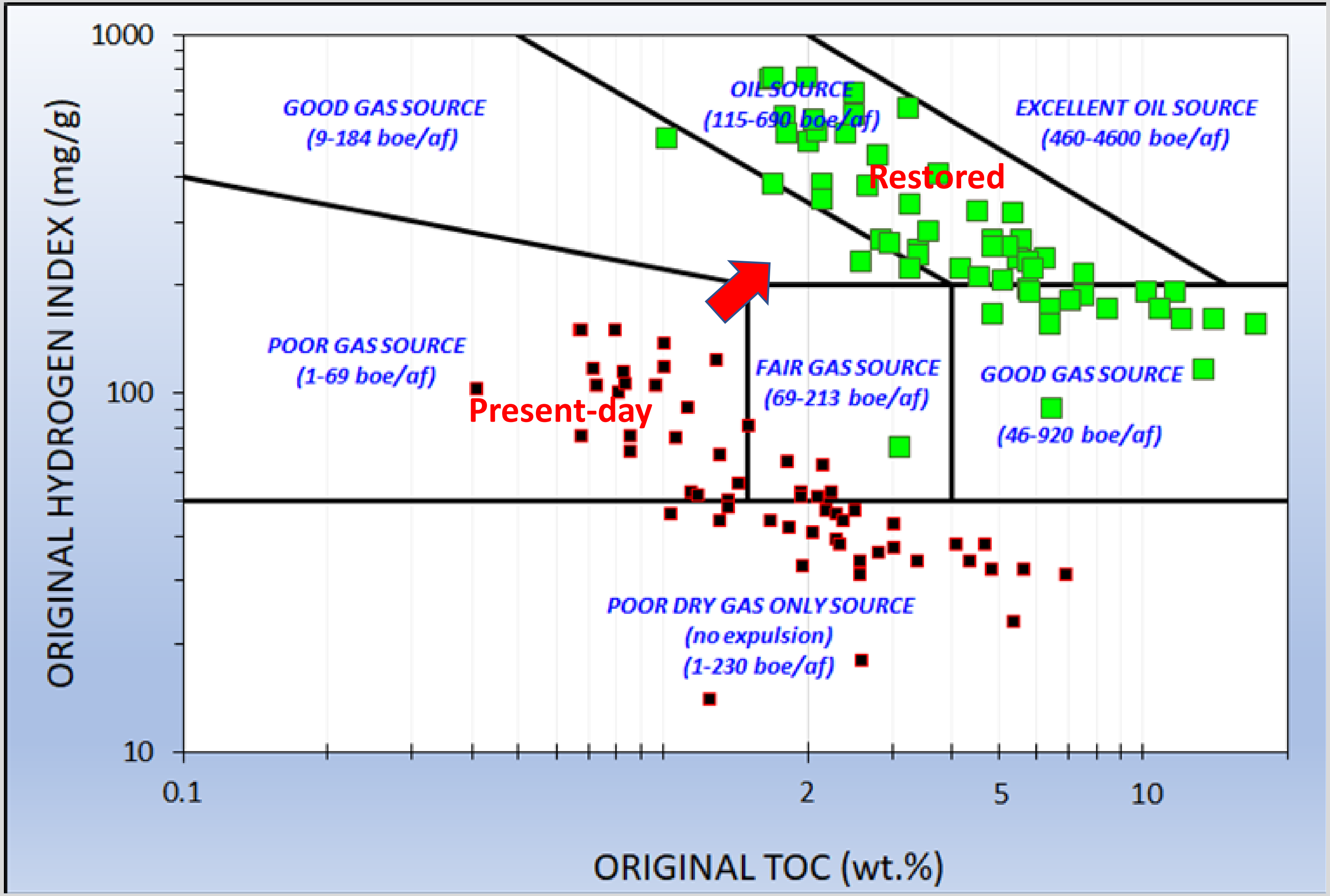


$HI_o = 652.57/(1+\exp(-(427-433)/-8.44))$

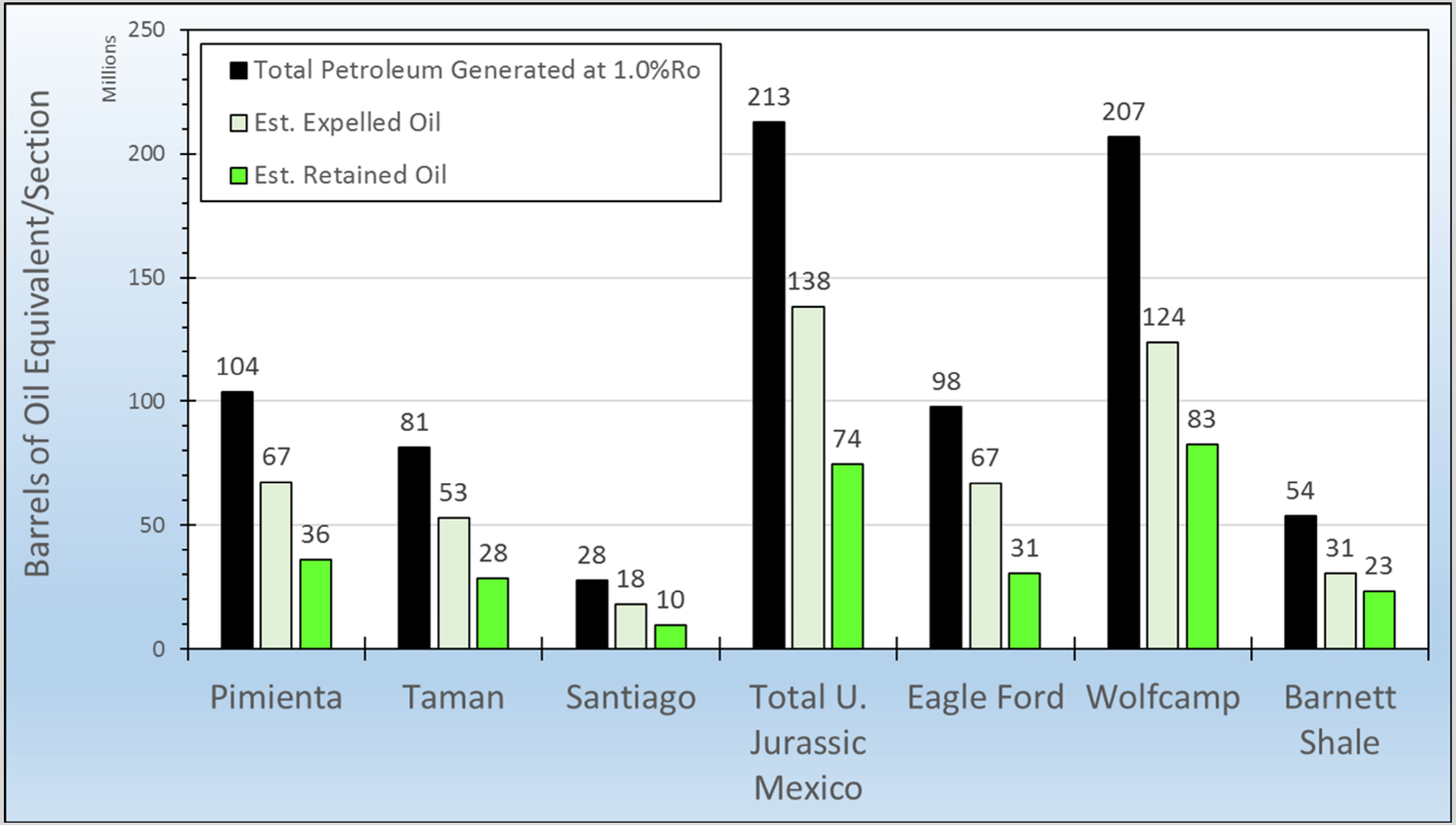
Predicted Original HI:

P90 HI_o = 394 mg/gT
P50 HI_o = 536 mg/gT
P10 HI_o = 602 mg/gT

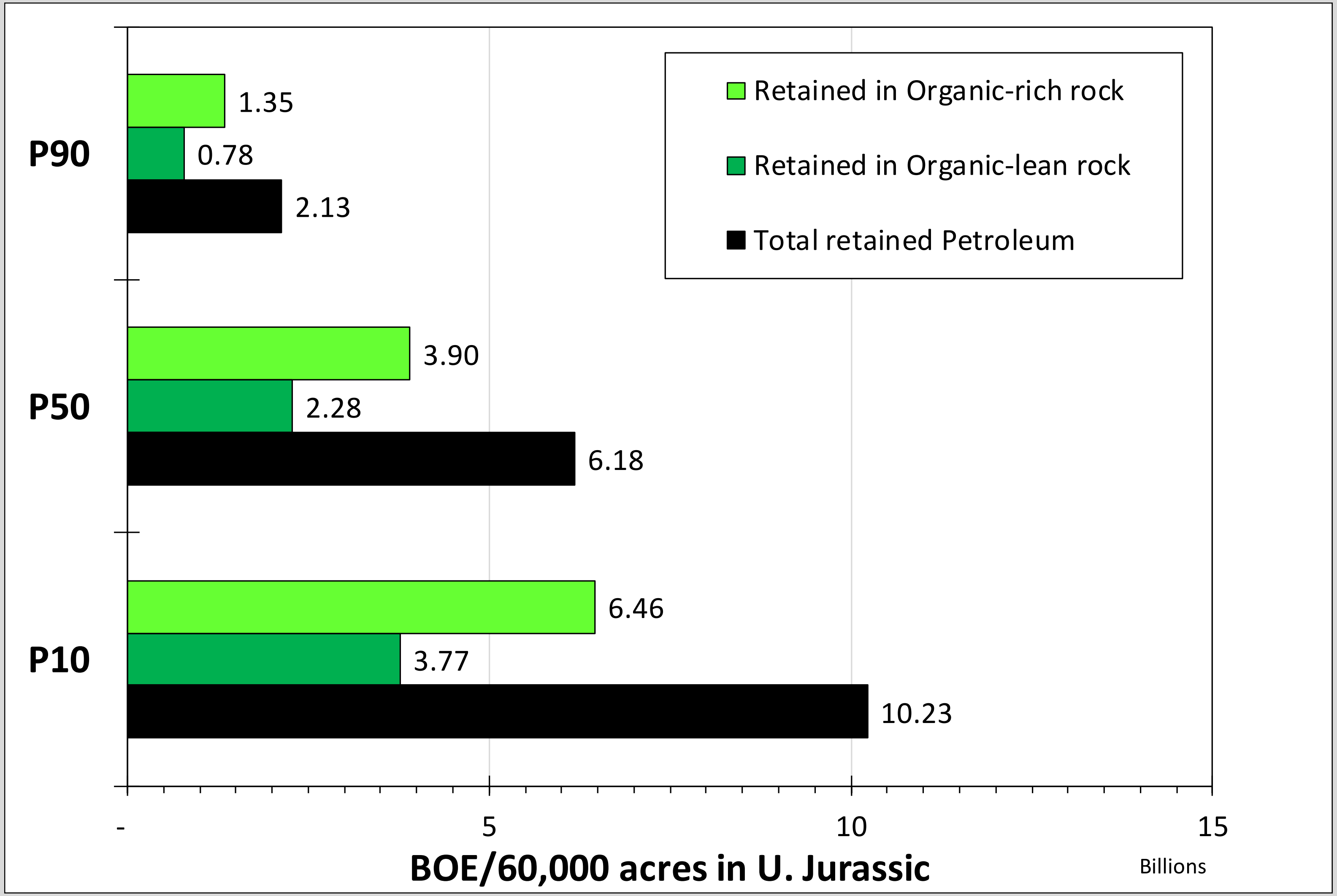
U. Jurassic Restored Source Potential



Why a Super Basin ?



Retained, Expelled, and Total Petroleum Generated

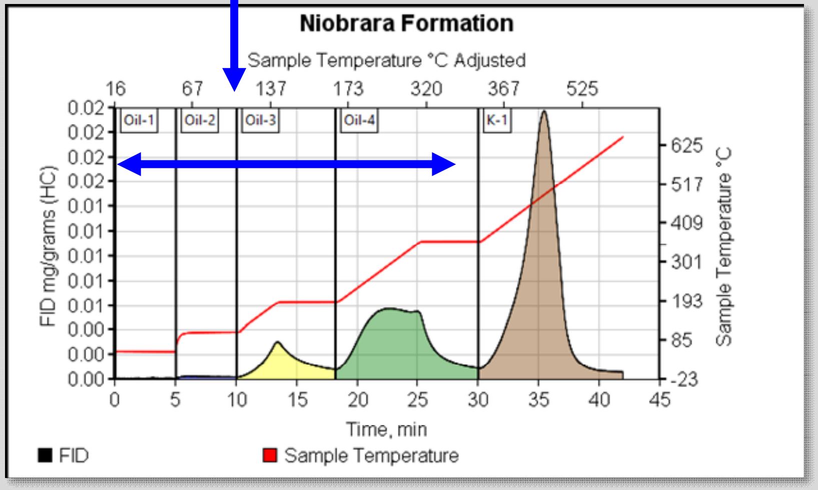


An advantage of this system, much expelled oil in this system is that much oil is retained in the hybrid portions of the U. Jurassic ~ Permian Basin

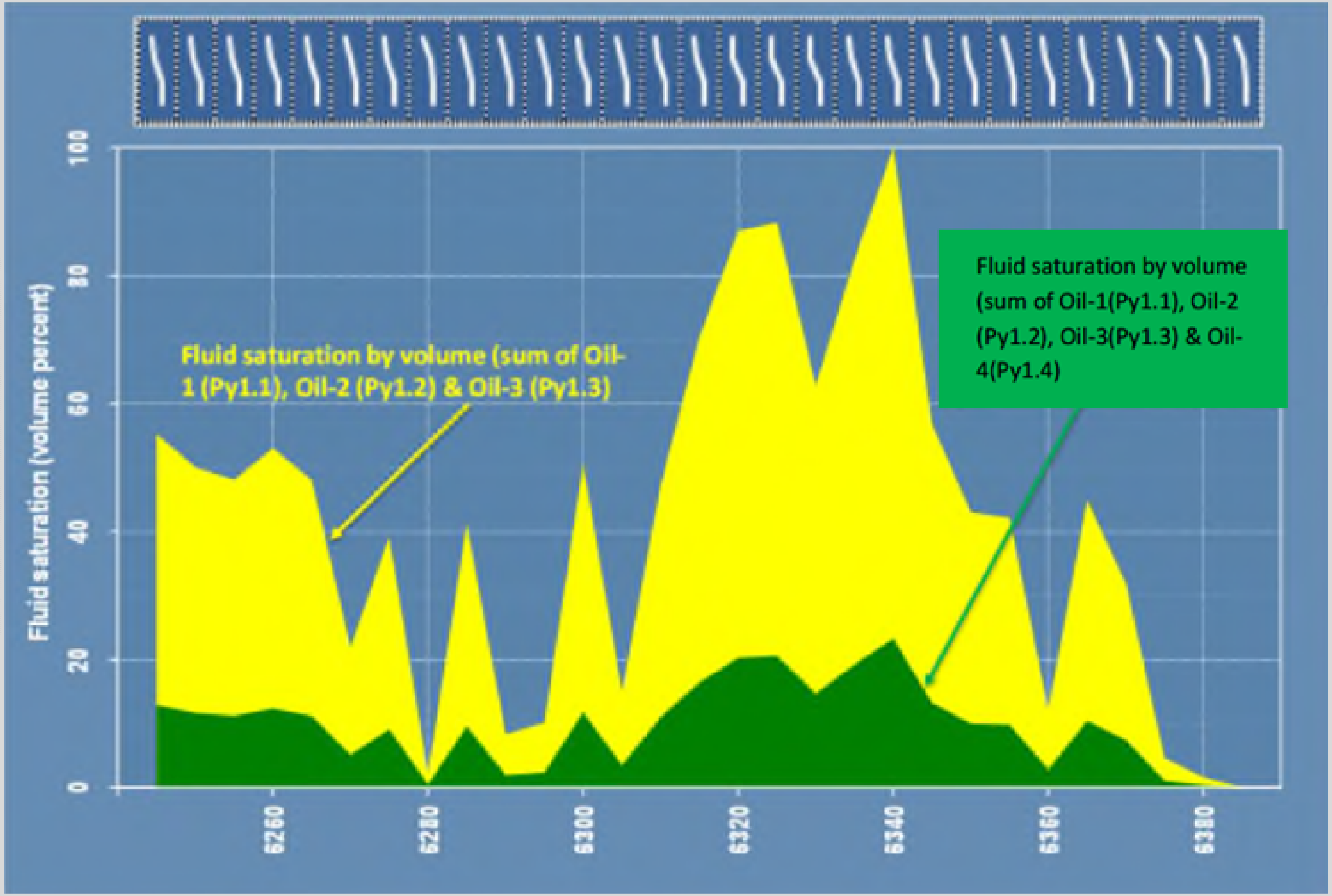
Prediction of Fluid Saturation U. Jurassic, TMB, Mexico

HAWK-PAM

Light Oil to Heavy Oil and Kerogen

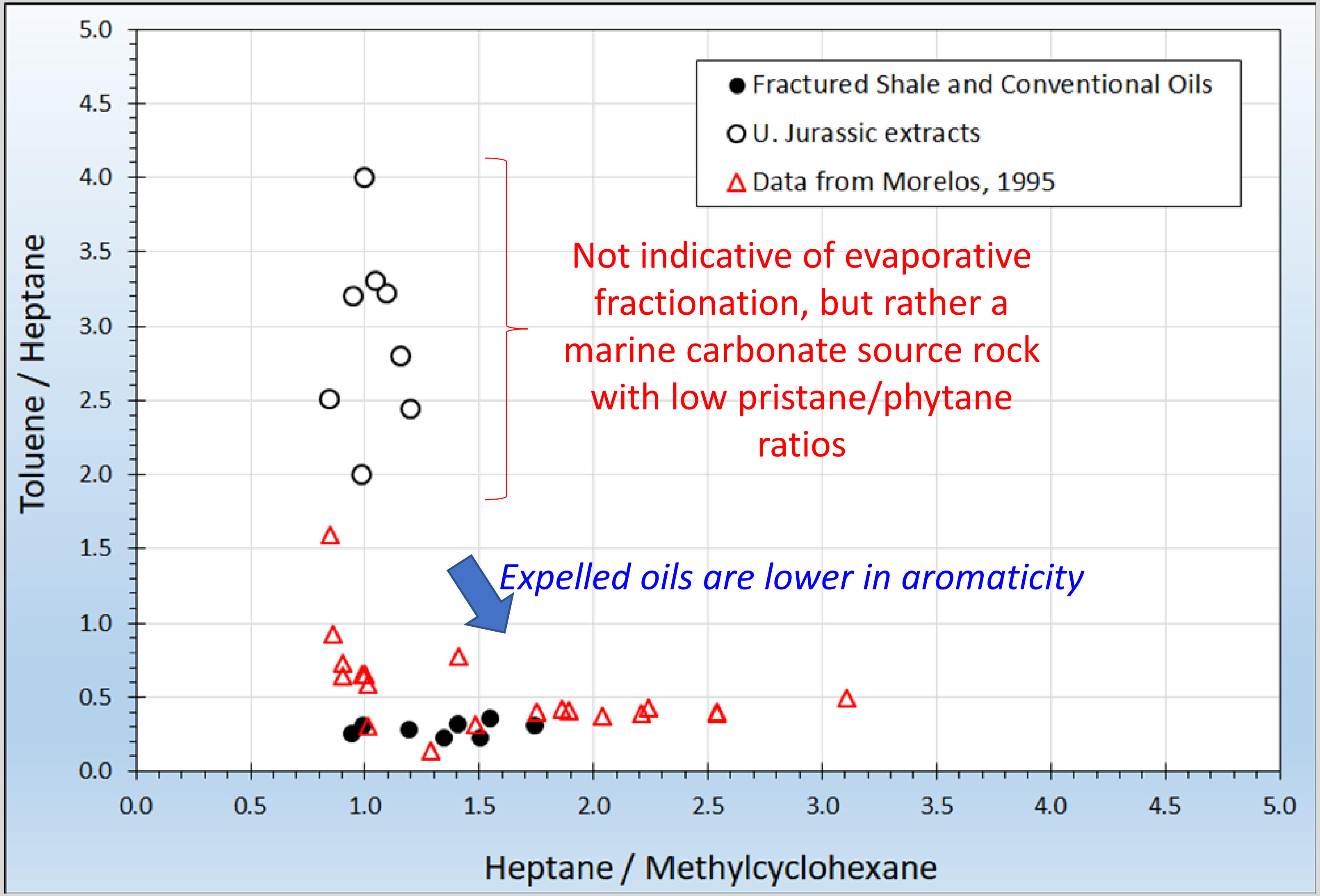


Maende, 2015



Pepper, 2019

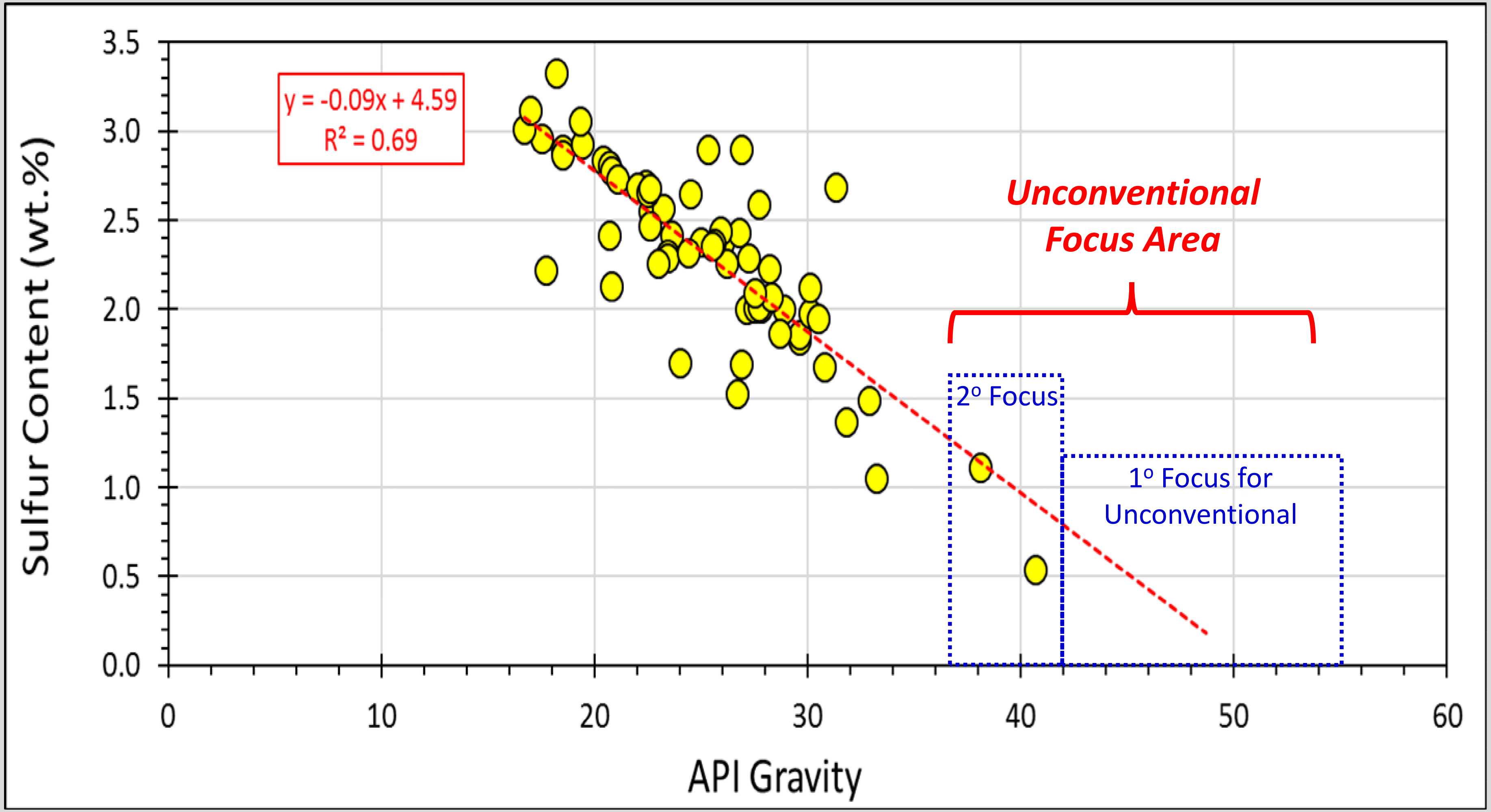
High Aromaticity Ratio in Carbonate Source Rocks
Fractionation results in lower values in oils



Evaporative fractionation would suggest loss of gas pressure, but in this case indicative of a carbonate source rock

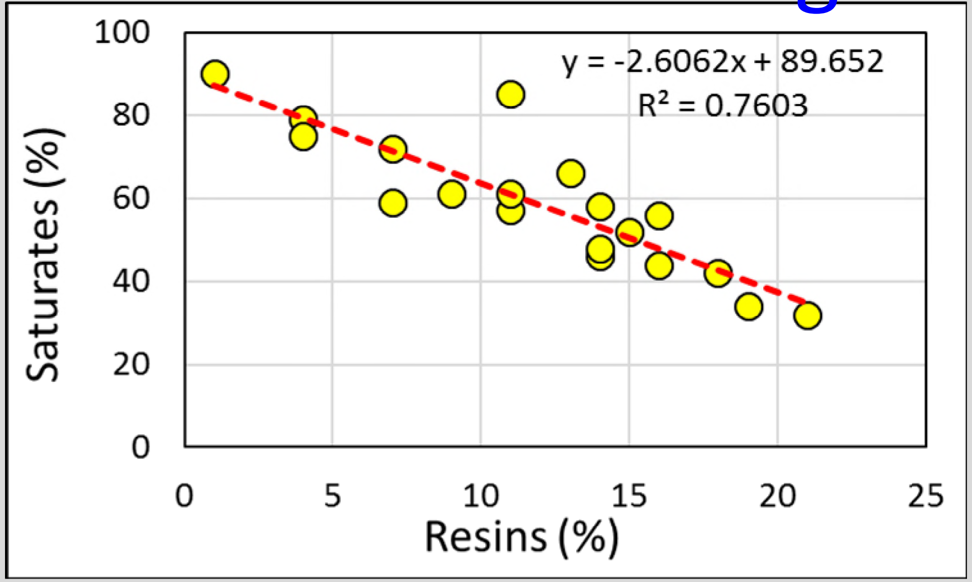
Thermal Maturity
and
Relationship to Oil Quality

Sulfur Contents decrease with increasing maturity



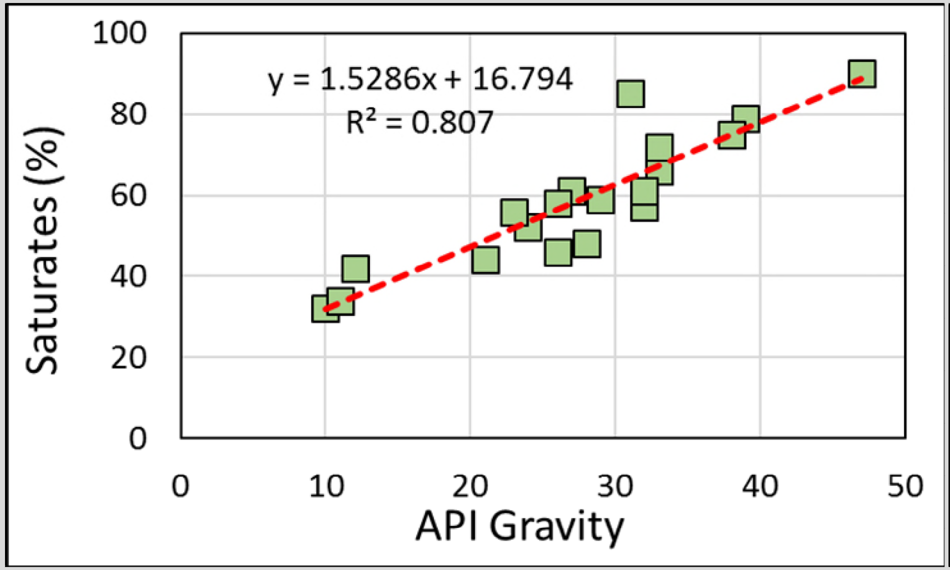
(conventional reservoir data from Vargas, 2000)

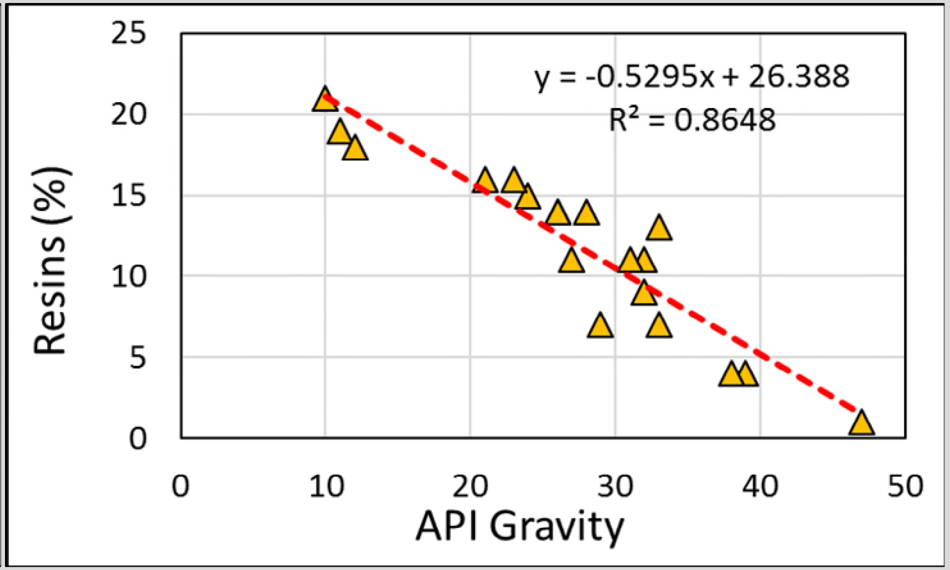
Oil Cracking of Resins Results in increased saturates and higher API oils



Saturates increase with decrease (cracking) of resins

API gravity increases with increase in saturated hydrocarbons

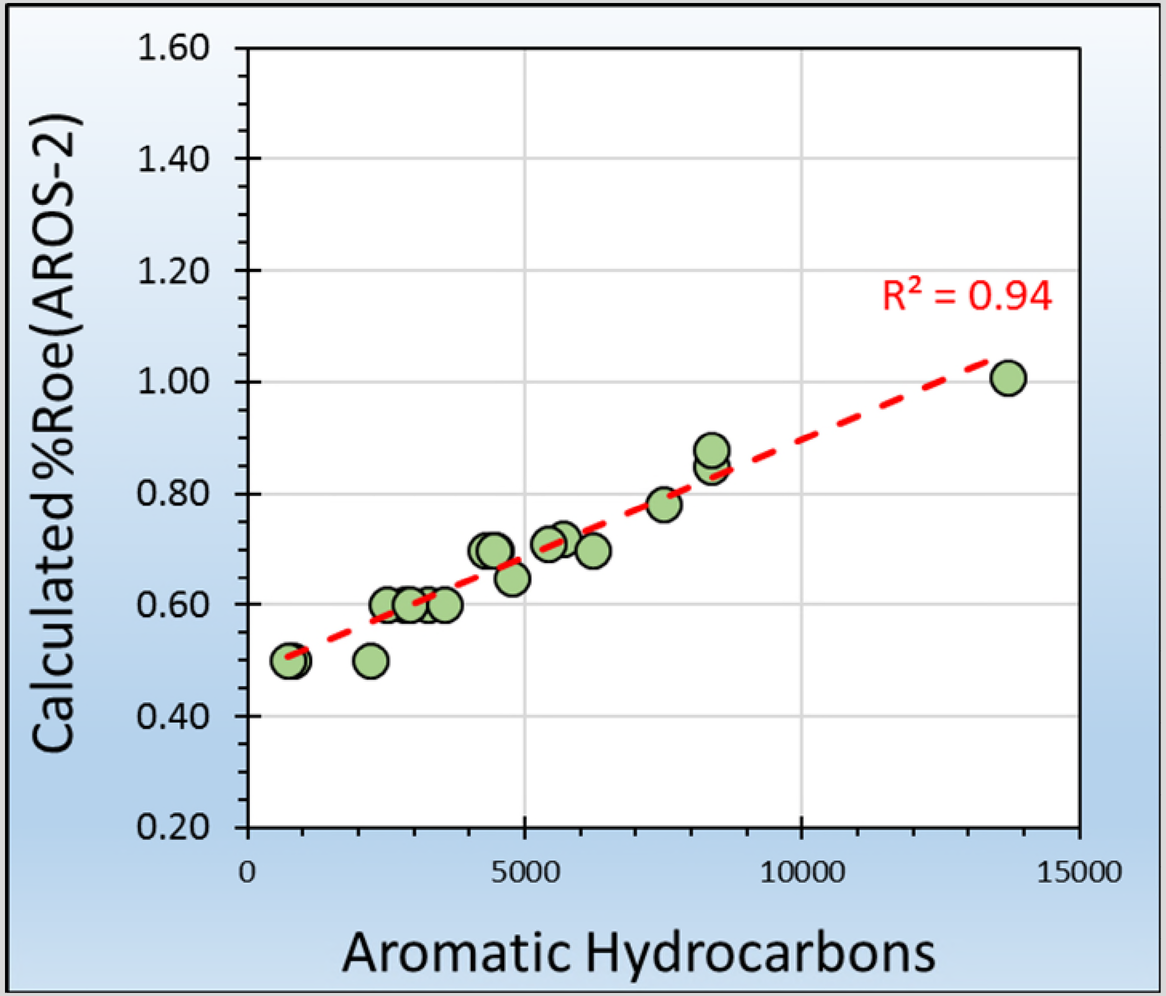


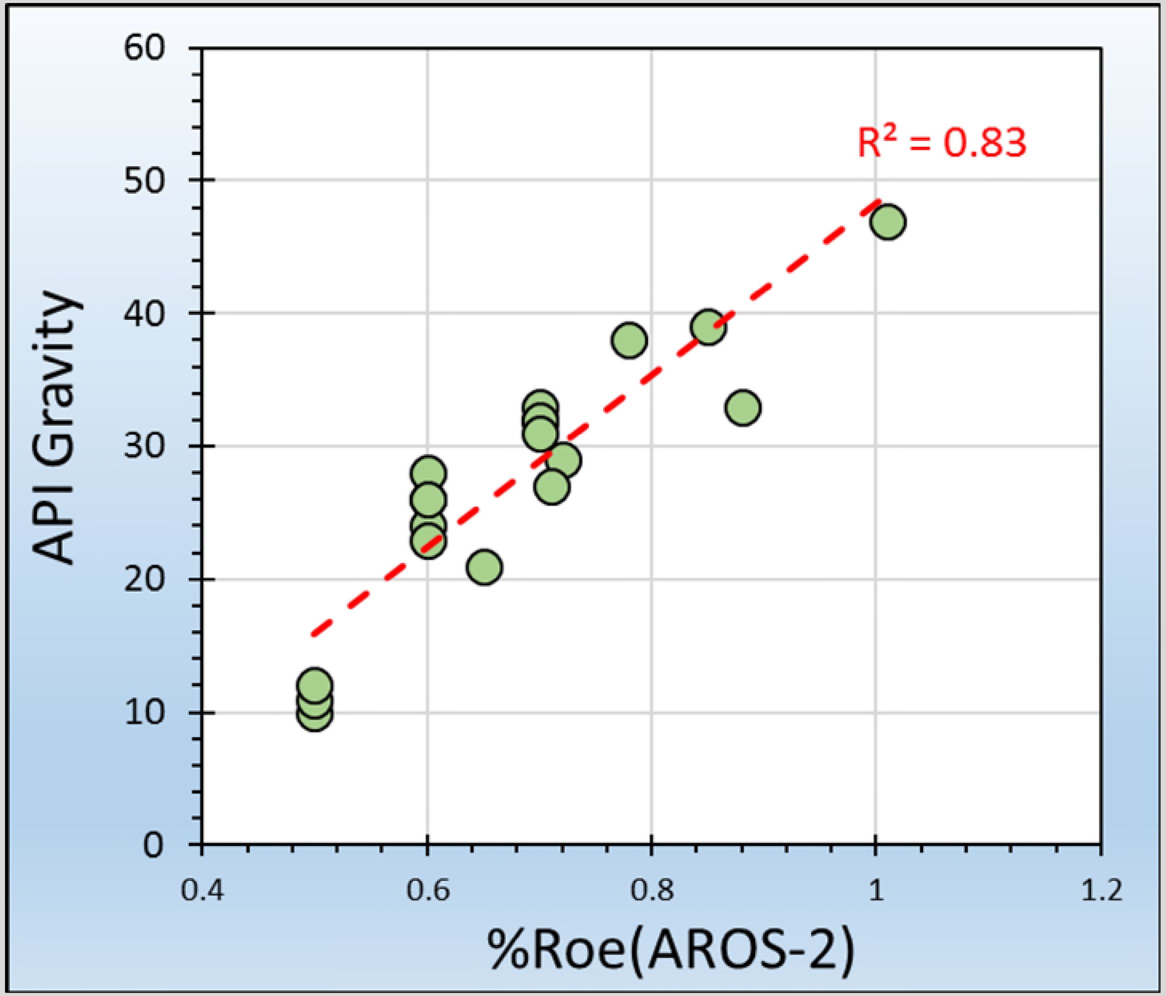


API gravity increases with decrease in resins

Data from Santamaria, 1996

Correlation of Aromatic Hydrocarbons to Oil Quality

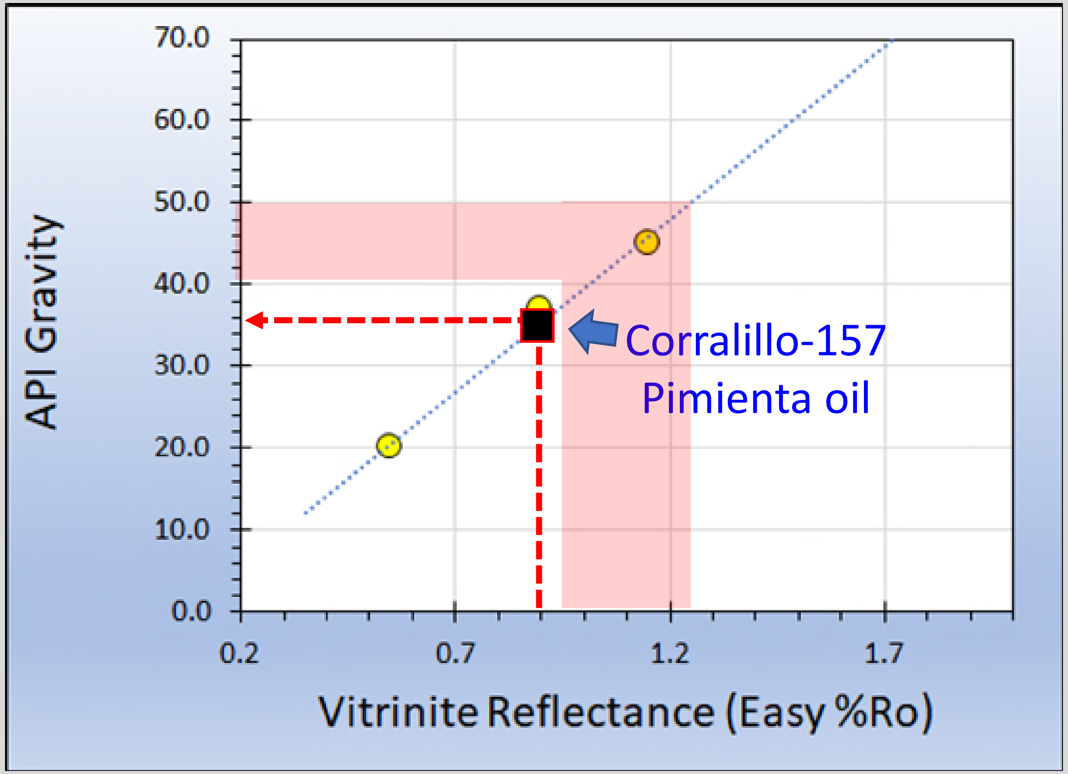


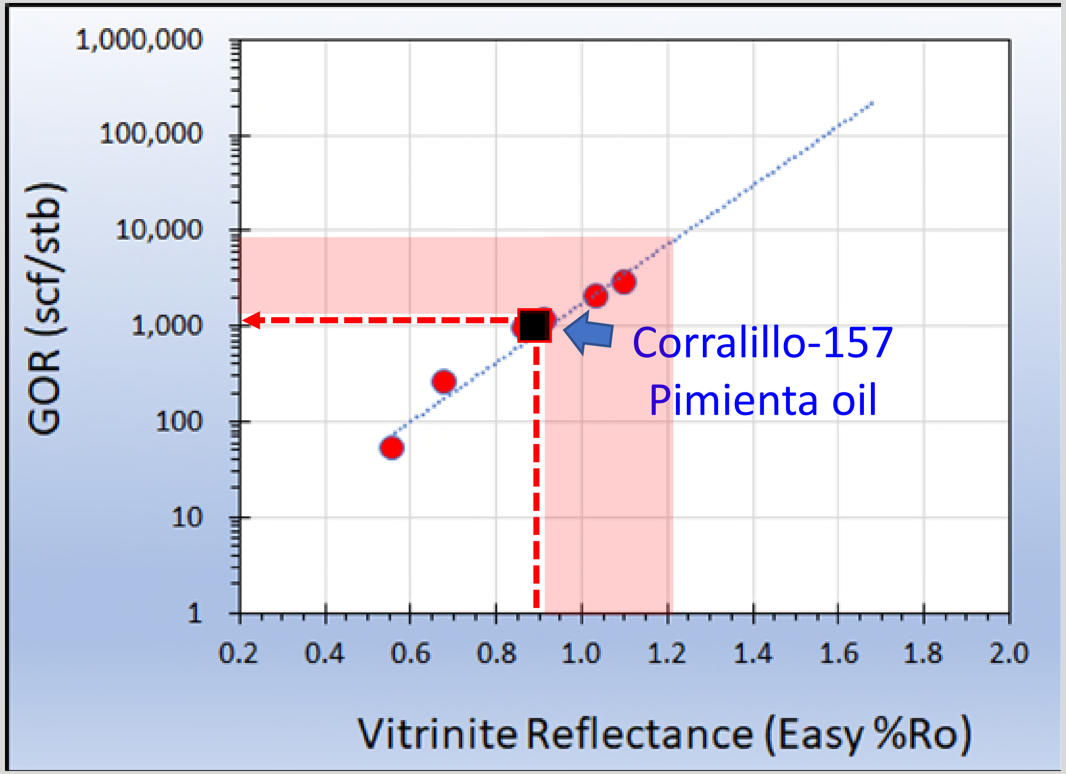


Data from Santamaria, 1996

Calibrating Optimum Maturity to Oil Quality essential for locating best producible oil

Pemex Corralillo-157 produced from U. Jurassic, Pimienta Formation

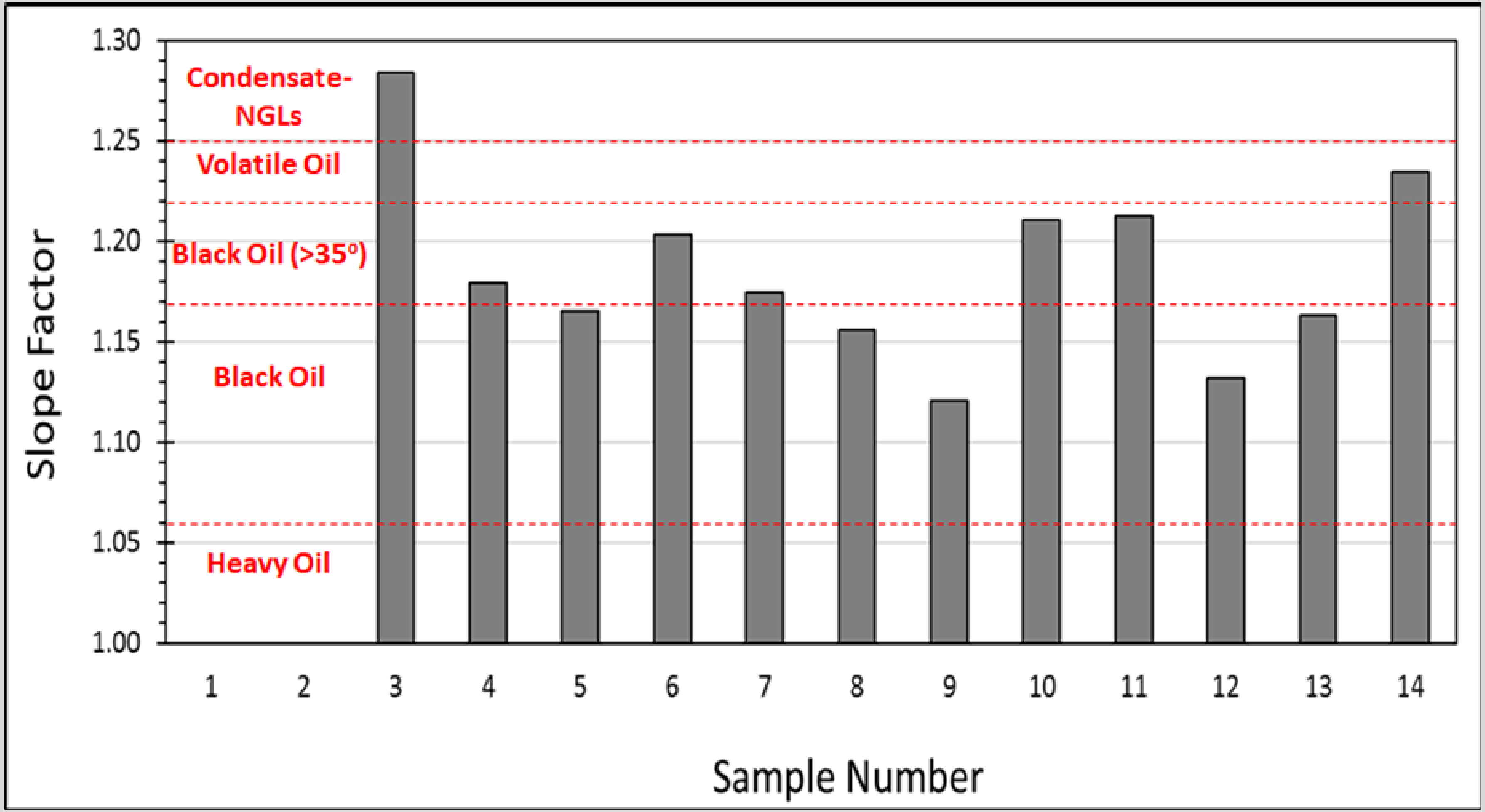




Optimum API window: 40-49 API

Optimum GOR window: 1000 – 3500 scf/stb

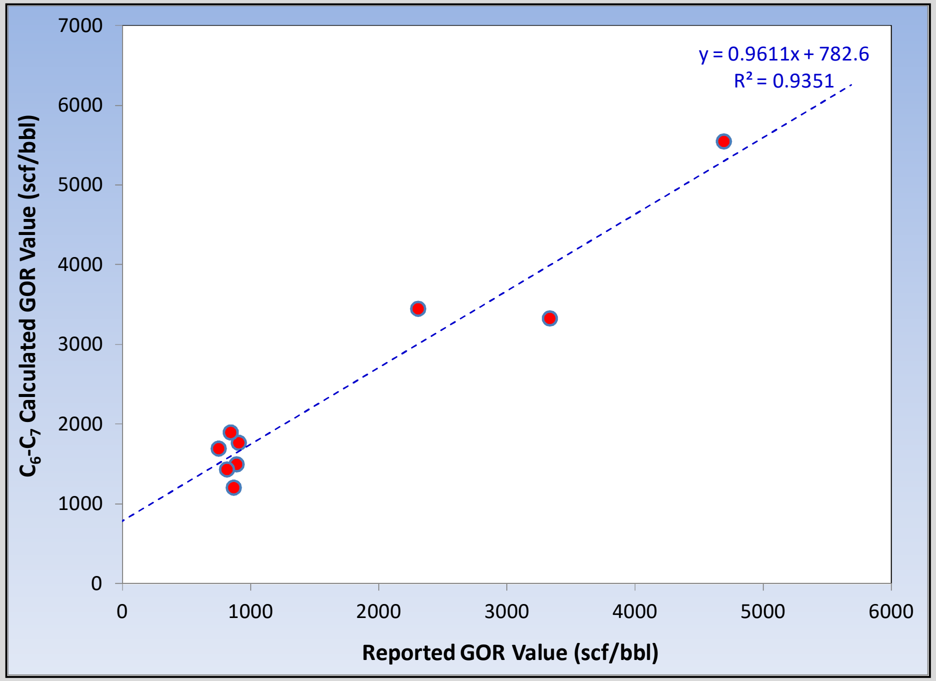
Rock GC Fingerprints allow prediction of light oil fairways



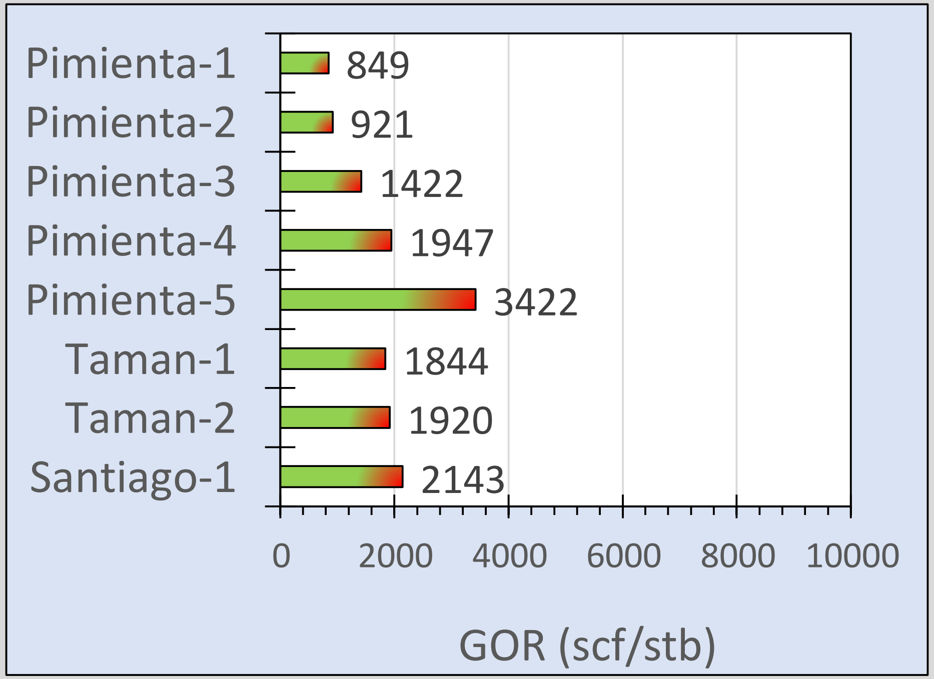
GC=gas chromatographic

Light hydrocarbon correlation from oils and rock extracts to *in situ* GOR

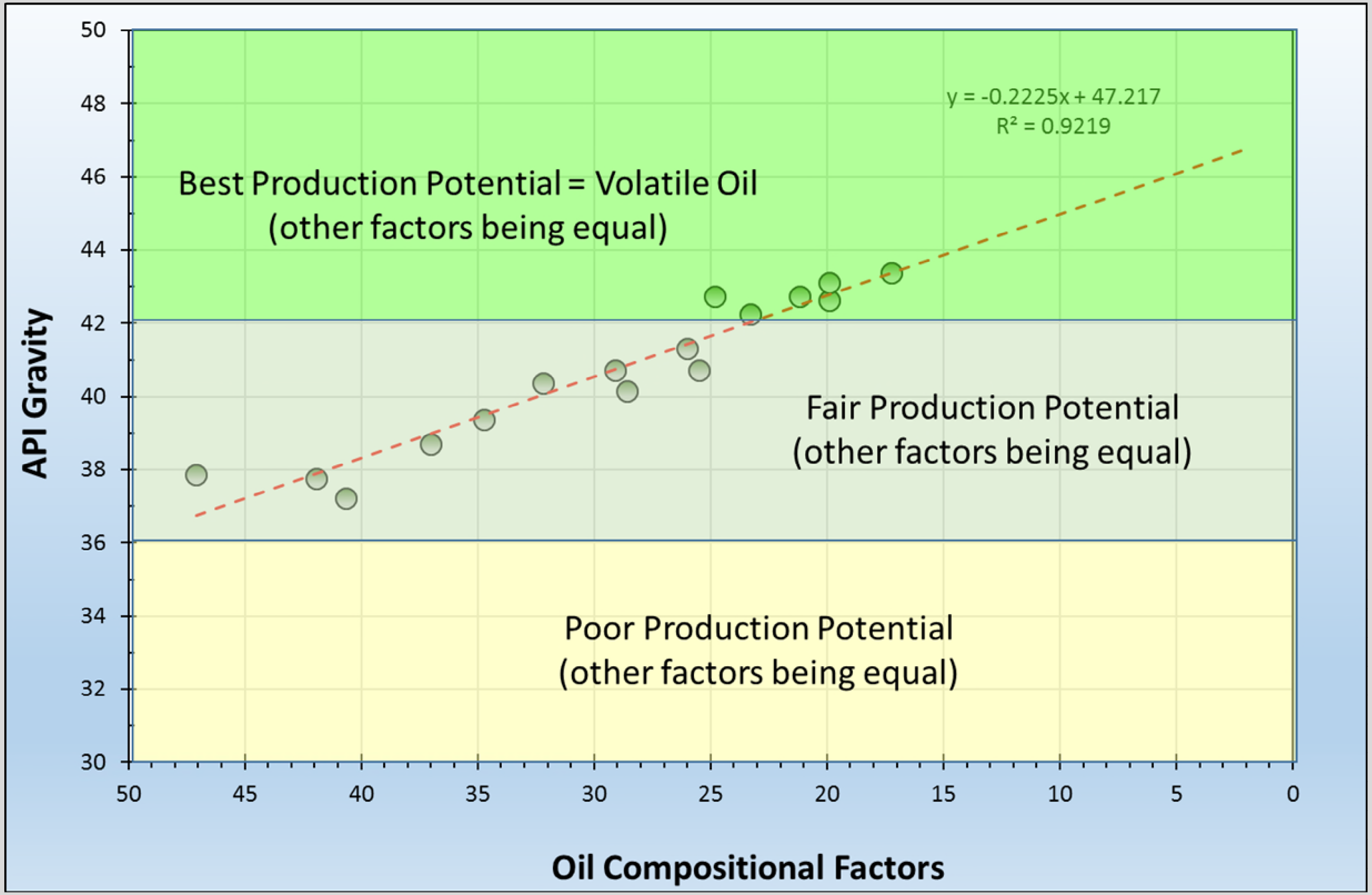
Eagle Ford Oils
GC predicted GOR values



U. Jurassic (Mexico) rock extracts
GC predicted GOR values



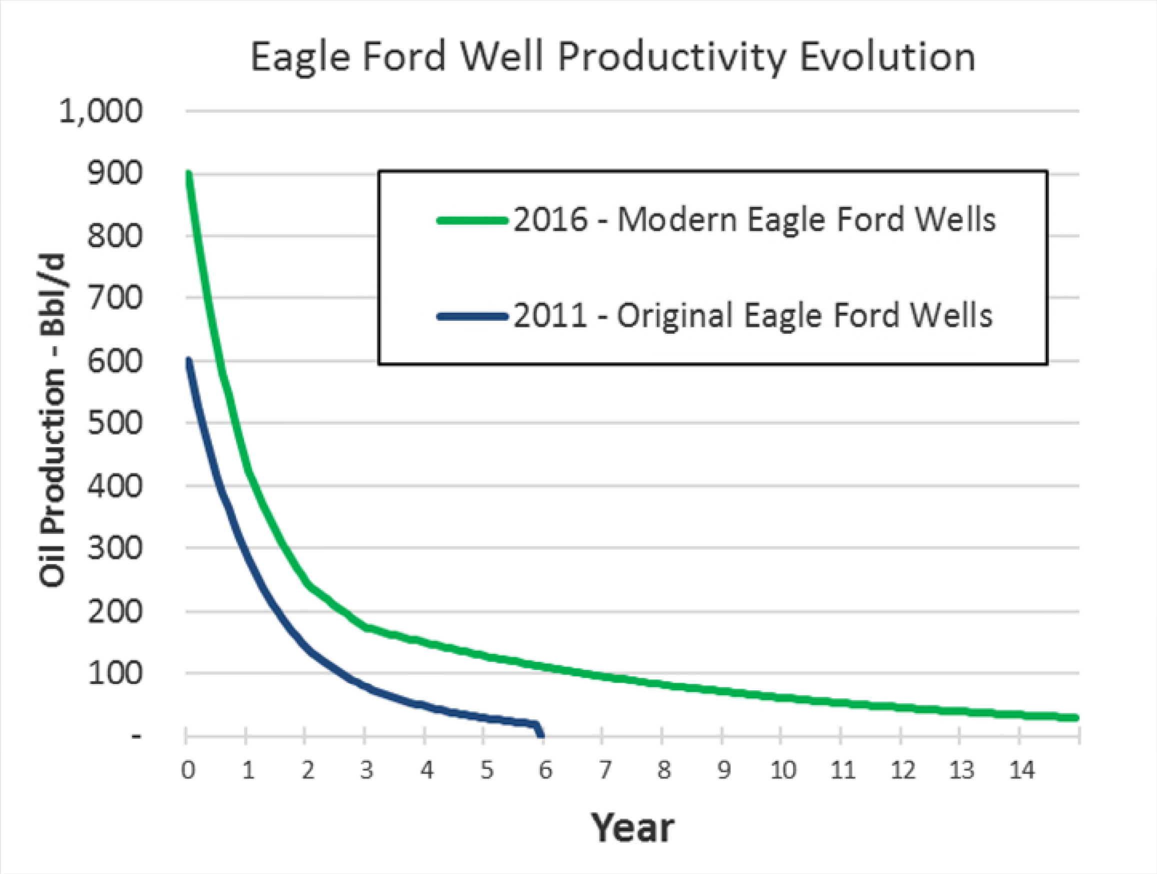
Using Geochemical Data for Prospecting and Targeting

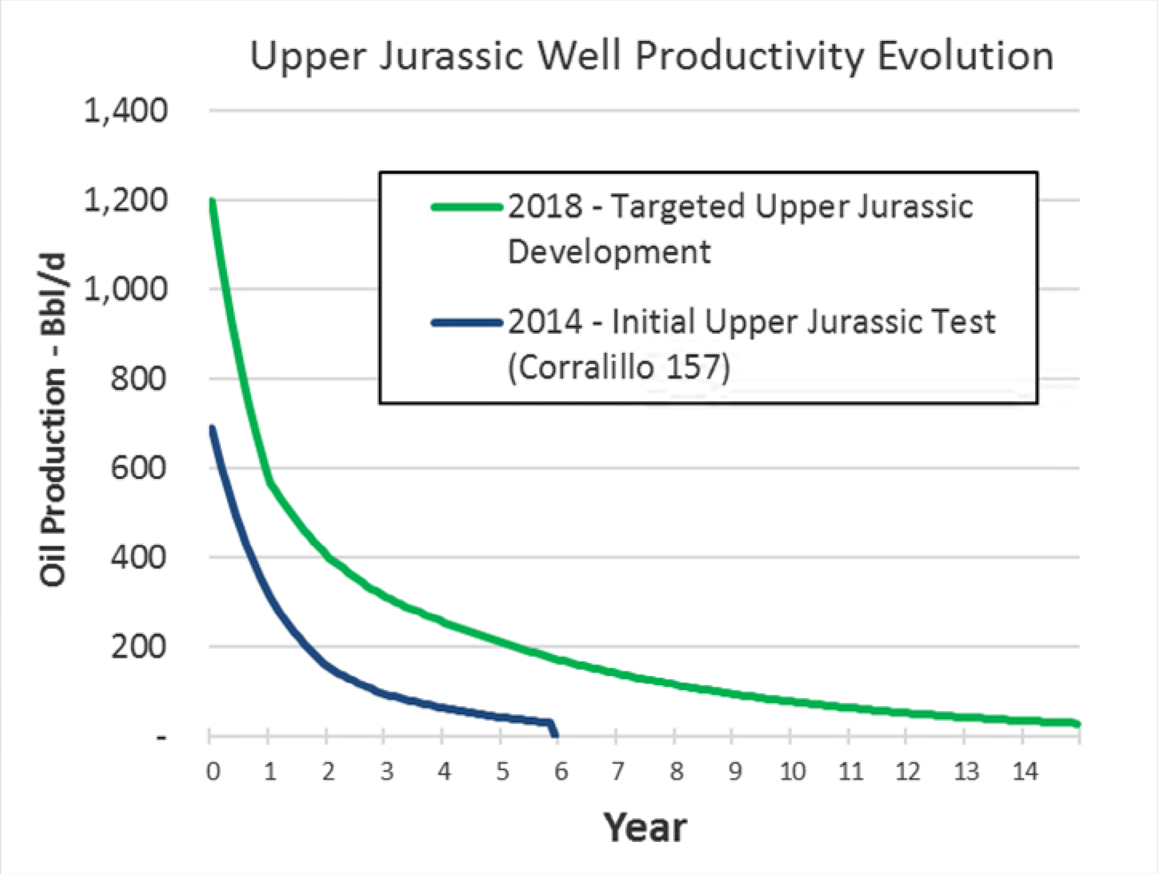


Production Projections
suggest early results comparable to Eagle Ford

Eagle Ford Oil Well Productivity		
	Initial Prod *Bbl/d*	**Recovery** *Bbls*
2011 Original Wells	600	300,000
2016 Modern Wells	900	800,000

Upper Jurassic Well Productivity		
	Initial Prod *Bbl/d*	**Recovery** *Bbls*
2014 Original Test Well	650	300,000
2018 Targeted Amatitlan Wells	1,200	1,000,000





Synopsis

- U. Jurassic Petroleum System in Tampico-Misantla Basin, Mexico has excellent potential for tight oil production when drilled in appropriate areas and completed using advanced technologies
- Oil quality improves (higher API and GOR, lower sulfur) with thermal maturation
- U. Jurassic system is comparable to Eagle Ford Shale in organofacies and lithofacies except it is 3-5x thicker
- Best production areas have been optimized by calibration to produced oil and analysis of rock and rock extracts across the basin
- Available production result from Pimienta suggest comparable yield as early Eagle Ford well production

Gracias !

Thank you !

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