Some of My Source Rocks are Now Reservoirs—Geological and Petrophysical Characterization of Organic-Rich Rocks

Q. R. Passey, K. M. Bohacs, M. Rudnicki, S. Sinha, O. R. Lazar, and W. L. Esch
ExxonMobil Upstream Research Company
quinn.r.passey@exxonmobil.com

Abstract

A spectrum of combinations of rock and hydrocarbon properties in fine-grained rocks can result in commercial production, effectively spanning conventional 'tight oil' to 'shale-gas' reservoirs. Most currently producing 'shale' reservoirs are mature to overmature oil-prone source rocks. Through burial and heating, these reservoirs evolved from organic-matter-rich mud. Their key characteristics include: total organic carbon (TOC), thermal maturity level, mineralogy, organic matter type, geomechanical properties, and thickness.

The accumulation of organic-rich rocks (ORRs) is a complex function of many interacting processes that can be summarized by three main control variables: rate of production, rate of destruction, and rate of dilution. The marine realm includes three physiographic settings that accumulate significant organic-matter-rich rocks: constructional shelf margin, platform/ramp, and continental slope/basin. In general, the fundamental geologic building block of shale-gas reservoirs is the parasequence, or its equivalent, and commonly 10's to 100's of parasequences comprise the organic-rich formation whose lateral continuity can be estimated using techniques and models developed for source rocks.

Shale-oil reservoirs share many attributes with shale-gas reservoirs, but also have some distinct differences. Key additional dimensions include fluid properties, especially hydrocarbon density, viscosity, and phase. Over geological time, fluid density and phase control fluid saturation in the matrix, and in the short term, viscosity and phase affect flow and production rates. Hence, two main classes of attributes affect ultimate 'shale' reservoir performance: rock properties (mainly permeability) and fluid properties (mainly viscosity).

The higher thermal maturities of 'shale-gas' reservoirs result in some contrasts with 'shale-oil' reservoirs: they tend to have less smectite (inter-layer water) due to illitization, but develop significant porosity associated with kerogen and bitumen. SEM images of ion-beam-milled samples reveal development of a distinct separate nanoporosity system contained within the organic matter, in some cases comprising >50% of the total porosity, and these pores tend to be hydrocarbon wet, at least during most of the thermal maturation process.

Appreciation of the similarities and differences between 'shale-gas' and 'shale-oil' enables more efficient, effective, and economic exploitation of the full range of resource types.

Datapages/Search and Discovery Article #90212 © AAPG Geoscience Technology Workshop, Expanding Unconventional Resources in Colombia with New Science-From Heavy Oil to Shale Gas/Shale Oil Opportunities, Bogota, Colombia, December 10-11, 2014