Basin Modeling: A Key Tool For Assessing Unconventional Play

F. Schneider, J.m. Laigle, L. Kuhfuss Monval, P. Lemouzy, P. Jermannaud

a Beicipfranlab, 232, Av. Napoleon Bonaparte, 92502 Rueil-Malmaison, France

paul.jermannaud@beicip.com; frederic.schneider@beicip.com

Copyright 2014, ALAGO.

This paper was selected for presentation by an ALAGO Scientific Committee following review of information contained in an abstract submitted by the author(s).

Summary
The objective is to demonstrate how a basin modeling study can help 1) evaluating of the initial organic matter distribution, type and quality inside a formation, and 2) assessing the present day total organic content (TOC) and maturity level of the formation. These parameters have a first order control on the volume of hydrocarbons generated and still retained in the formation.

We present an improved expulsion model accounting for the retention capacity as a function of maturity.

Introduction
Hydrocarbons are generated from kerogen during the source rock burial thanks to temperature elevation. It can be either of biogenic origin, or of thermogenic origin.

Hydrocarbons composition and volumes generated and retained depend on the initial organic matter properties and maturity. In the past, expulsion models were designed in order to quantify the expelled amounts. These models have to be revisited and improved in order to better quantify the retained gas/oil.

The retention capacity is tightly linked to the TOC content, the organic matter type and the maturity. Hydrocarbons can be stored in source rocks by adsorption and as free hydrocarbons inside the porosity.

There are two types of porosity in mature source rock that represent a storage place for hydrocarbons:

1/ Effective porosity inside non-organic rock fraction. The evolution of this porosity vs. depth is controlled by burial and possible diagenetic phenomena.

2/ Porosity inside the organic matter itself. This porosity is created consequently to the loss of kerogen mass resulting of the transformation of organic matter into hydrocarbons.

Accurate compositional kinetic parameters for kerogen thermal decomposition are key elements in this kind of study to predict the hydrocarbons fluids quality and type as a function of maturity. IFP kinetics schemes have proven to provide accurate and describe reactions scheme, that able to predict early or late gas. A solution for modeling biogenic gas has also been proposed.

The modeling of hydrocarbons generation allows estimating the mass loss in the kerogen and the organic porosity consequently
created as a function of maturity.

Gas adsorption potential on organic material is calculated using a Langmuir model implemented within the simulator which takes into account spatial distribution of pressure, temperature, and remaining TOC.

The effective porosity in the shale matrix is estimated from log analysis, using a methodology that allows correction from the effect of organic matter.

The integration of these tasks allows estimating the retention the formation, accounting for shale effective and organic porosity and adsorption capacity depending mainly on TOC distribution and decreases with maturity.

The Gas Initially in Place (GIIP) can then be directly deduced from the basin modeling simulation results, as a function of this retention capacity. The numerical model computes a GIIP value at play scale and gives also access to spatial variations of gas distribution.

Using experimental design and response surface-based methodology, the calculated GIIP may be risked as a function of the uncertainty associated to the values of some key input parameters. GIIP percentiles are then computed (P10, P50 and P90).

Examples
The methodology has been successfully applied in various worldwide formations, in Algeria, Sudan, Argentina, or even United States.

Figure 2. Workflow used to assess shale gas potential

Conclusions
The methodology presented allows estimating the hydrocarbons retention capacity of the formation and the composition of hydrocarbons still retained. These properties can vary significantly laterally and vertically, and that the shale gas potential of a formation can then not be simply deduced from a local evaluation that would be extrapolated throughout the basin. Shale development presents huge opportunity and faces large geological uncertainty. Innovative tools and methods are key to diminish the geological risk from resource evaluation to optimal well development.

Basin modeling play a key role in the shale evaluation process as it allows integrating all knowledge into a consistent and comprehensive model, from early stages of exploration to pilot zone identification. Large research effort is still required to understand and to quantify the physical processes that occur in shaly organic matter (retention, adsorption, diffusion).

References

