From Core to Pore: Multi-scale, Multi-dimensional characterization of fine-grained reservoir rocks

Eric T. Goergen[1], Kimball Skinner[1], Herman Lemmens[2] and Aukje, Benidictus[3]

[1]*FEI, Hillsboro, Oregon, USA*
[2]*FEI, Eindhoven, Netherlands*
[3]*FEI, Brisbane, Queensland, Australia*

Abstract

Mineralogy and microstructure are key variables defining the physical properties of a rock. Rocks that have a heterogeneous mineralogy/microstructure will exhibit equally heterogeneous physical properties. Shale typically displays significant mineralogical and microstructural variation. Quantifying shale mineralogy and microstructure permits more accurate determination of a variety of physical properties important to modeling production potential: e.g. organic versus inorganic porosity, permeability, brittleness etc…

The microstructural elements that define properties of interest for a typical shale exist over 9 orders of magnitude in length-scale (nanometer to meter). Therefore, a main challenge exists in upscaling mineralogical and microstructural observations in a way that provides characterization of nanometer-scale observations that are representative of the rock at centimeter to meter-scales.

Three recent technological advances have paved the way for routine, accurate microstructural characterization from the nanometer to meter scales: Ultrahigh resolution scanning electron imaging, automated mineralogy and 3D imaging (X-ray computed tomography (CT) and FIB/SEM analysis). When combined, data from these sources can be used to quantify shale at a resolution that is only now possible.

We present examples of integrating multi-scale 2D and 3D electron imaging with proven automated mineralogy algorithms to more accurately evaluate the mineralogy/microstructure of shale and other fine-grained reservoir rocks. This multi-scale multi-dimensional workflow also provides a pathway for upscaling observations in a repeatable and quantifiable way. Integration of mineralogical and microstructural data provides a unique opportunity to evaluate shale and other fine-grained reservoir systems with unparalleled fidelity.