Image-based Characterization of Carbonate Mudrocks to Link Nano-scale Pore Characteristics to Thermal Maturity


Abstract

Objectives/Scope: The organic-rich carbonate mudrocks that compose some unconventional reservoirs consist of inorganic minerals and organic bodies, both containing pores that store and transport fluids. After initial burial, these organic bodies thermally mature to produce pores that contain hydrocarbons. As maturation continues, additional hydrocarbons are produced and those generated earlier are cracked to lighter hydrocarbons which changes porosity and pore morphology. Measurements of thermal maturity, porosity, and pore characteristics can help assess reservoir quality during exploration.

Methods, Procedures, Process: Whole core was collected from several wells and sub-sampled for pyrolysis, bulk porosity, and imaging. Pyrolysis measured the TOC, hydrogen index (HI), production index (PI), and Tmax. The bulk porosity of the sample was measured as received and after cleaning using the Gas Research Institute Method (GRI). Large field-of-view SEM images (LgFOV) were collected. Following stitching, a non-local means filter was applied, and the images were segmented using a commercially available supervised machine learning tool to isolate the pores. Post-processing was completed to correct for mislabeled components and generate a cleaned binary LgFOV pores image (LgFOVp).

Results, Observations, Conclusions: This paper presents an integrated study linking thermal maturity to porosity, pore size distribution, and pore characteristics. Pore sizes and shape features were extracted for each pore in the LgFOVp image using an in-house code developed in MATLAB. The averages and distributions of the image-based porosity, pore size, and pore shape features are compared across several wells within the same basin and for multiple samples collected at different depths within each well. Given the large variation in resolved pore sizes, the in-house tool also separates the pores by user-defined equivalent circular pore diameter (dp) groups and writes labeled images (LgFOVp,lbl) of the pore groups for finer inspection. Results will be presented comparing thermal maturity and bulk porosity to the image-based porosity and pore characteristics using samples of varying thermal maturity to develop correlations between these properties.

Novel/Additive Information: By integrating the results from pyrolysis, bulk porosity, and image-based porosity, the PSD and pore shape characterization from many samples within a single well and across many wells can be mapped within a basin, improving the fundamental understanding of pore development and generating new models to guide exploration and development decisions.