3-D Visualization and Classification of Pore Structure and Pore Filling in Gas Shale

Michael Suhrer, Elizabeth Diaz, Avrami Grader, and Carl Sisk
Ingrain, inc., Houston, TX.

Little is known and understood about two key parameters in gas shales: the gas-filled porosity and permeability. Digital rock physics technique, presented in this paper, contains three basic steps: (a) 3D CT imaging at 200 nanometer resolution, and/or FIB-SEM (focused ion beam combined with SEM) imaging at 3-15 nanometer resolution (b) segmentation of the digital volume to quantitatively identify the components, including the mineral phases, organic-filled pores, and free-gas inclusions; and (c) computations of TOC (Total Organic Content), porosity, pore connectivity, and permeability. A number of gas shale samples have been used, to specifically analyze the pore systems, including dual porosity, organics distribution, gas-filled porosity distribution, and how these properties relate to the maturity of the organic material. Pore geometries (pores filled either with organics or free gas) of these samples fall into the following categories: (a) relatively large (up to 4 micron) poorly disconnected pores; (b) such pores connected by very thin (down to 15 nanometers) conduits; (c) dual porosity system where the large pores are interconnected by large conduits and very thin conduits are interconnected and also connected to the large pores. Within each of these three categories, the pore space may be (a) completely filled with organics or (b) partially or completely filled with gas. The latter is of most interest as it is a gas source. In such systems we observe various geometries of pore space, including (a) disconnected pores floating in the organics and (b) connected pores within the organics. TOC, open pore volumes, as well as pore-space connectivity are not just qualitatively estimated from the images but quantitatively computed for a given sample. Our ongoing effort is to relate the quantitative patterns thus computed to the maturity of shale.