Worldwide Shale Resource Plays and Potential*

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Abstract

The United States is now energy independent in natural gas resources perhaps for the next 30 to 100 years due to the development of unconventional shale-gas reservoirs. Despite this success the development of similar tight reservoirs in other parts of the world has been slow to follow suite despite the need for natural gas especially in Europe and China. While the reservoirs are uniquely recalcitrant due to their nanodarcy permeability and low porosity, they contain vast amounts of hydrocarbons. Despite the success of independent petroleum companies in developing shale-gas, natural gas is generally underutilized despite its abundance and being the lowest carbon dioxide emitting carbon-based energy source.

Unconventional shale resource plays include both shale-gas and shale-oil resource plays. Shale-gas plays include both biogenic and thermogenic systems, but thermogenic systems are by far the most productive. Thermogenic shale-gas plays range from low thermal maturity with modest flow rates (e.g., New Albany Shale, Illinois Basin) to gas window maturity with much higher rates (e.g., Barnett, Woodford, Fayetteville, and Muskwa shales). The highest flow rate systems are hybrid systems where mudstone is intermittently mixed with siliceous, carbonate, or silty lithofacies. Examples of this system type are the Haynesville, Bossier, Marcellus, Lewis, and Montney shales.

Shale-oil plays are mudstone systems containing producible oil (not oil shale systems requiring heating of organic matter). These are subdivided into three system types consisting of highly fractured, hybrid, or mudstone shale-oil plays (e.g., Monterey, Bakken, and Barnett shales, respectively). Bakken tight oil producible reserves are estimated to amount to 5 billion barrels given present day technologies for development.

As need for hydrocarbon resources has escalated, efforts are now underway worldwide to develop shale-gas. Exploration efforts are underway in Europe, Africa, South America, Asia, and Australia-New Zealand.

The purpose of this paper is to provide general characteristics of the existing and potential shale resource plays in North America as well as globally.

Selected References

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Lopatin, N.V., I.M. Kos, S.L. Zubairaev, and T.P. Emets, 2001, Some geological and geochemical prerequisities of oil production from productive reservoirs – US in Ai-Pim-Maslikhov zone of West Siberia: Geology, Geophysics and Production of Oil, v. 6, p. 13-32 (in Russian).

Loucks, R.G., R.M. Reed, S.C. Ruppel, and D.M. Jarvie, 2009, Morphology, genesis, and distribution of nanometer-scale pores in siliceous mudstones of the Mississippian Barnett Shale: JSR, v. 79/12, p. 848-861.

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Worldwide Geochemistry

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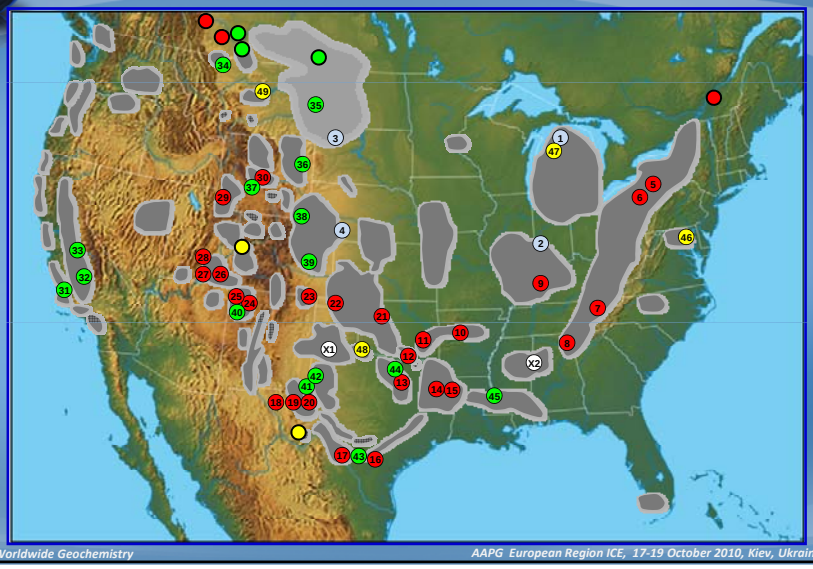
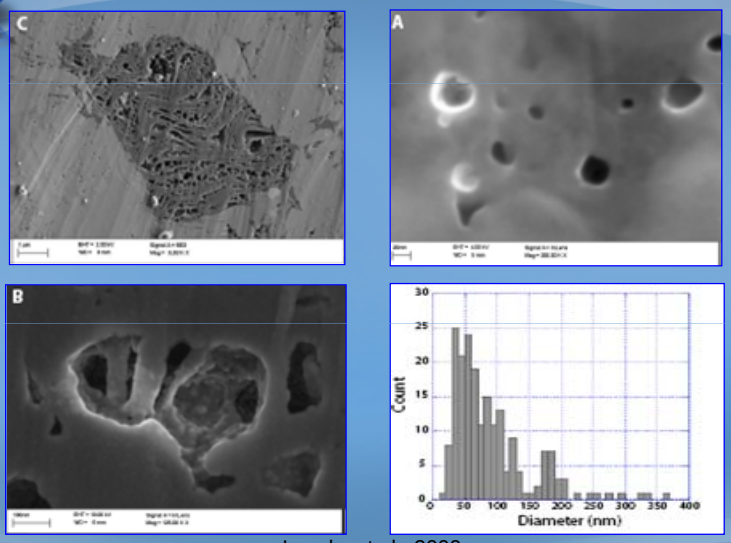
Outline

- Overview of North American Shale Resource Plays
- Evaluation of Shale Gas Potential
- Background for evaluation of oil resource systems
- Geochemical logging of various oil resource systems:
- Worldwide overview
- Summary

US Shale-Gas and Oil Resource Systems

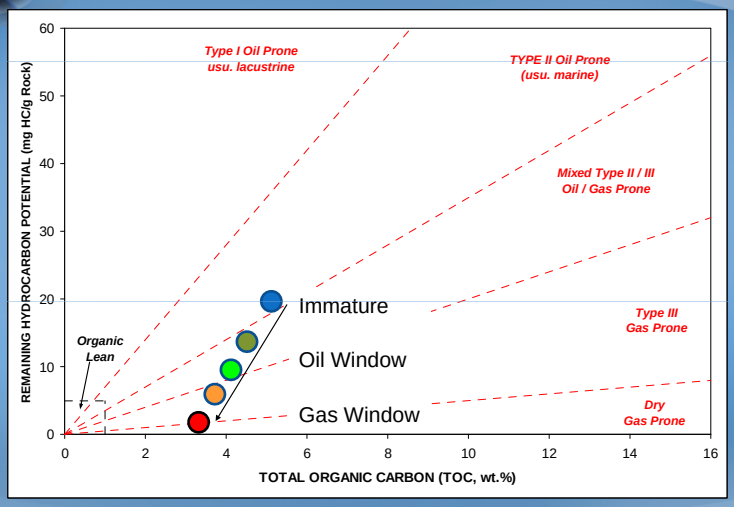


Organic Porosity Development



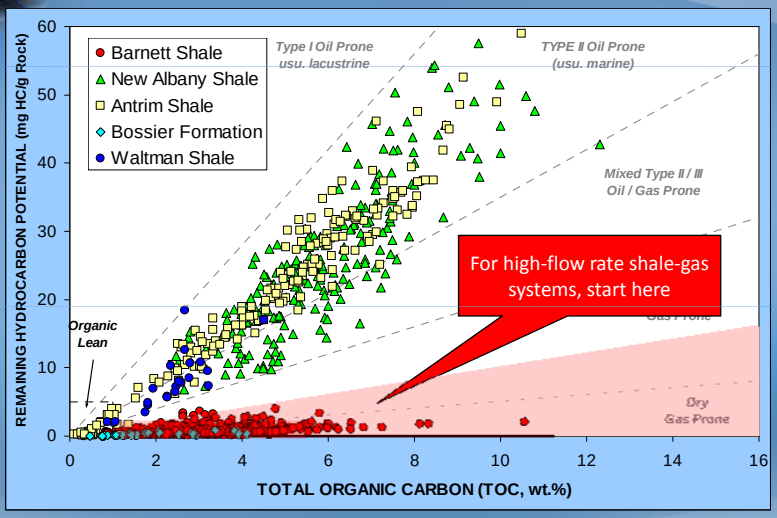
Loucks et al., 2009

Barnett Shale (or any other Type II Marine Shale) Decomposition Trend



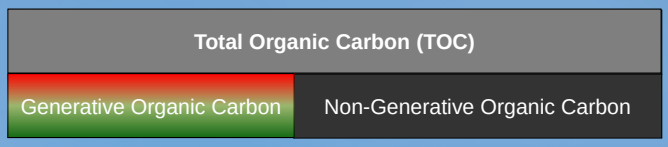
Database of Various Shales:

biogenic, low-grade and high-grade thermogenic gas systems



Total Organic Carbon (TOC) of a shale resource system at high thermal maturity

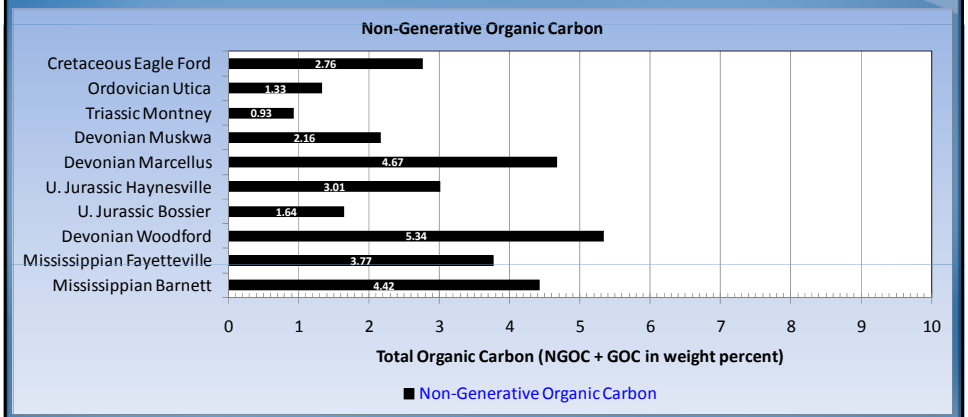
versus original TOC



If the original hydrogen index is known or estimated, the percentage GOC of original TOC can be easily computed, i.e.,

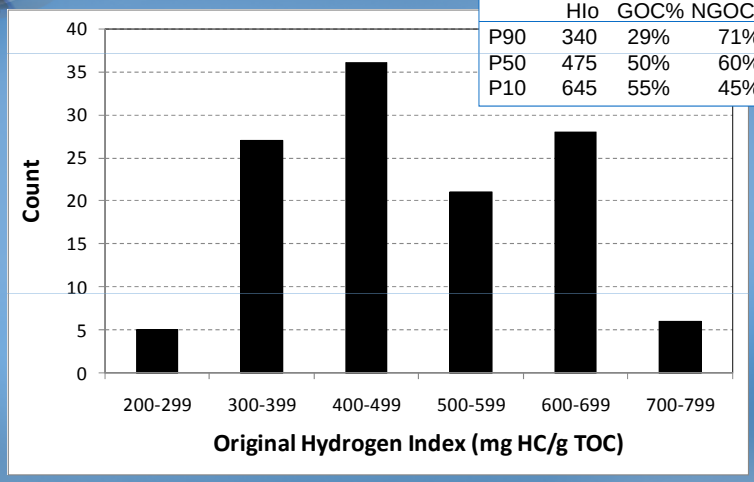
GOC%of TOC = (HIo / 1177) x 100

Top North American Shale-Gas Plays: Present-Day TOC Values

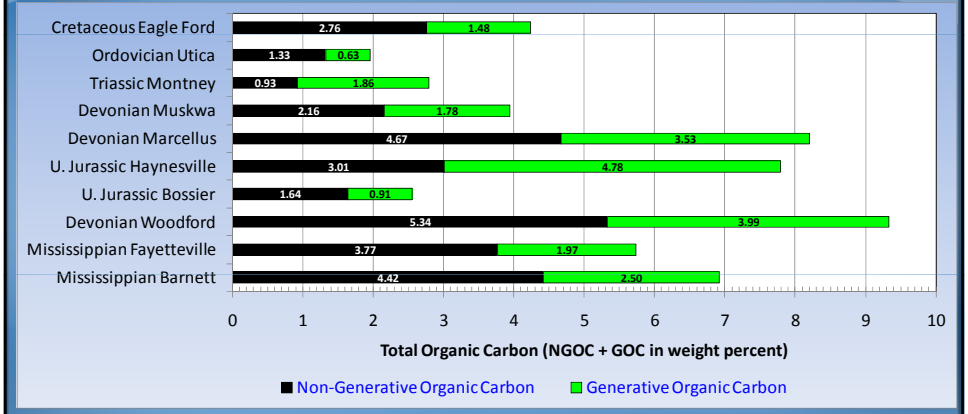


Overall Distribution of hydrogen indices

	HIo	GOC%	NGOC%
P90	340	29%	71%
P50	475	50%	60%
P10	645	55%	45%

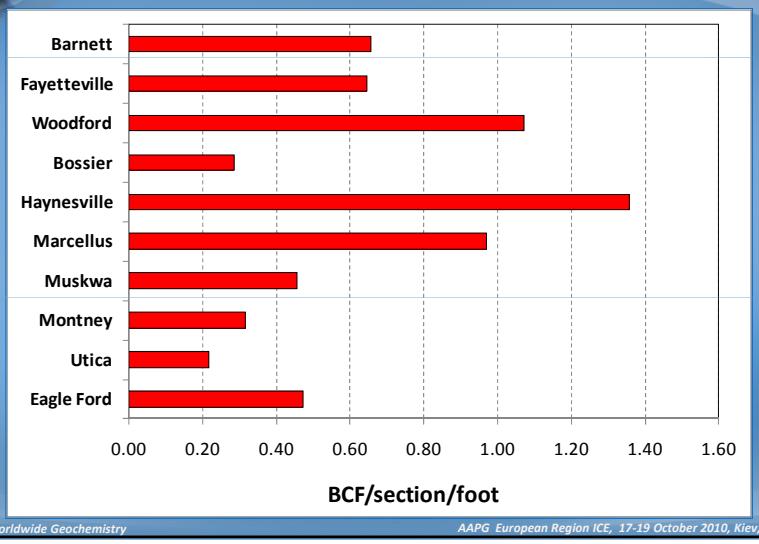


Top North American Shale-Gas Plays: Calculated Original TOC Values



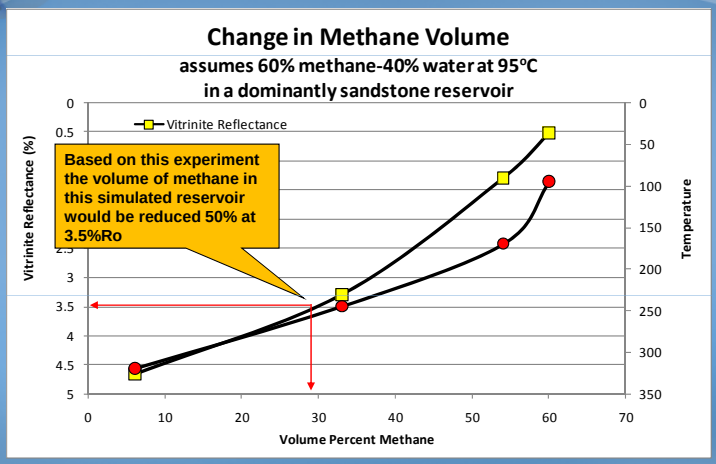
Computations of Retained GIP

(assumes 70:30 oil:gas, HI_o based expulsion percentage, 47% oil to gas)

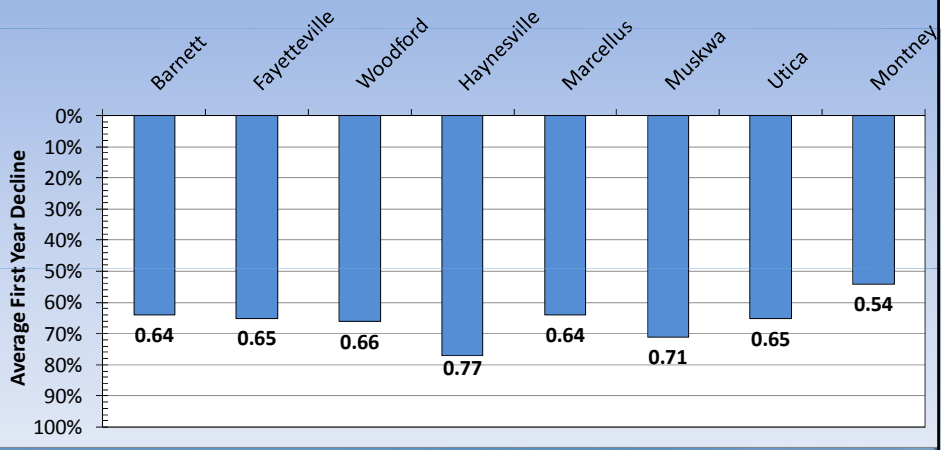


Decrease in Methane Volume

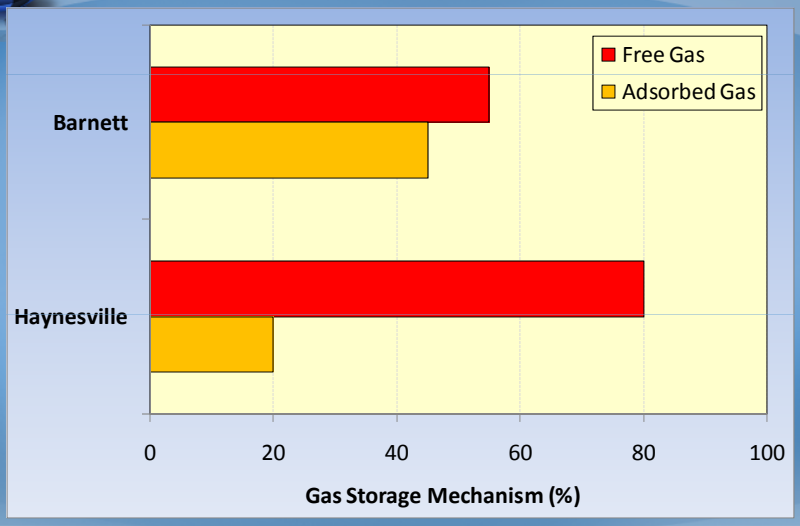
with increasing thermal maturity/temperature



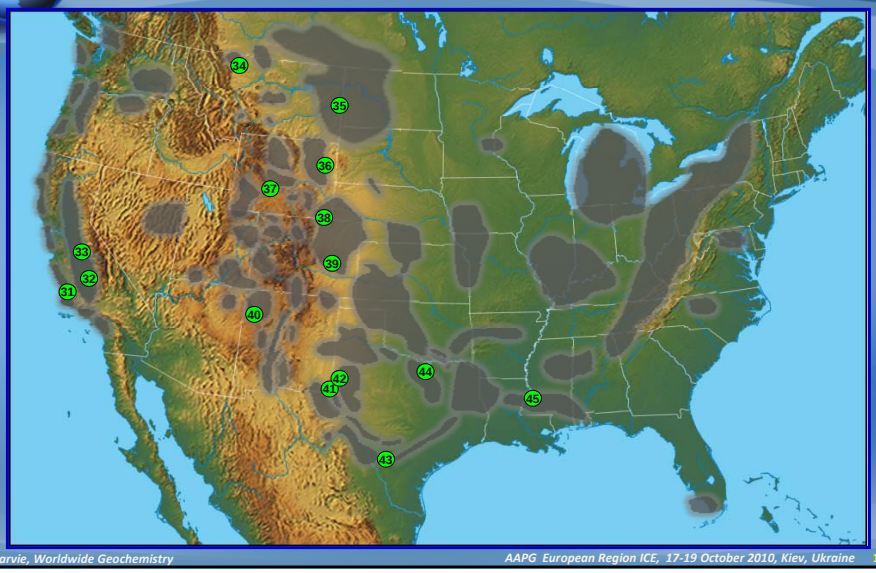
Average First Year Decline



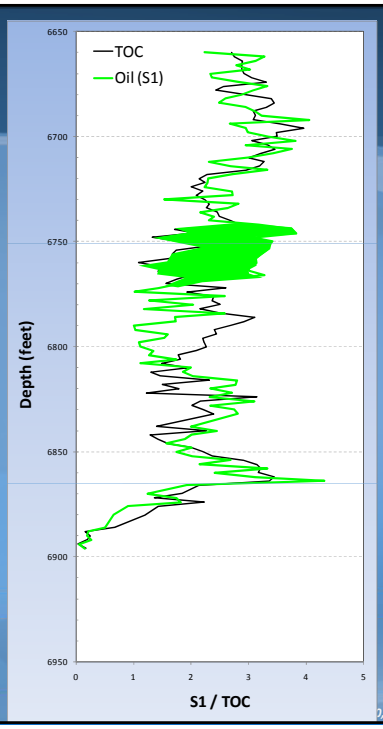
Storage Mechanism Variability:
Impacts Gas Recovery – Rate and Ultimate



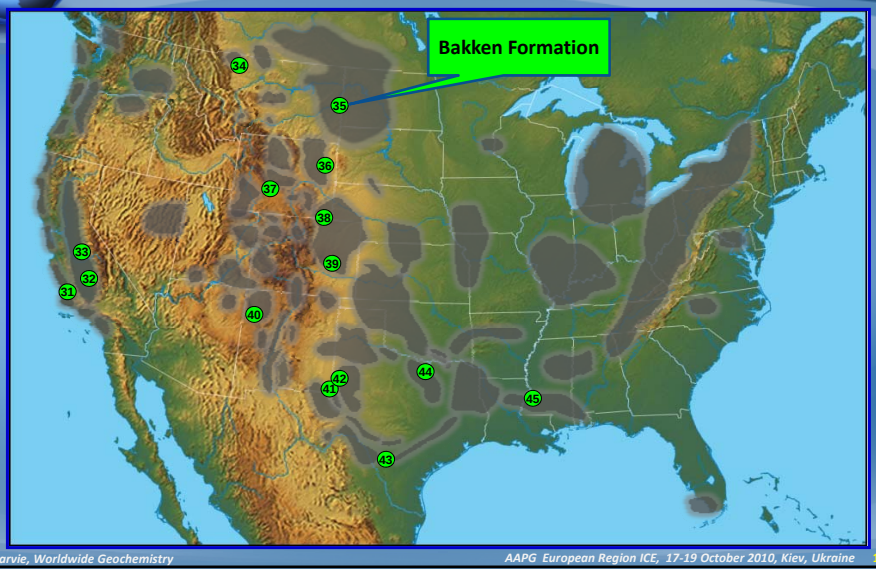
U.S. Oil Resource Plays



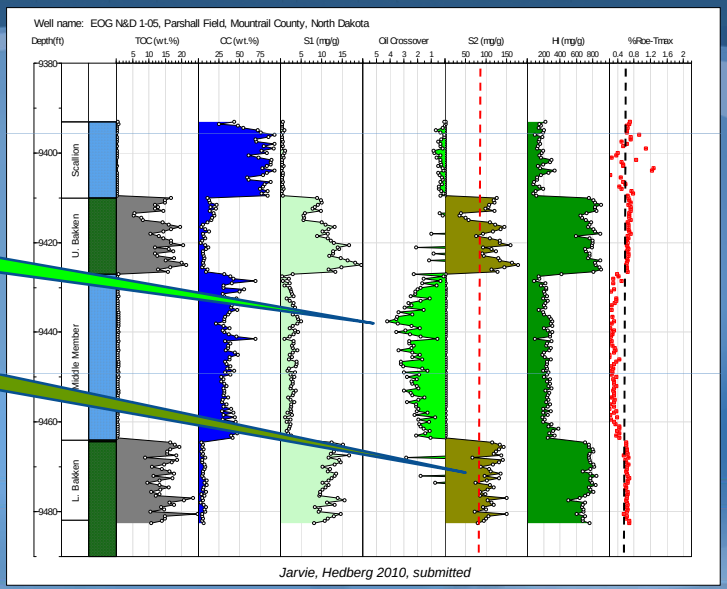
Niobrara Oil Resource Well Showing Crossover



U.S. Oil Resource Systems:
Bakken Formation, Williston Basin



Bakken Formation:
Saturation and Adsorption Indices (SI and AI)



Bakken Shale EUR 5 billion bbls oil
So what is the key??

Carbonate
Shale
Carbonate
Shale
Carbonate

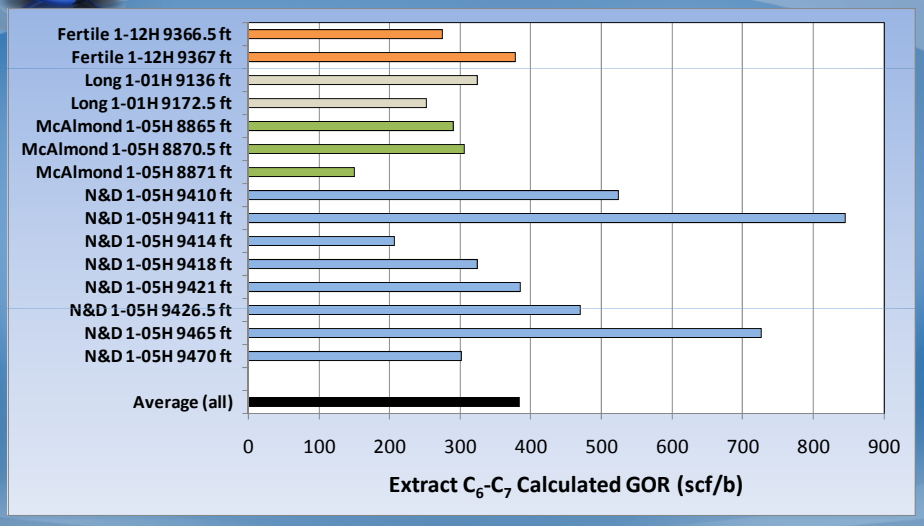
(in some areas, carbonate replaced by silty sand

The "better Oreo cookie" model

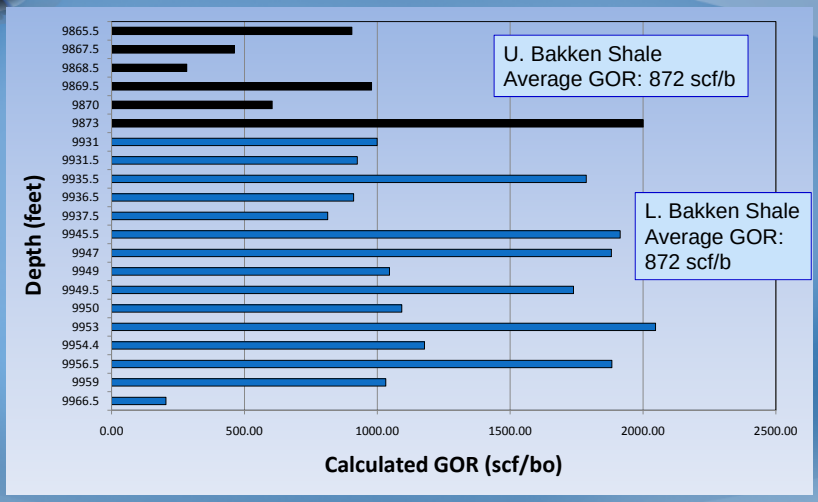
Other shale-oil resource plays showing similar features:

1. Niobrara Shale
2. Eagle Ford Shale
3. Mowry Shale
4. Barnett Shale
5. Monterey, Antelope, and McLure shales

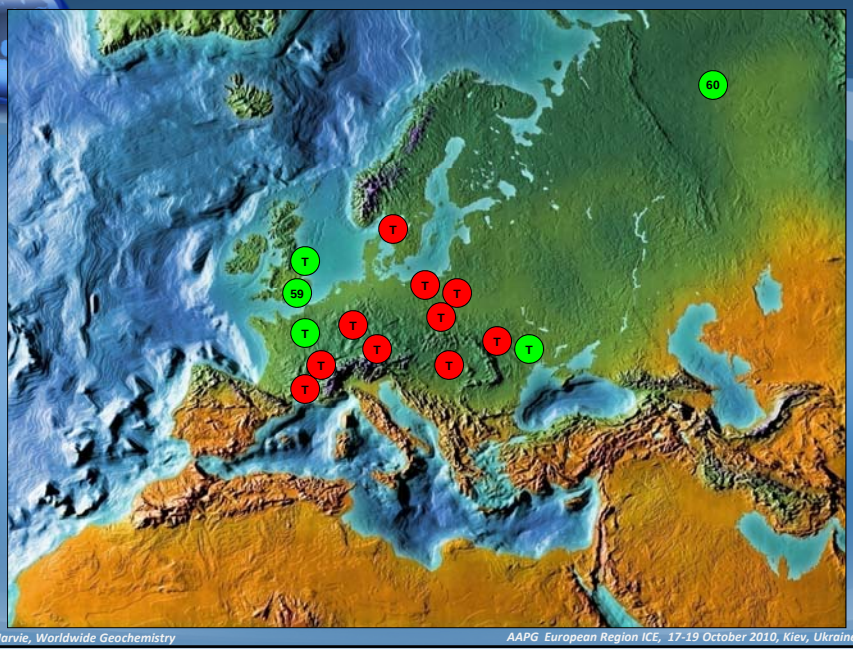
Parshall Field Wells U. Bakken Calculated GOR Values:
Typical Production GOR *ca.* 400 scf/b



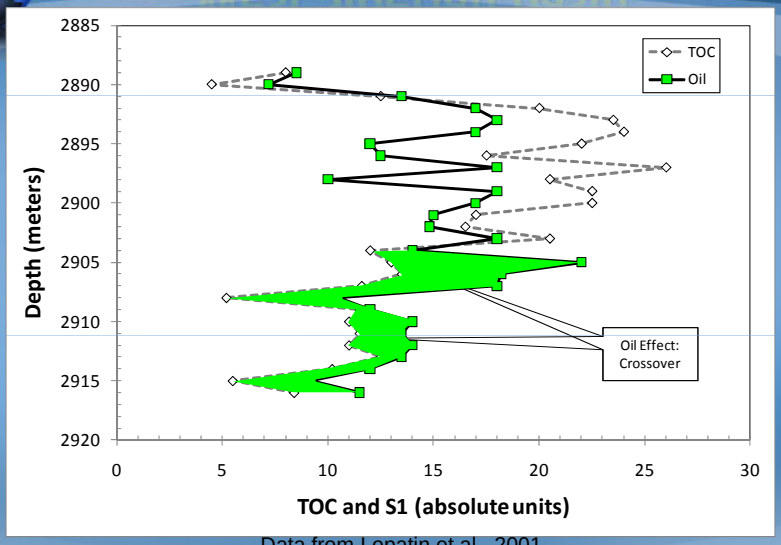
U. And L. Bakken Calculated GORs: Sanish Field



European Shale Resource Plays Underway

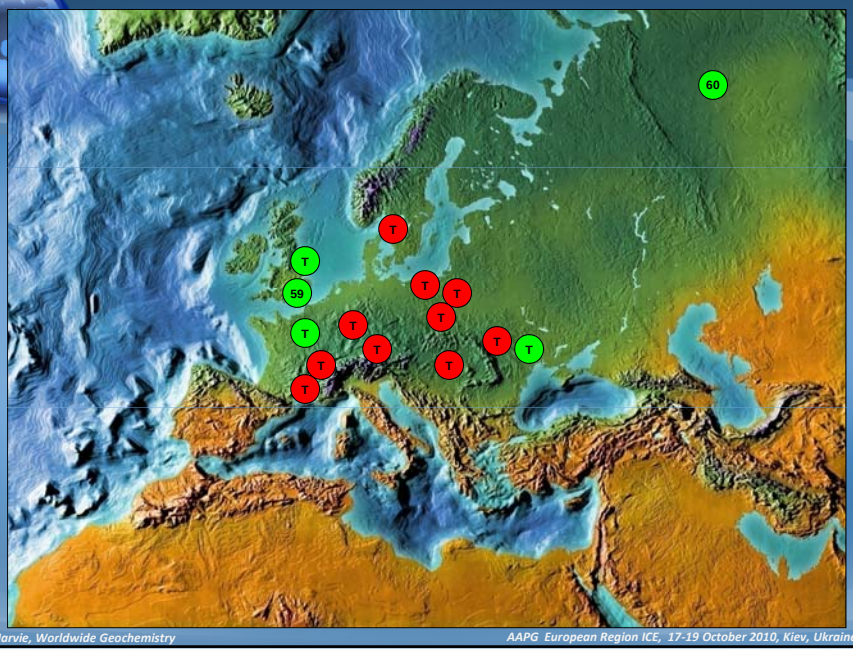


U. Jurassic Bazhenov Shale
West Siberian Basin

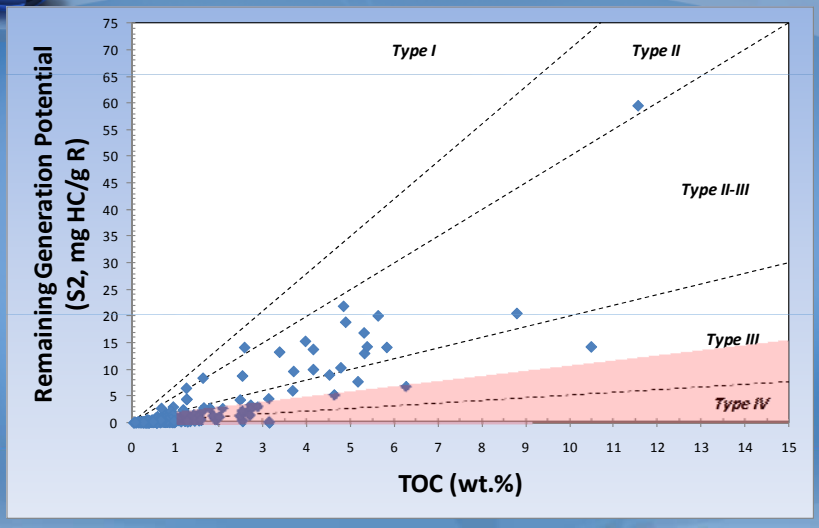


Data from Lopatin et al., 2001

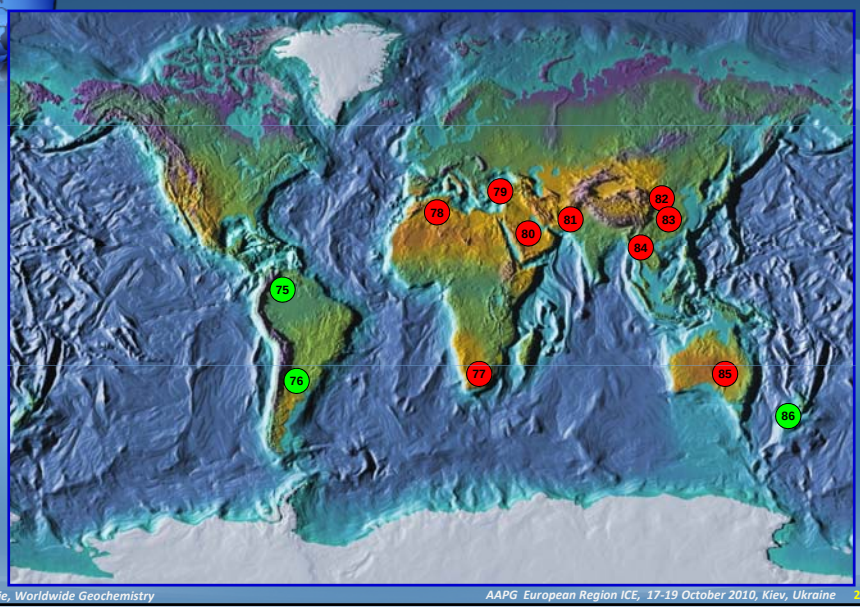
European Shale Resource Plays Underway



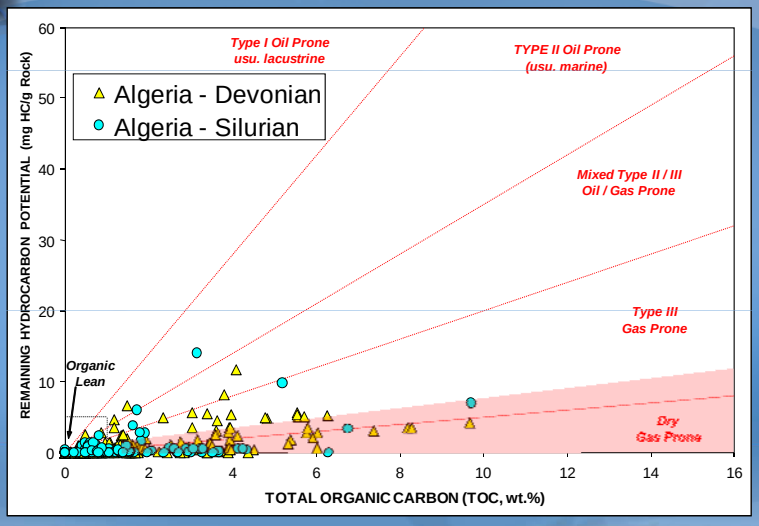
Poland Shale-Gas Potential



Worldwide Shale Resource Activity

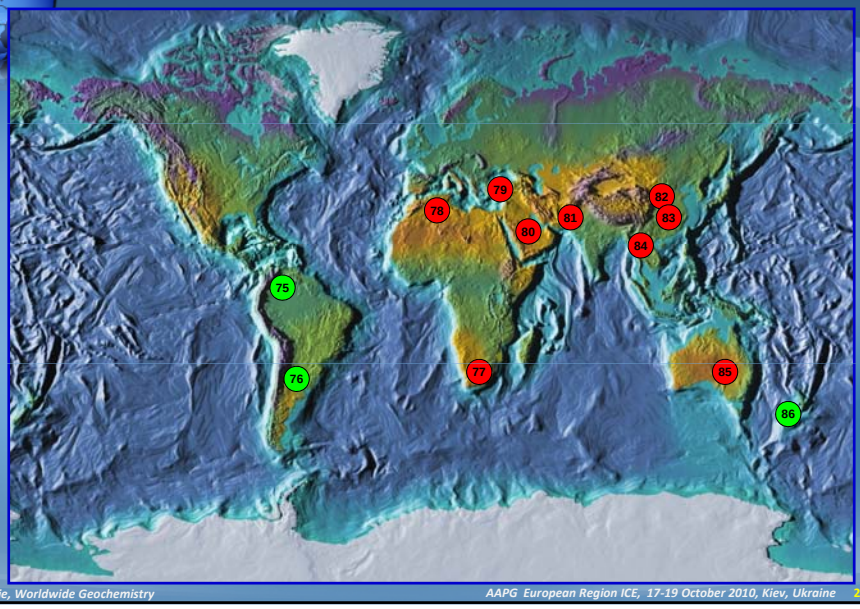


Devonian and Silurian Source Rocks in Algeria

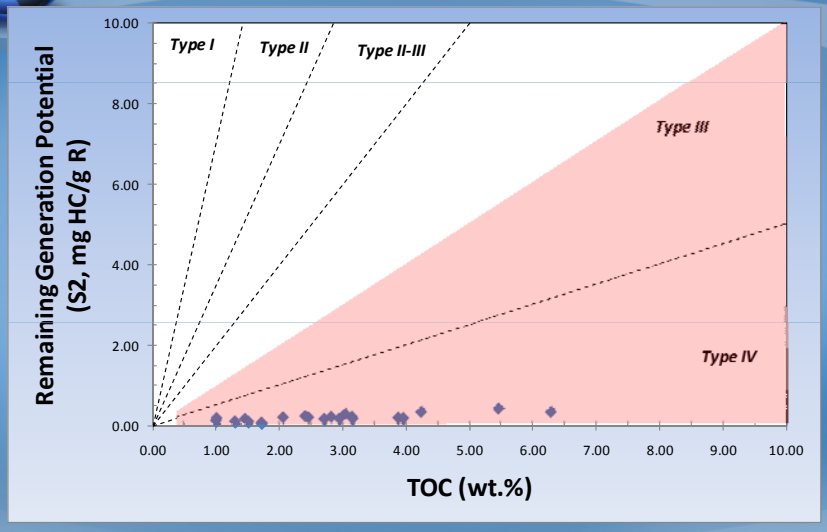


Jarvie et al., 2005

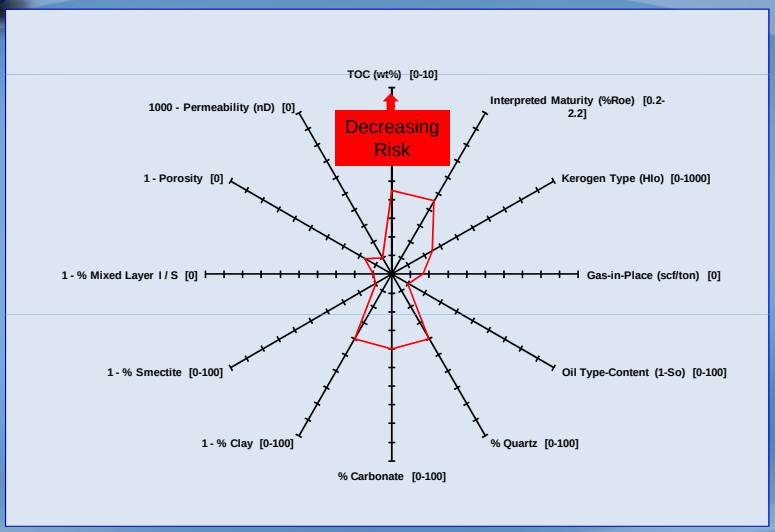
Worldwide Shale Resource Activity



Permian Roseneath Shale



Shale-Gas Reconnaissance Risk Diagram



Summary

- Determining original shale source rock generation potential is valuable in assessing shale-gas potential pre-lease, pre-drill gas-in-place (GIP) values
- "Oil Effect" describes a geochemical crossover whereby the free oil (S1) exceeds TOC in absolute units or over 100 mg HC/g TOC
- Organic-rich, high maturity (1.0-3.0%Roe) source rocks with high quartz content appear to the best candidates for high flow rate shale gas
- Source rocks with high carbonate or in close association with carbonates appear to be the best shale-oil resource systems
- Reconnaissance risk factors include geochemical, geological, petrophysical, stimulation, and logistical issues

Thank you
and
peace be with you !

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