Derisking of Unconventional Gas and LTO Opportunities: Application of Basin Modelling*

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Abstract

Unconventional Light Tight Oil (LTO) and shale gas (SG) plays are self-charged systems, relying on the indigenous organic matter as the source of hydrocarbons. The fine-grained organic rich sediments or tight layers in their vicinity act with their residual pore space as the reservoirs. Pressure and temperature can significantly increase during burial and even more decrease during erosion and uplift. These changes strongly influence the phase behaviour of the generated and trapped hydrocarbons thereby affecting their flow properties, potential migration routes, retention capacity of the source rock, and predicted volumes initially in place (Figure 1). Shell's integrated Cauldron Shale Gas Simulator calculates resource density on a regional to basin scale, typically during the opportunity identification and screening phase. Informed decision-making in exploring for such unconventional opportunities relies on integrating all available (i.e., sometimes scarce) data and their associated uncertainties for basin scale physical elements and processes into a working geologic model.

Introduction

Successful exploitation of shale gas opportunities depends on 1) resources in place, 2) favourable geomechanics, and 3) use of appropriate production technology to optimize rates and ultimate recovery. Unique characteristics of gas storing shales are that they are both source and reservoir at the same time, and require no structural or stratigraphic trapping mechanism to retain the gas. The generated hydrocarbons are stored in the very tight pore network of those rocks in very close vicinity to where they were generated in the first place. In this context and for a proper resource estimate, the properties of initially formed petroleum from the kerogen and its PVT behaviour through time and space are amongst the most critical elements. This is particularly relevant in basins, which have experienced significant geological uplift, associated erosion, and have thus undergone pressure and temperature changes in the pore network since the hydrocarbon generation. The impact is major since mechanisms such as phase separation and/or fluid expansion can dramatically change the volume and the properties of the originally stored fluids , i.e., at the time and conditions of original hydrocarbon charge.

Discussion

Basin modeling is a well-known simulation technique and has been successfully applied to basins in the exploration for conventional petroleum systems. Two of the main goals of modern basin modeling are:

- contribute to identifying the areas of highest resource density
- account for the highly variable character of gas storing shales and unconventional plays around the world.

This in turn will help to de-risk potential unconventional gas and oil opportunities.

The limited availability of basin simulators capable of handling unconventional petroleum systems is essentially because the processes and conditions predominating in unconventional petroleum systems and taking place within the tight pore system during the continuous burial (and uplift) are not well understood to this date. Shell's shale gas simulator adds functionality to conventional basin modeling which is specifically tailored to the requirements of unconventional petroleum systems. This includes detailed modelling of the timing of oil and gas generation, of the origin and type (i.e., free vs. sorbed gas, liquids) of products generated within the pore network and the behavior of those products in a dynamic system with changing pressure and temperature conditions. The role of the organic matter for (a) generation of additional pore space during maturation and (b) as a supplier for additional storage capacity in shale gas settings is still a matter of investigation and the subject of an ongoing research effort.

Summary

The capabilities and fields of application of the Cauldron Shale Gas Simulator are demonstrated on case studies from the Barnett Shale (US) and Lithuania (Figure 2). In the case of the Forth Worth Basin, the areas with highest oil saturation were calculated by the simulator and show a good qualitative match to published locations of "shale oils wells". The Lithuanian example shows how the simulator was used to de-risk a LTO play and significantly influence the country entry decision.

Reference Cited

Pollastro, R.M., 2007, Total petroleum system assessment of undiscovered resources in the giant Barnett Shale continuous (unconventional) gas accumulation, Fort Worth Basin, Texas, *in* R.J. Hill and D.M. Jarvie, (eds.), Special issue; Barnett Shale: AAPG Bulletin, v. 91/4, p. 551-578.

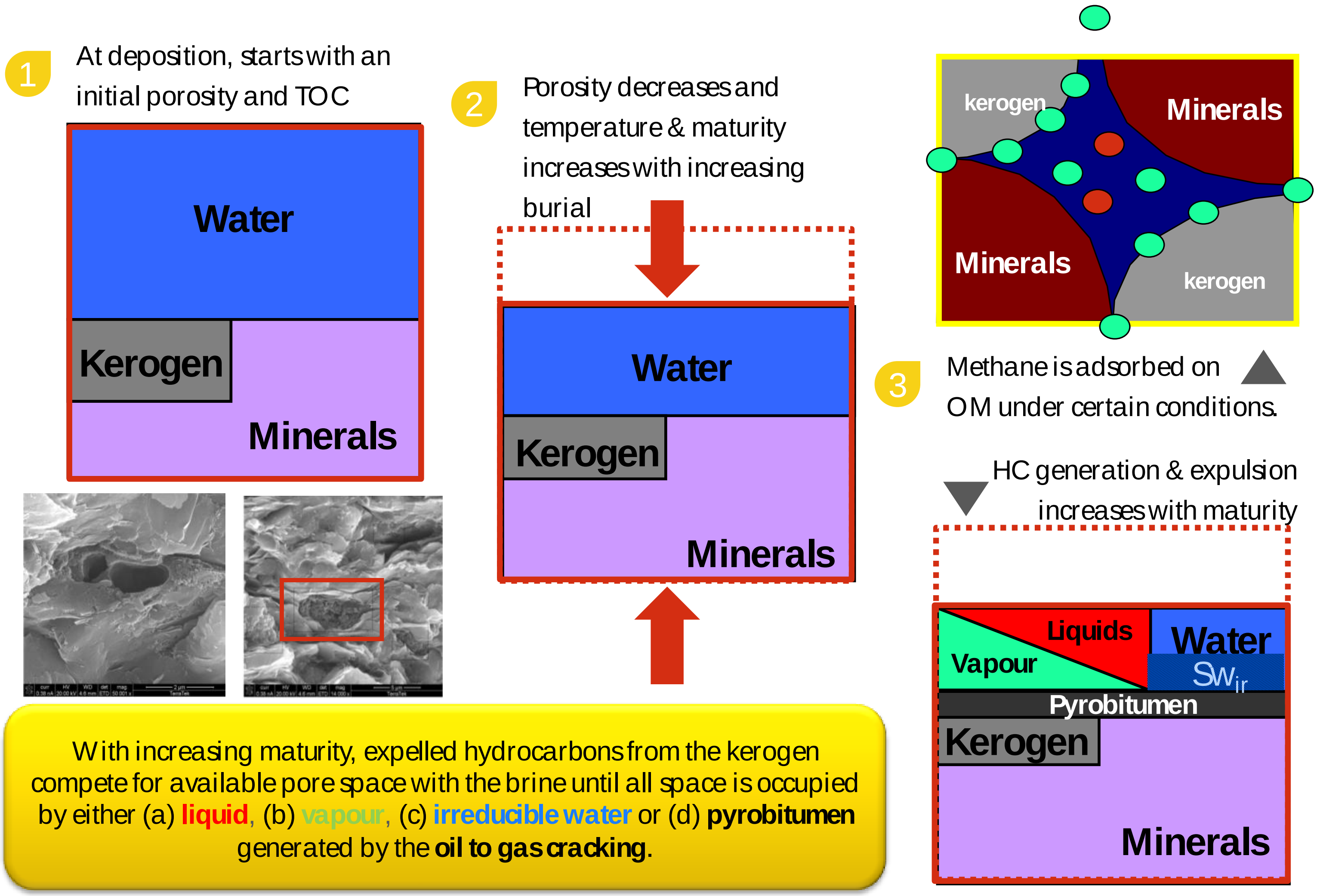

Figure 1. Processes taking place in a pore during continuous burial and maturation.

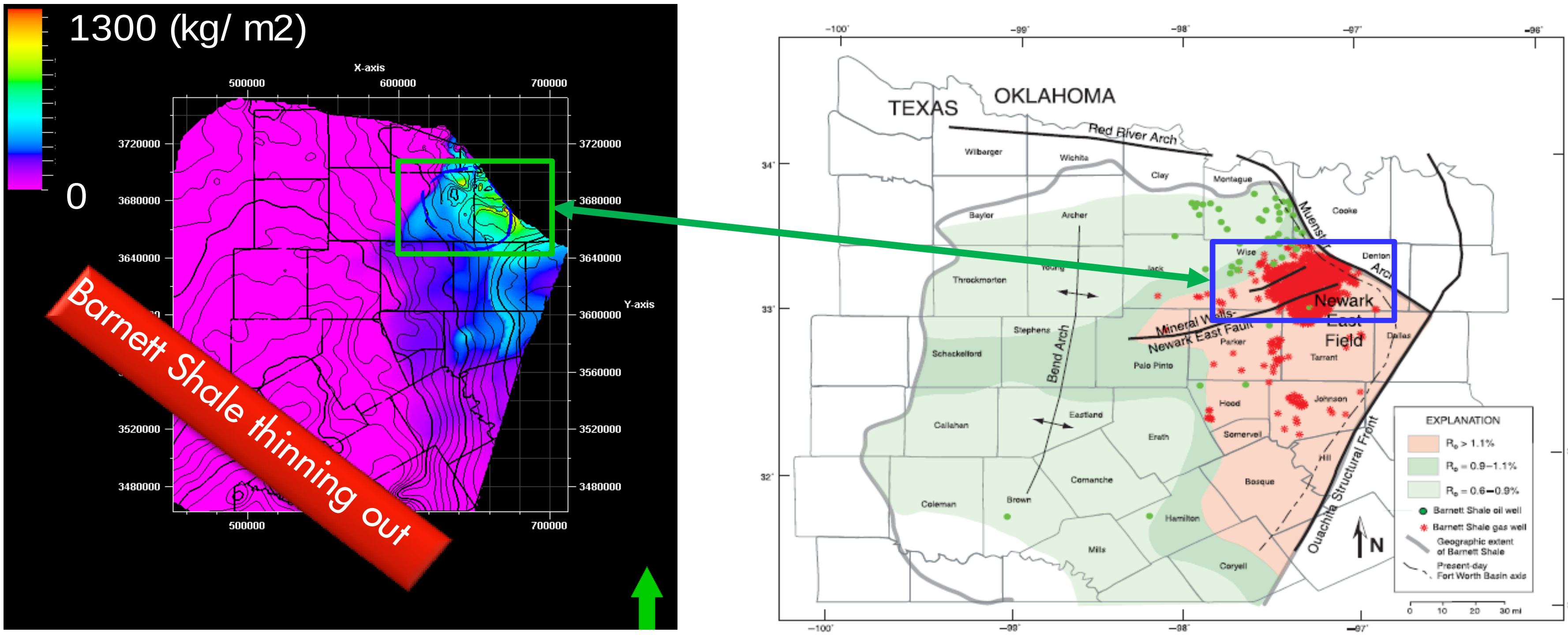

Figure 2. Highest gas content in the basin model (left) compared to areas with highest density of shale gas wells in the Barnet Shale of the Fort Worth Basin, Texas (Pollastro, 2007).