Source Rock Characterization, Development Strategies, and Fracture Complexity: Highlights of Shale Science Research at EGI

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INTRODUCTION

Basin modeling tools are critical in order to simplify and understand petroleum system dynamics for both a regional basin as well as a prospect scale. With modern computer technology advances pushing the limits towards ever finer model resolution in terms of finite element cell size, maximum number of cells and assigned cell properties– model input parameters and calibration data are held to unprecedented levels of scrutiny. As a result, the basin modeling community is increasingly focused on controlling those parameters and datasets in both conventional as well as unconventional model applications.

For the latter, it has become evident that **in-situ problems** truly deserve an **in-situ solution**. This means, that basin modelers and geologists both need to understand and describe sub-surface problems at 'landing zone' scale within a potential source rock or tight shale formation.

RATIONALE & SIGNIFICANCE

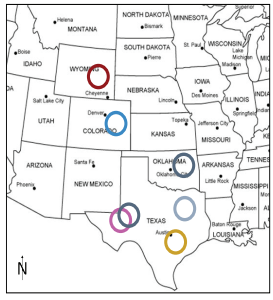
To make sound business decisions for successful exploitation of unconventional resources geoscientists are required to provide an accurate prediction of expected **in-situ fluid type, pressure**, and the **regional extent of the play fairway** along a producing trend as well as away from well control. This process involves a critical revision of workflows and tools used in conventional basin modeling including a long overdue look back at kinetic models.

Kinetic models describe the conversion rate of kerogen (reactive organic matter) to oil and gas and thus form the backbone of any petroleum system model and subsequent assessment. However, existing **generic models** (such as Durand, 1980 and Pepper and Corvi, 1995) **do not capture** the large degree of **variability** in the **composition of organic matter** between different source rocks. The generic default models may lead to incorrect predictions of in-situ hydrocarbon volumes, key fluid properties, and ultimately to poor play fairway delineation.

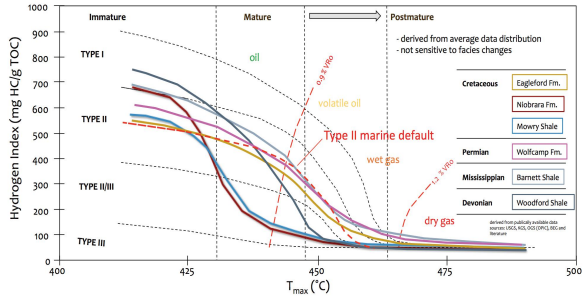
Specialized instrumentation and procedures are needed to accurately measure the kinetic parameters that describe the decomposition of kerogen to oil and gas. We are using the HAWK™ Instrument from Wildcat Technologies to run **bulk pyrolysis** with certain kinetic parameters using KINETICS 2015 (GeoIsoChem Corp., Braun and Burnham, 1994) to **calibrate existing models to North American shale plays**. These measurements provide the basis for robust and reliable fairway predictions from a source rock centric perspective.

In the Calibrated Kinetic Model example from the **Woodford Shale** of the **Anadarko Basin**, we show how an improved understanding of kerogen kinetics can significantly change the prediction of fluid type and the location of the play fairway.

Not all shales are created equal – do not accept the model defaults

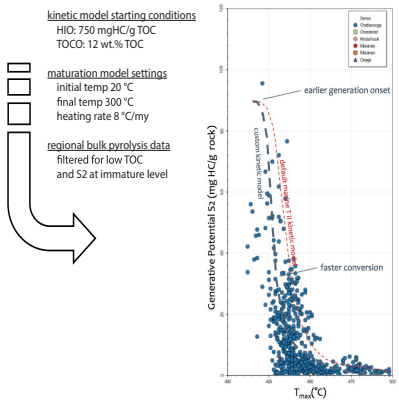


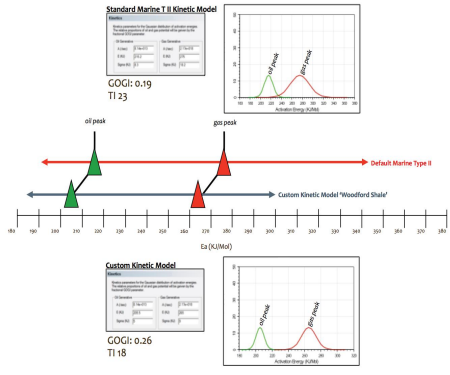
Selection of North American Mid-continent, South Texas and Rocky Mountain Basins marine Type II source rocks

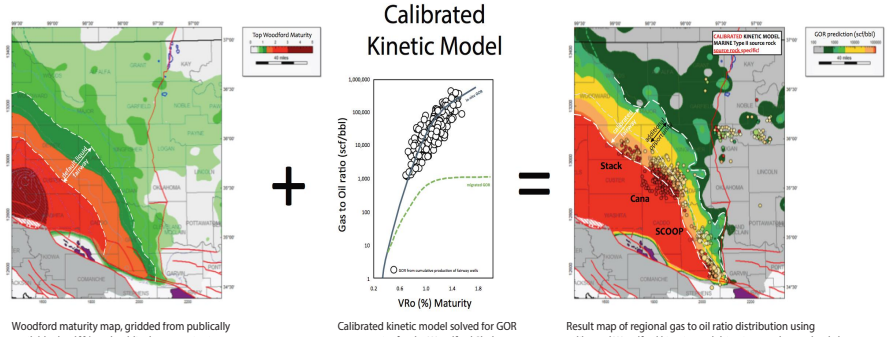


Tmax vs. Hydrogen Index from pyrolysis, illustrating conversion of kerogen to oil and gas with increasing maturity. Despite a strong marine organofacies character present in all of the plotted source rock formations a large variability can be observed in their behavior towards maturity, conversion rates and overall resulting petroleum system timing.

Close-up look at the Devonian Woodford Shale of the Anadarko Basin







Woodford maturity map, gridded from publically available data[1,2,3,4], and public data repositories[a] serves as a basis for kinetic model GOR prediction.

Calibrated kinetic model solved for GOR vs. maturity for the Woodford Shale as an average curve of all available data[5,6] inside and outside of fairway trend.

Result map of regional gas to oil ratio distribution using calibrated Woodford kinetic model, in-situ trends can clearly be illustrated as they appear in stark contrast to migrated fluids east of the Nemaha Ridge. Calibrated fairway indicates liquid window extending into shallower depths.

References

Durand, B. (1980): Sedimentary organic matter and kerogen. Definition and quantitative importance of kerogen; in Durand (ed.) Kerogen, Insoluble Organic Matter from Sedimentary Rocks. Editions Technip, Paris, France.

Braun, R. L., and Burnham, A.K. (1994): KINETICS: A computer program to analyze chemical reaction data: Lawrence Livermore National Laboratory Report, UCRL-ID-21588, Rev. 2, 14 p.

Pepper, A.S. & Corvi, P.J. (1995): Simple kinetic models of petroleum formation. Part I: oil and gas generation from kerogen; Marine and Petroleum Geology, Vol. 12 - 3, 1995, p. 291-319.

Data Resources

1. Cardott, B.J. (1989): Thermal maturation of the Woodford Shale in the Anadarko basin, in K.S. Johnson, ed., Anadarko basin symposium, 1988: OGS Circular 90, p. 32-46.
2. Cardott, B.J., (2012): Thermal maturity of Woodford Shale gas and oil plays, Oklahoma, USA: Int. Jour. of Coal Geol., v. 103, p. 109-119.
3. Comer, J.B. (1992): Organic geochemistry and paleogeography of Upper Devonian formations in Oklahoma and western Arkansas, in K.S. Johnson and B.J. Cardott, eds., Source rocks in the southern Midcontinent, 1990 symposium: OGS Circular 93, p. 70- 93.
4. Higley, D.K. (2011) Undiscovered petroleum resources for the Woodford Shale and Thirteen Finger Limestone–Atoka Shale assessment units, Anadarko Basin: U.S. Geological Survey Open File Report 2011–1242, 3 sheets.
5. OCC Oil and Gas division – historical production data 2013
6. Production data from drilling info website 05.26.2015 url: http://1dhqyu3drpye39jm482ecnjl.wpengine.netdna-cdn.com/wp-content/uploads/2014/01/SCOOP-Woodford-MaxIP.png

a. Public data repositories available data sources: USGS, KGS, OGS, BEG and literature

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