My Source Rock is Now My Reservoir - Geologic and Petrophysical Characterization of Shale-Gas Reservoirs

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Oil-prone source rocks comprise sediments that are rich in organic carbon and contain organic material sufficiently hydrogen rich to convert mainly to oil during thermal maturation. The organic materials that are generally the richest in hydrogen include marine plankton, freshwater algae, spores, pollen, leaf cuticle, tree resin, and anaerobic bacteria. All of these materials are initially oil prone and are classified as Type I or II kerogen. Within the last decade, there has been a large industry drilling program aimed at producing gas from shale lithologies (i.e., "shale-gas" reservoirs). These unconventional gas reservoirs often are highly overmature oil-prone organic-rich fine-grained rocks.

Key characterization parameters of shale-gas reservoirs include: total organic carbon (TOC), maturity level (vitrinite reflectance), mineralogy, thickness, and organic matter type (OMT). Recent studies indicate that although organic-rich shale-gas formations may be hundreds of meters in gross thickness (and may appear largely homogeneous), the vertical variability in the organic richness and mineralogy can vary on relatively short vertical scales. The vertical heterogeneity observed can be directly tied back to geologic and biotic conditions when deposited. 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.

Well logs can be used to calculate TOC, porosity, and hydrocarbon saturation. The use of high-resolution standard logs and borehole image logs enhances the interpretation of vertically heterogenous shale-gas formations. The nature of the porosity in many shale-gas formations appears to be different from conventional siliclastic reservoirs, where porosity is typically intergranular; with shale-gas formations, much of the porosity is contained entirely within the organic matter. SEM images of ion-beam-milled samples reveal that this nano-porosity system contained within the organic matter can comprise ~50% of the total porosity in these rocks, and 3D serial sectioning indicates that many of these organic pores are interconnected; moreover, much of the in-place gas appears to be associated with the organic-rich intervals. The relationships between the pores in the organic material and maturity, organic-matter type, gas saturation, and permeability remain under study.