

Thermal Maturity of Woodford Fluids Anadarko Basin, USA

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Conclusions

- ❑ **Maturity-dependent terpane, sterane & other biomarker ratios are used to estimate the C20+ (heavy-end) maturity of crude oils**
- ❑ **Likely reflects the source rock maturity when this early fraction of the oil was expelled (primary migration)**
- ❑ **Maturity-dependent alkyl naphthalene & phenanthrene ratios are used to estimate the ~C10-C15 (mid-range) maturity of crude oils**
- ❑ **Likely reflects the source rock maturity when this later, often more mature fraction of the oil was expelled**
- ❑ **Calculated maturities of laterally co-produced oils and gases from the Woodford Formation of the Anadarko Basin, OK generally agree**
- ❑ **However, anomalous positive methane carbon isotopes and high diamondoid concentrations were detected in some lower-maturity black Woodford oils.**

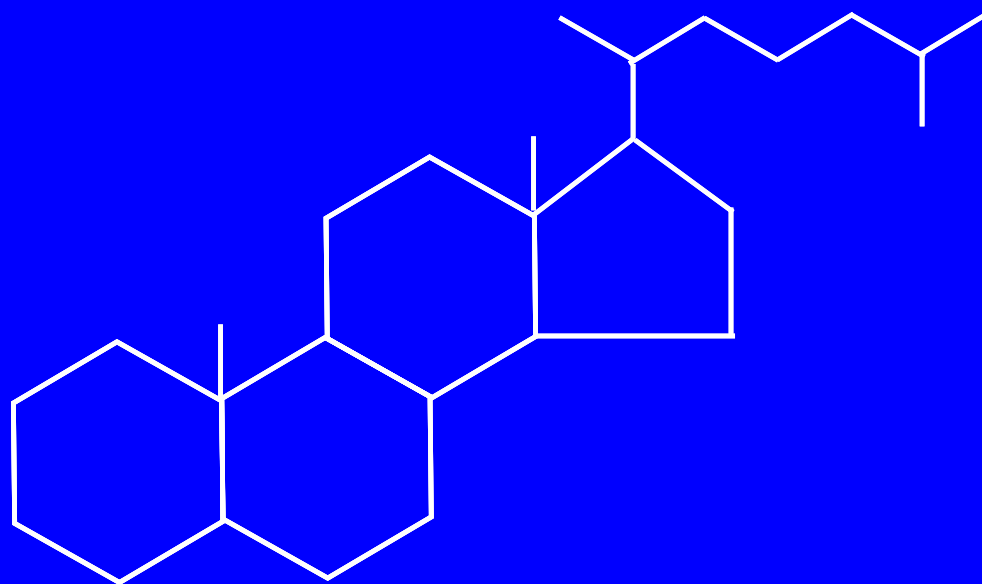
Biomarkers

- Hydrocarbons whose structures can be recognized in living organisms
- Occur in some reasonable abundance in nature
- Stable during diagenesis
- **They are Molecular Fossils!!**

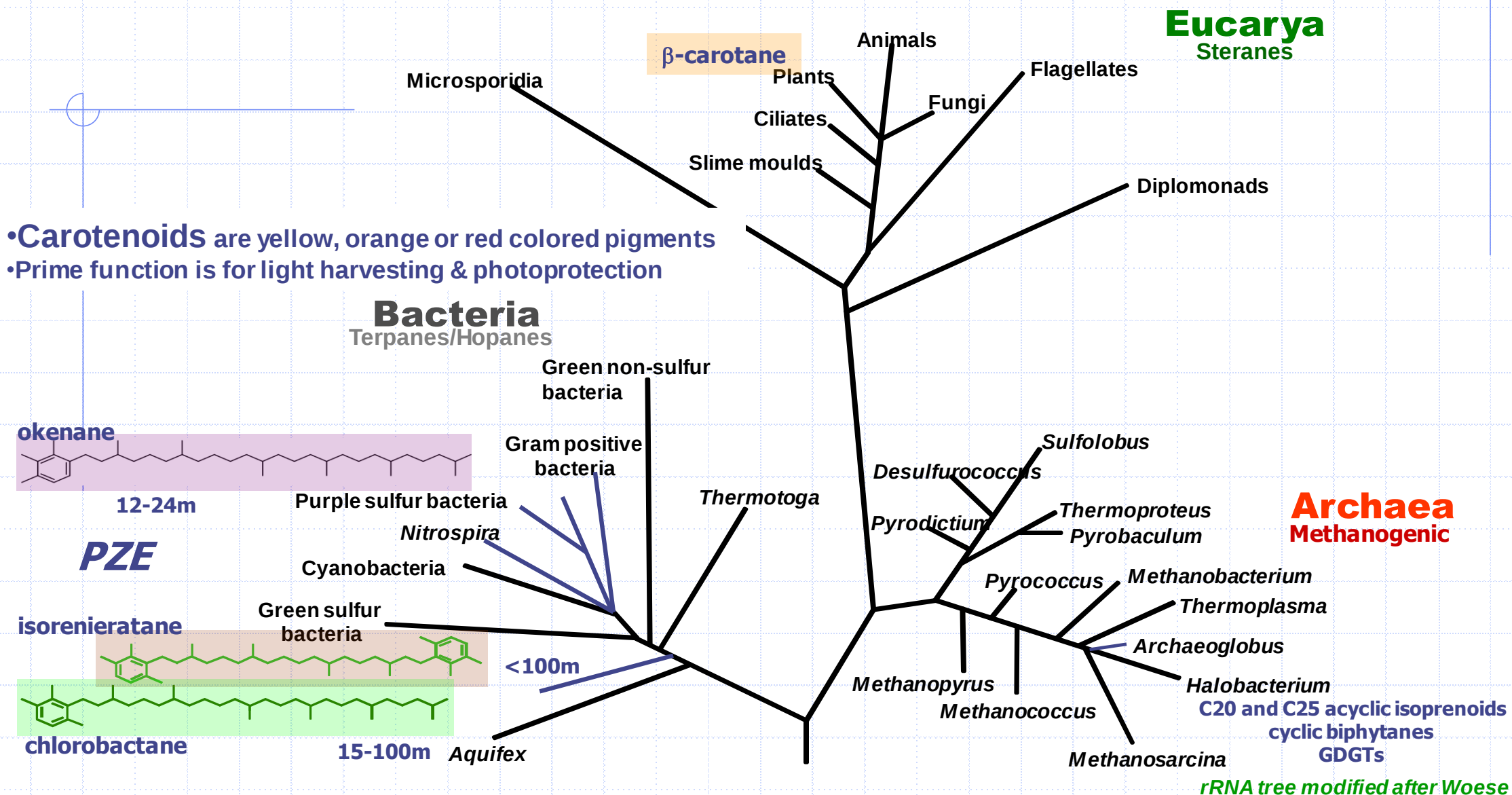
Example Biomarker

Steranes (m/z 217)

Cholestane C27

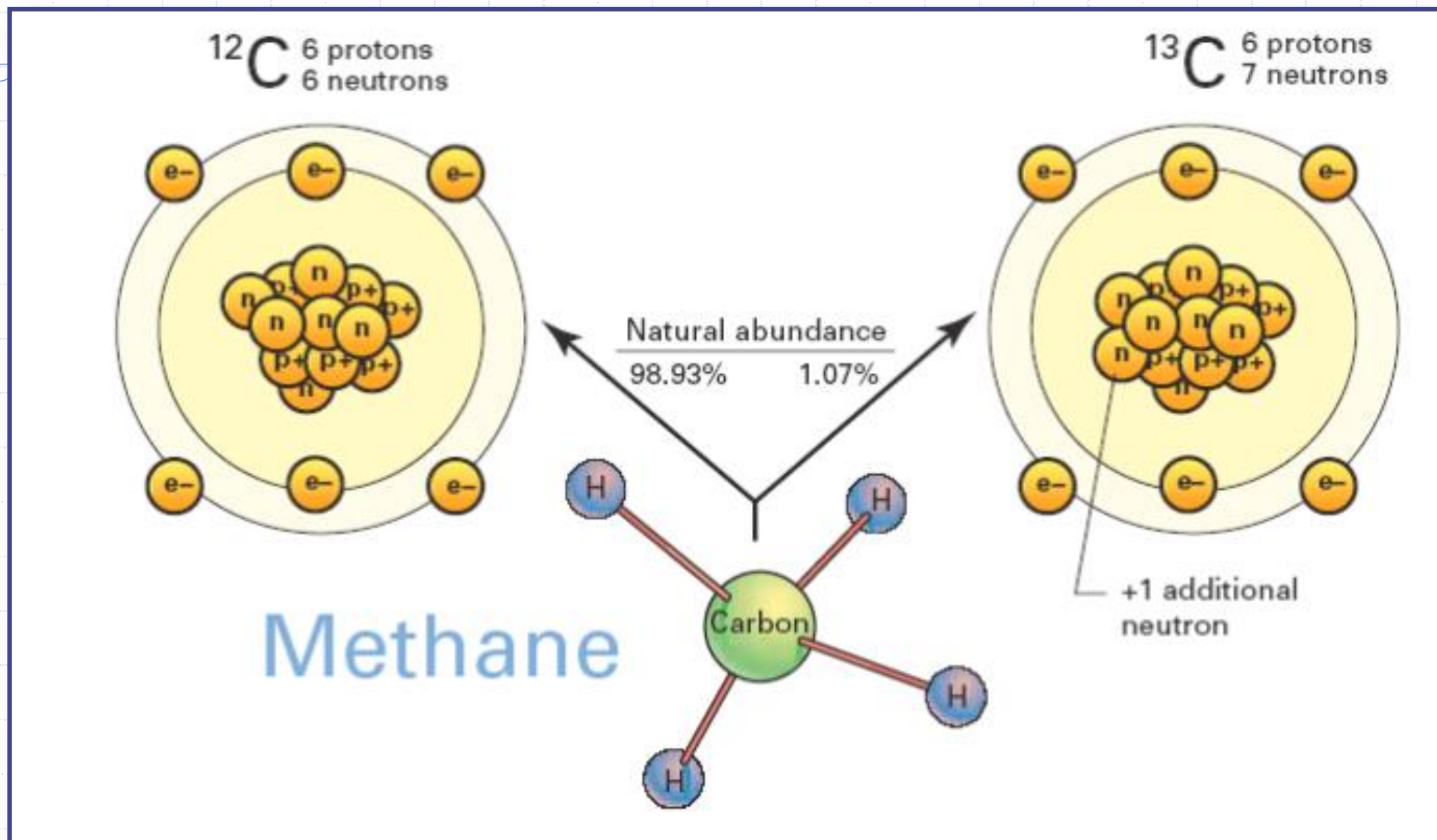


Biomarker 'Tree of Life'

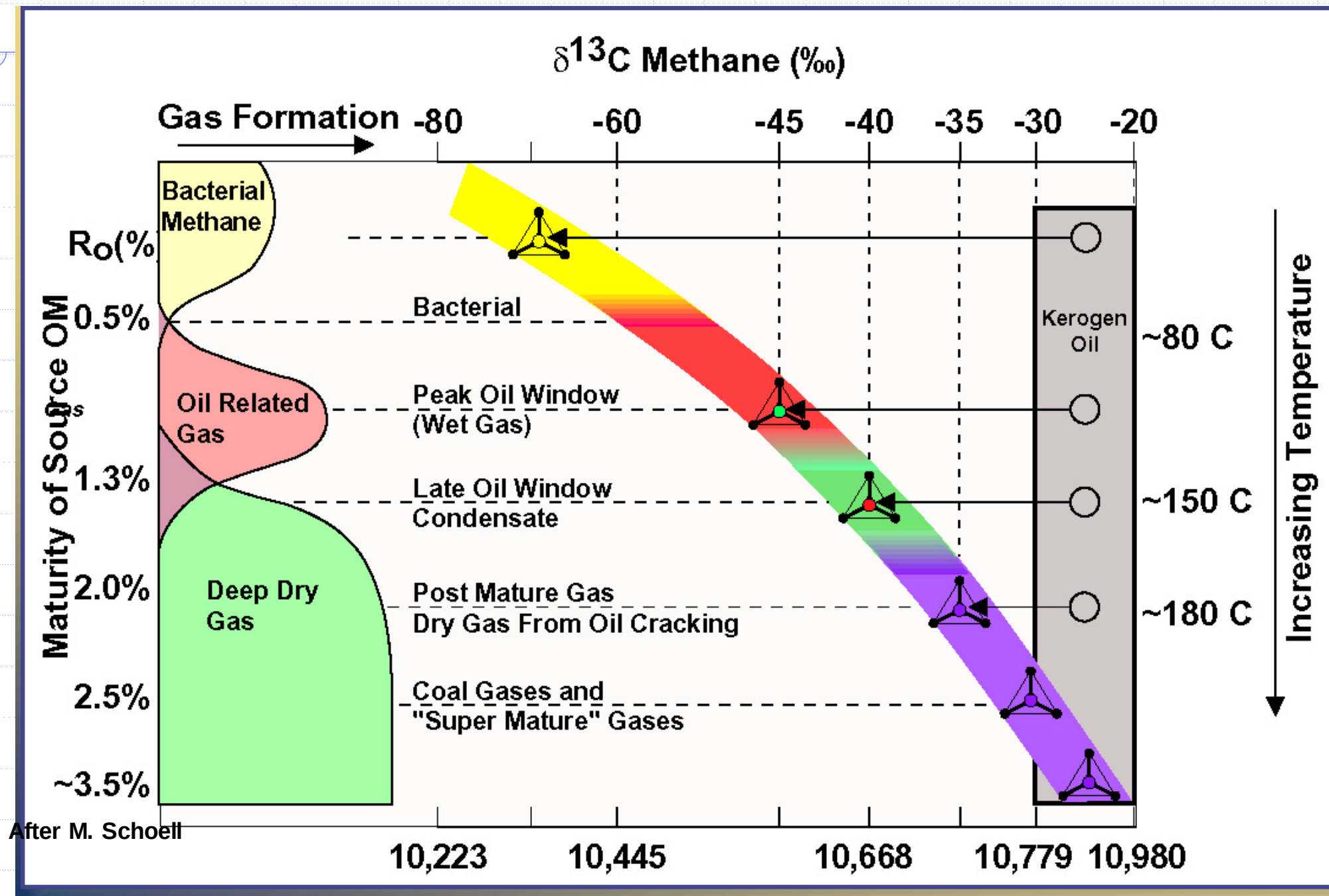


Maturity of Woodford Fluids

Carbon Isotopes – A Reminder!



Changes in Carbon Isotope Ratios with Thermal Maturation (after M. Schoell)

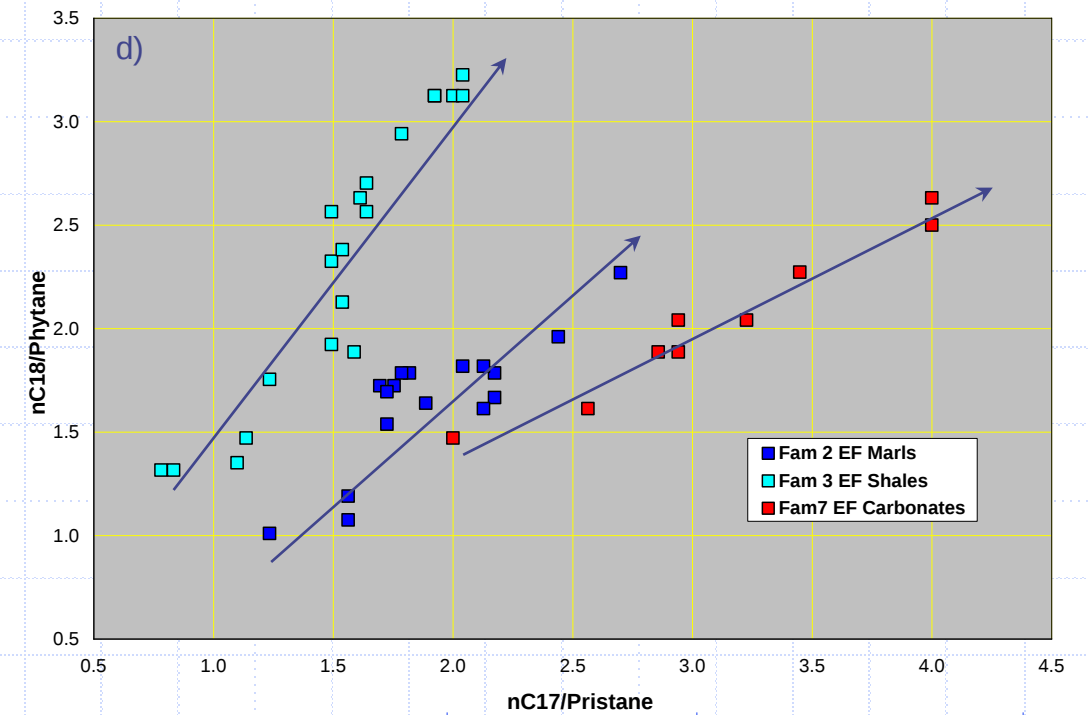
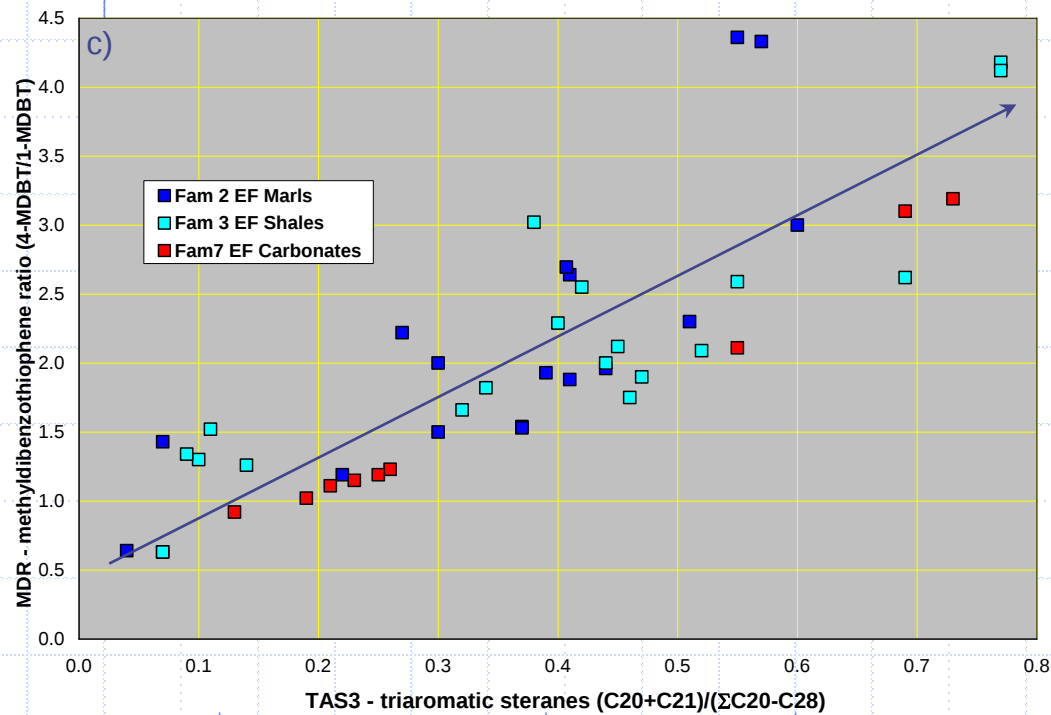
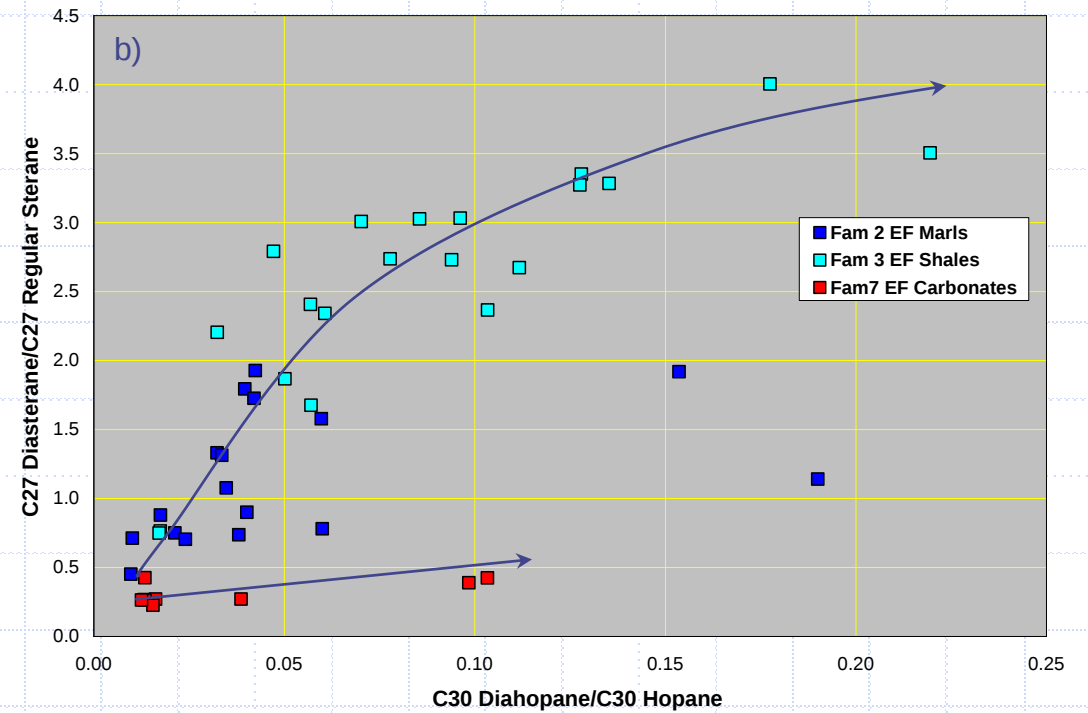
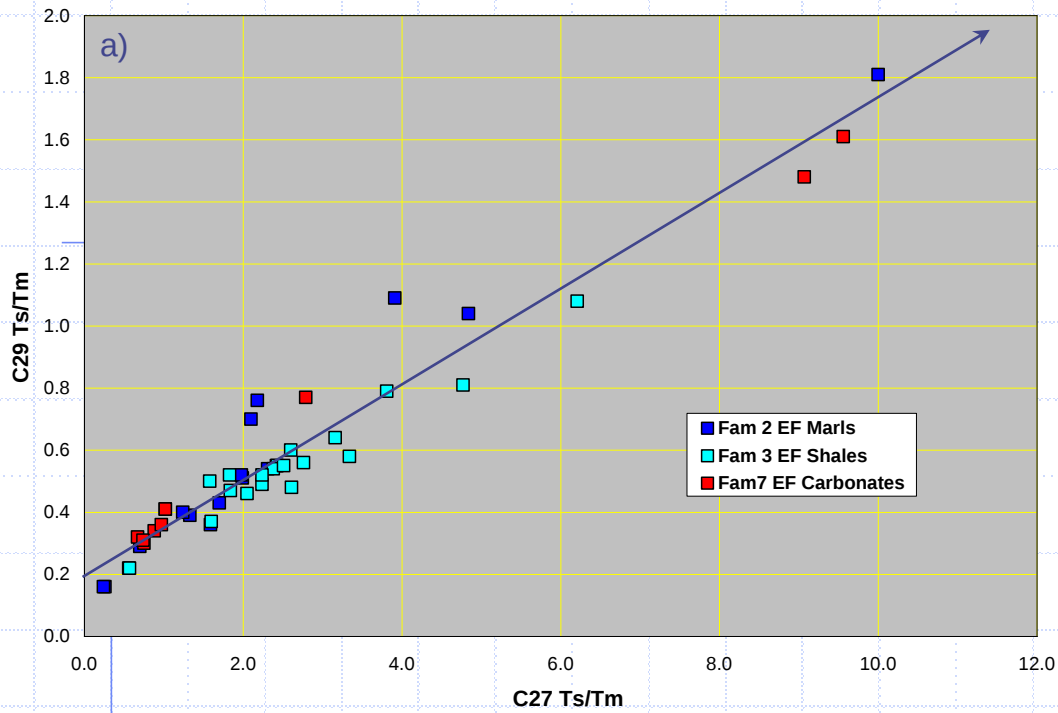


Biomarkers & Isotopes

Oil Biomarkers and Carbon Isotopes of Oils and Gases can provide insight into:

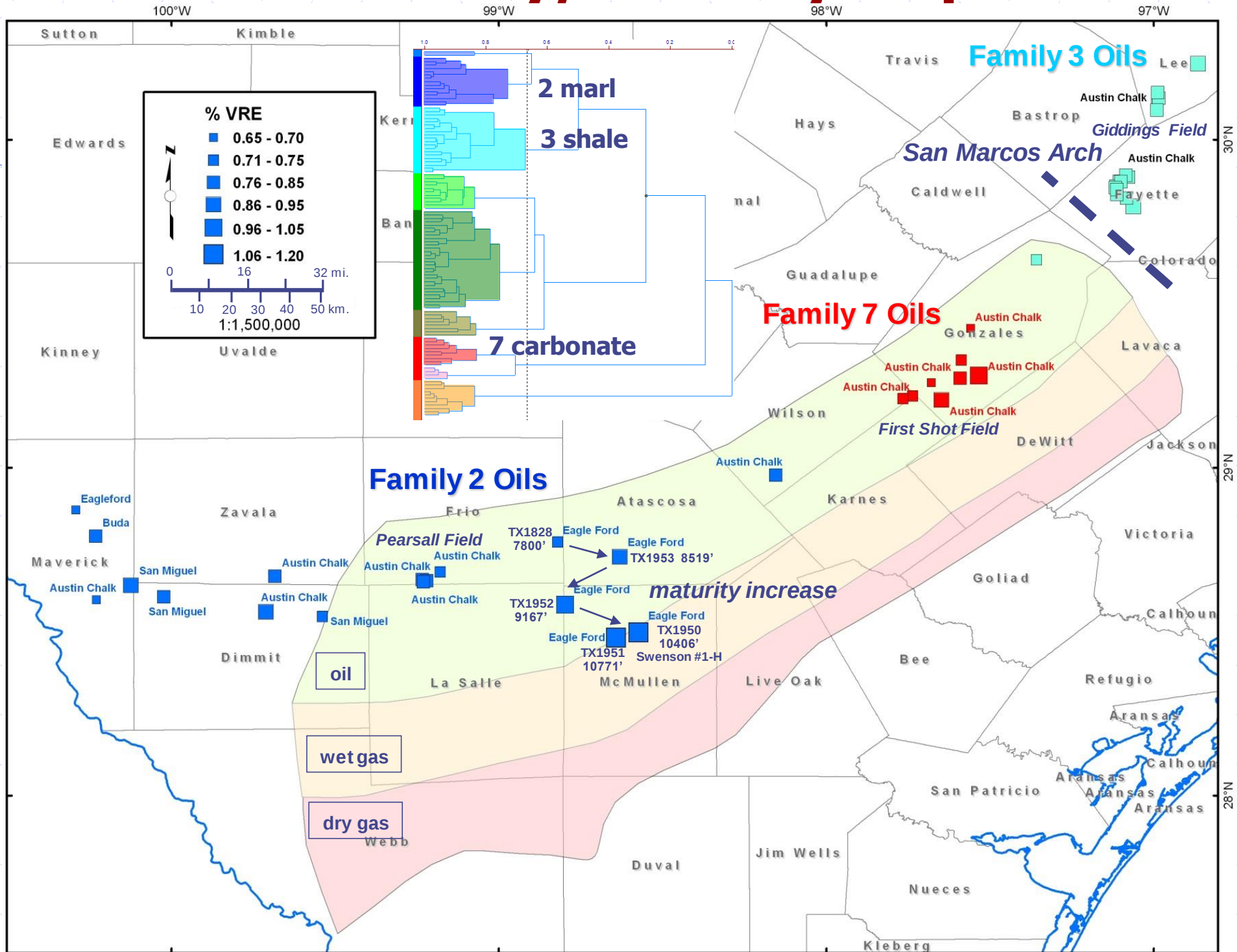
- ❖ Source Rock Type
- ❖ Depositional Environment
- ❖ Geologic Age
- ❖ **Organic Matter Maturity**
- ❖ **Migration Timing**
- ❖ Migration Distance & Direction (On a good day...)

Oil Thermal Maturity (VRE via biomarker maturity ratios)



Maturity of Woodford Fluids

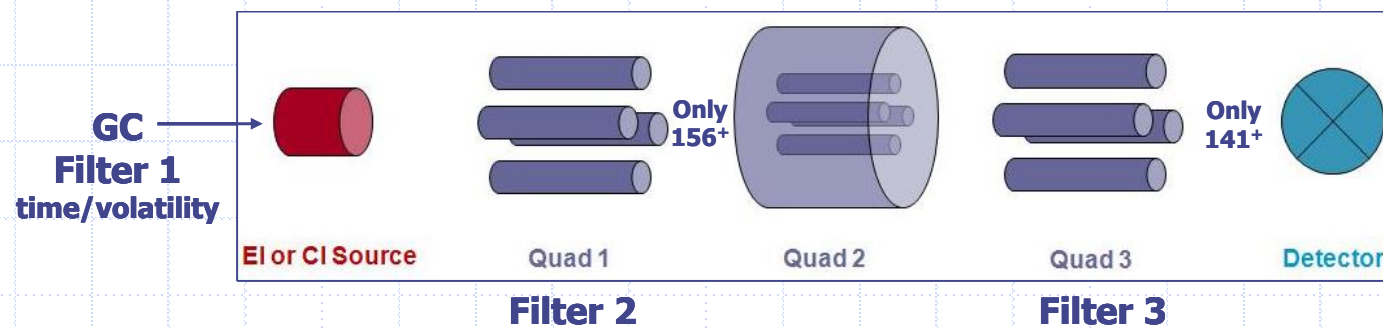
Oil Family/Maturity Map



Maturity of Woodford Fluids

But Wait – There's More!

Gas Chromatograph-Triple Quadrapole Mass Spectrometer (aka QQQ)



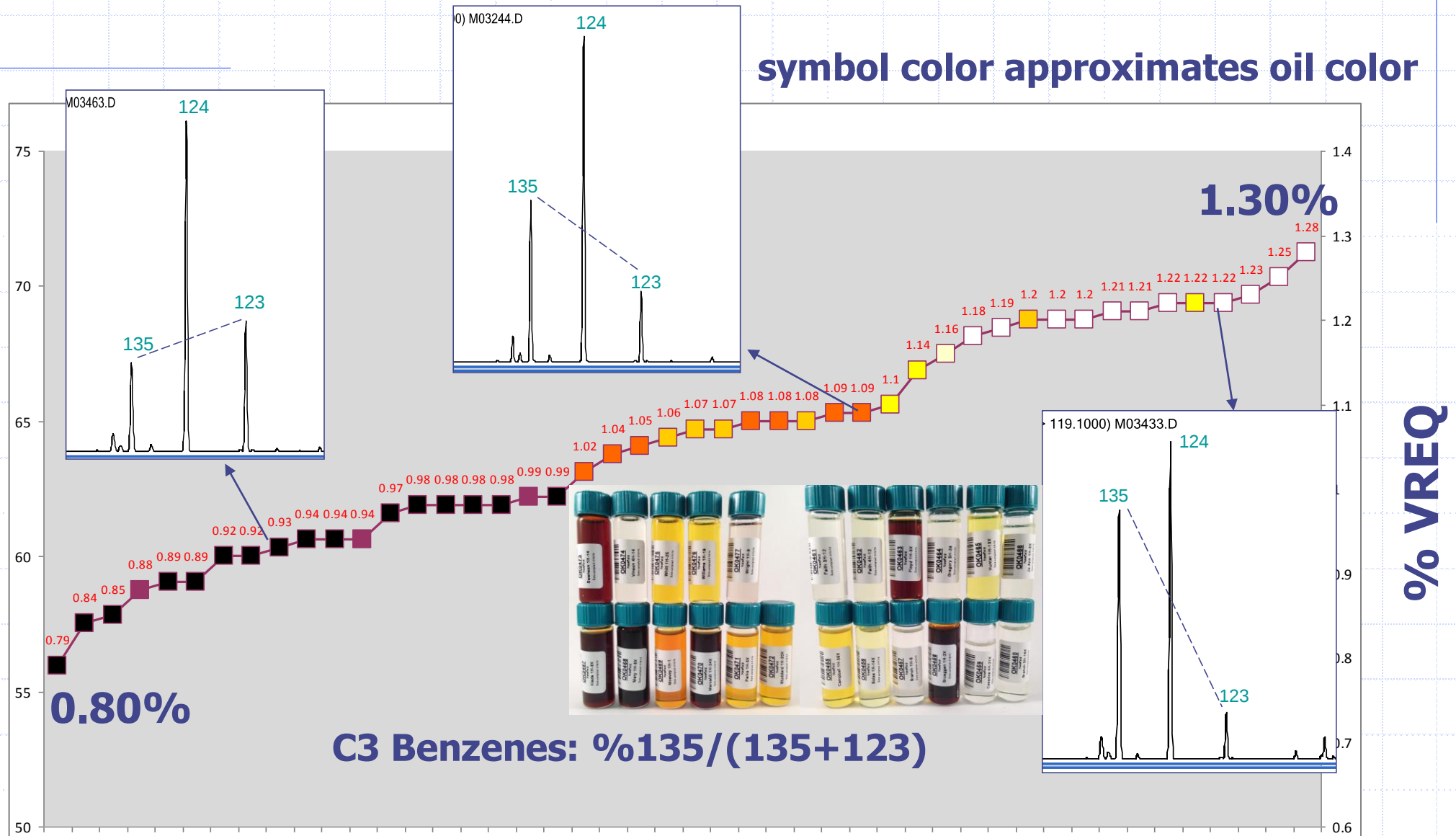
% VREQ	0.92	1.10	1.22
ppm Diamondoids	51	68	382
ppm Naphthalenes	146	90	61
ppm Phenanthrenes	37	21	7
ppm Dibenzothiophenes	30	12	1
ppm Methylchrysenes	4	4	1
ppm Steranes	31	9	0
ppm Tricyclic Terpanes	19	6	2
ppm Pentacyclic Terpanes	14	1	0
ppm Carotenoids	3	1	0
ppm Triaromatic Steroids	4	1	0
ppm Monoaromatic Steroids	5	1	0

**~200 Target Compounds
Quantified – in One Run
'dilute & shoot'**

**VRE = Vitrinite Reflectance Equivalent
Derived from the Triple-Quad**

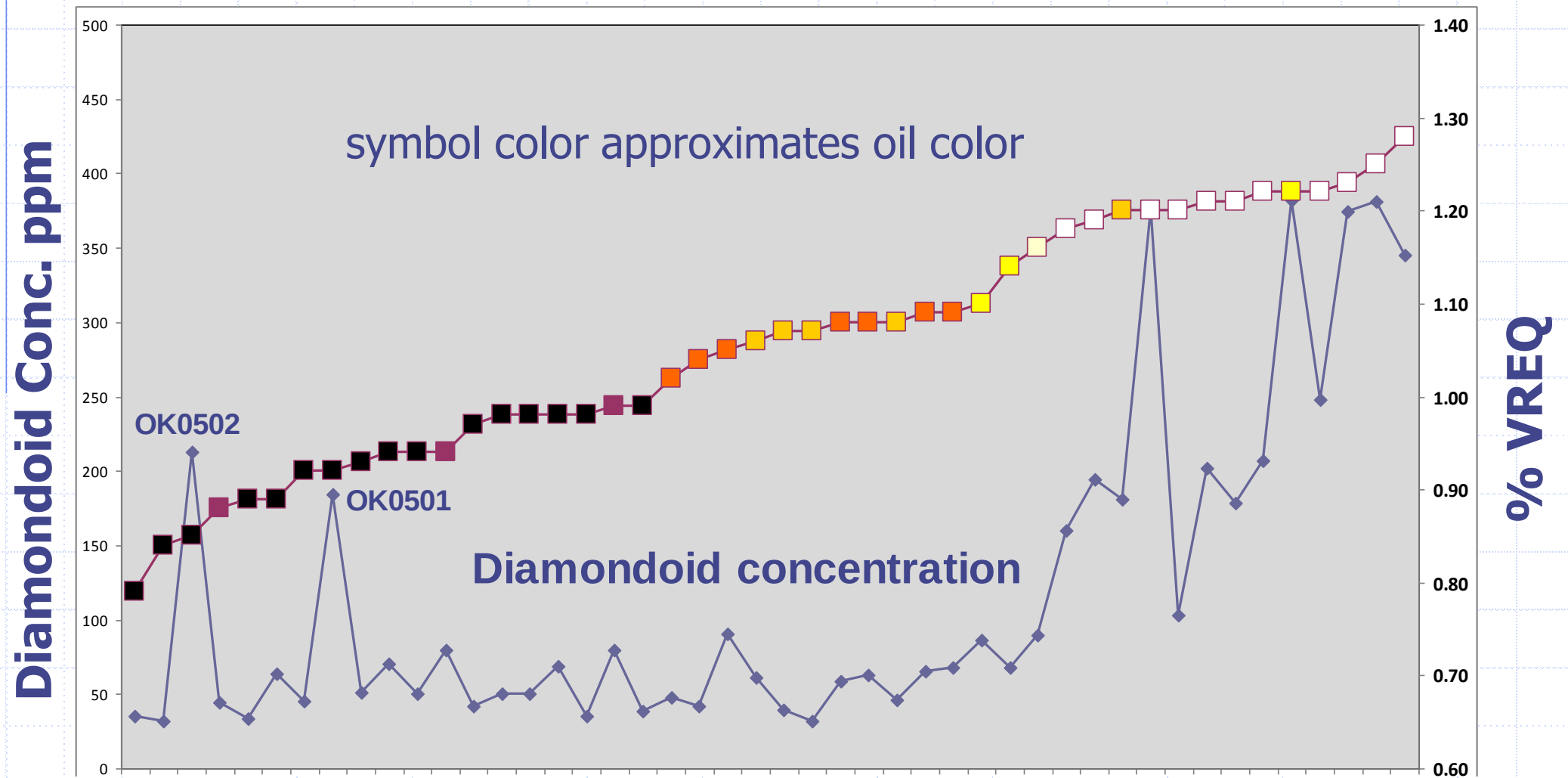
Woodford Oils & Gases Anadarko Basin

Alkyl Aromatic Ratios



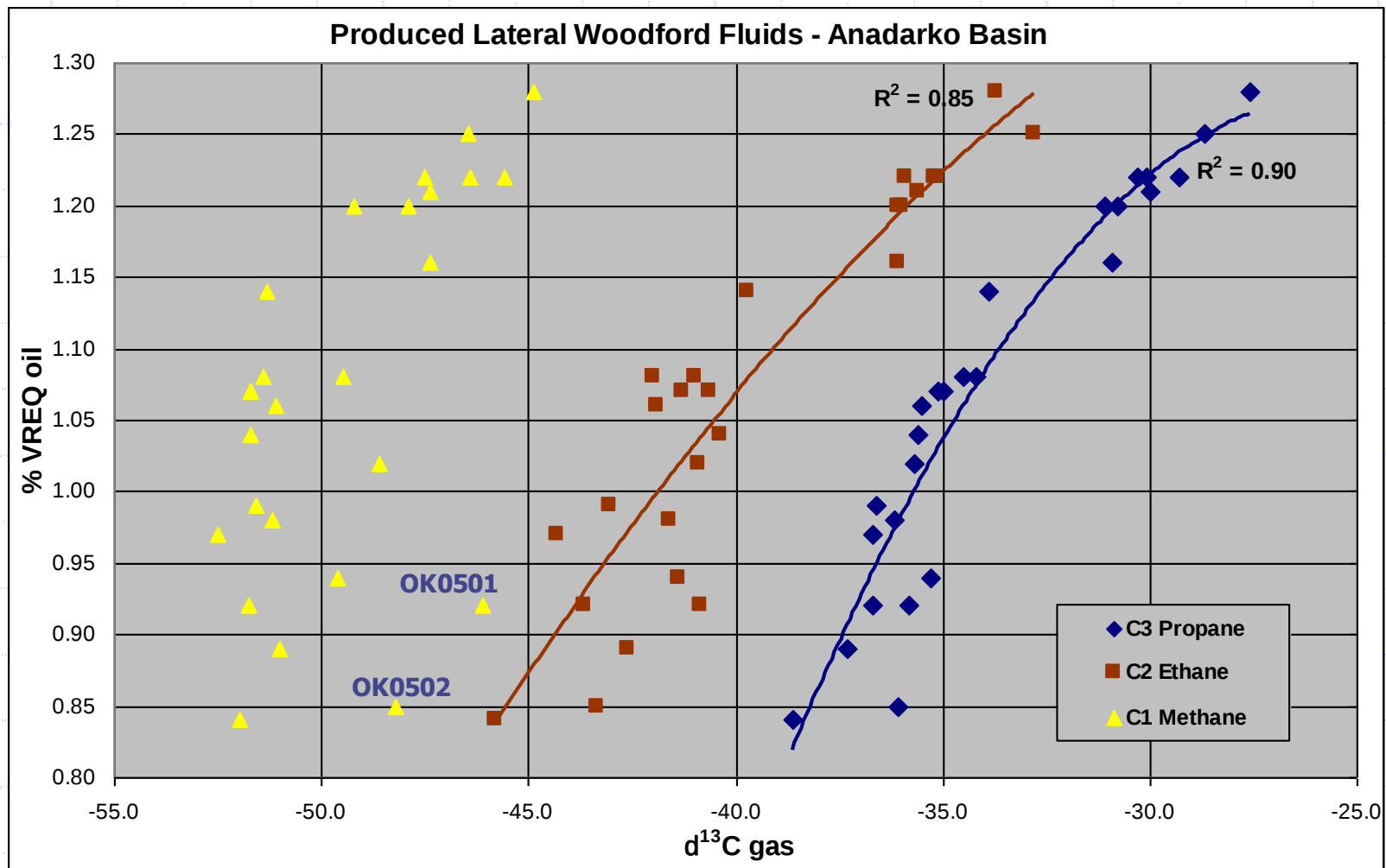
Maturity of Woodford Fluids

VREQ vs Diamondoids



Maturity of Woodford Fluids

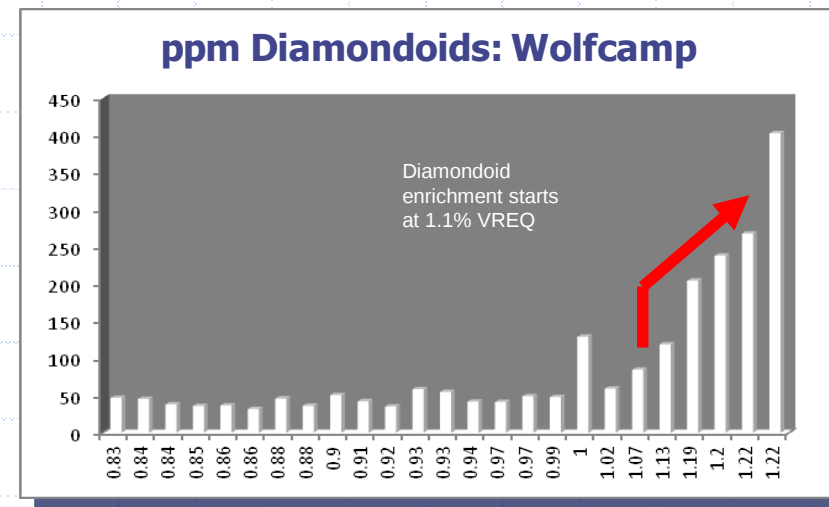
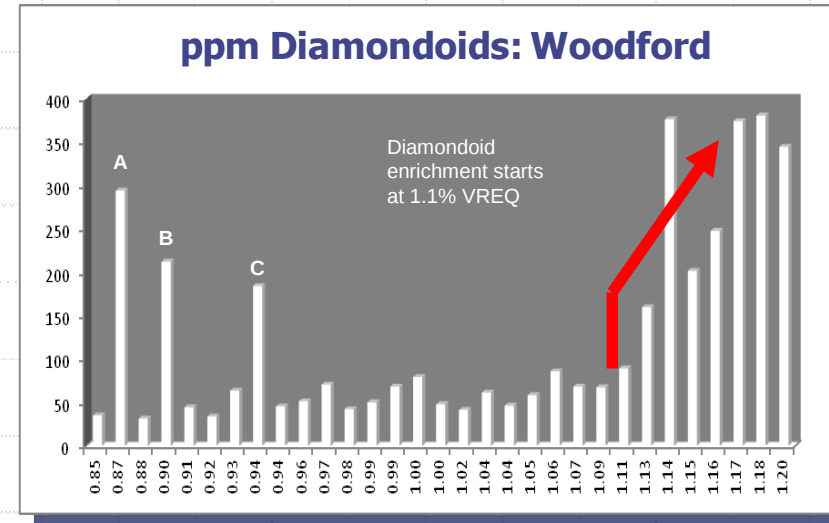
Co-Produced Liquid vs Gas Maturity



ppm C40 Carotenoids: Woodford

Wavelength (nm)	Concentration (ppm)
0.85	11
0.87	70
0.88	10
0.90	8
0.91	1
0.92	1
0.93	7
0.94	5
0.96	3
0.97	4
0.98	2
0.99	2
1.00	2
1.01	0
1.02	0
1.03	0
1.04	0
1.05	0
1.06	0
1.07	1
1.08	0
1.09	0
1.10	0
1.11	0
1.12	0
1.13	0
1.14	0
1.15	0
1.16	0
1.17	0
1.18	0
1.20	0

**Also measured using
GC-Triple Quad MS
(aka QQQ)**



Anadarko Woodford Source Rock Maturity

UD Woodford Fm.		%VRE	Measured		
		Tmax*	%Ro	%VREQ	
Kingfisher Co. OK Core 1	Ave	0.98	0.97	1.02	
9,393-9,432 ft	Std Dev	0.02	0.06	0.01	n=6
Canadian Co. OK Core 2	Ave	1.07	1.05	1.09	
10,326-10,426 ft	Std Dev	0.03	0.07	0.02	n=7

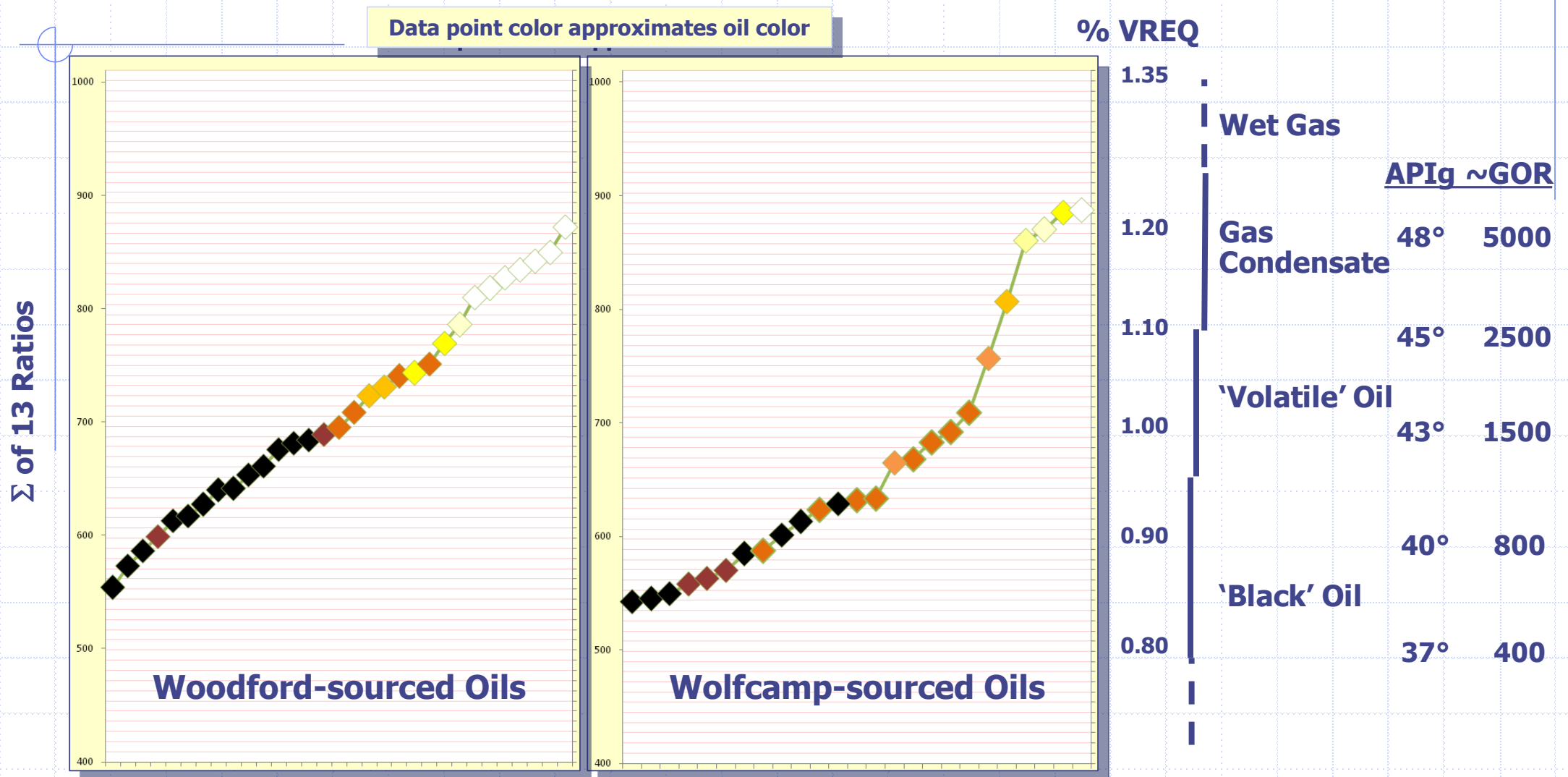
*after solvent extraction

TOC: 3-11%

HI = 200

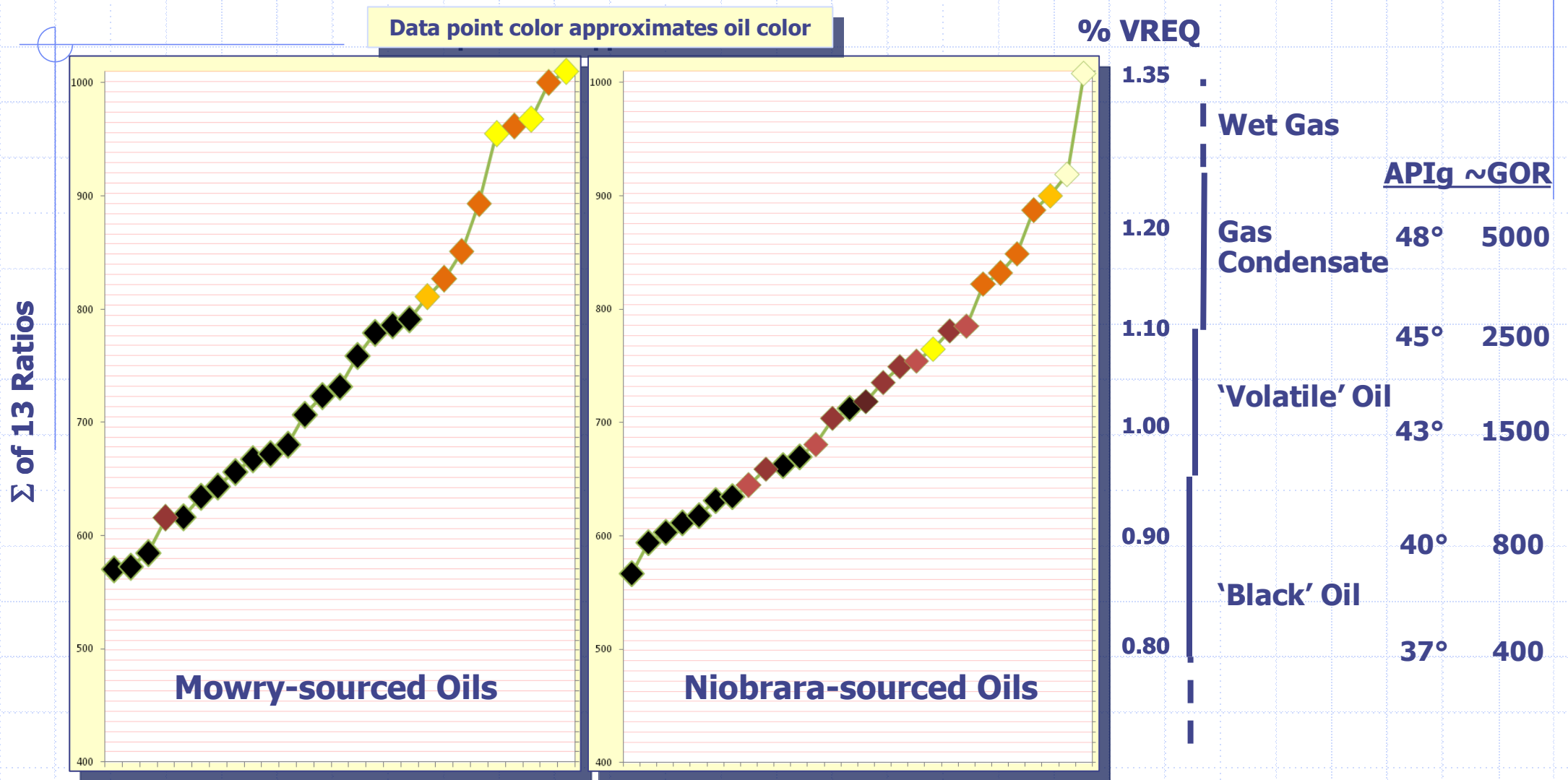
HI = 110

Oils from 'unconventional' source rock reservoirs: Anadarko & Midland basins



Maturity of Woodford Fluids

Oils from 'conventional' SS Cretaceous reservoirs: Powder River Basin



Maturity of Woodford Fluids

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- ❑ However, anomalous positive methane carbon isotopes and high diamondoid concentrations were detected in some lower-maturity black Woodford oils.
- ❑ ***Migration Happens!***

Thank You For Your Attention

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