

Multi-Scale Digital Rock Analysis of Porosity and Organic Matter in the Appalachian Basin, USA

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ABSTRACT

This study was based on core plugs from multiple formations within the Appalachian Basin. Data for integration include bulk rock porosity, LECO TOC measurements, and multi-scale SEM-based digital rock analysis (DRA) to show a comprehensive view of the rock properties within each of the five different formations; Rhinestreet, Genesee, Burket, Hamilton, and Marcellus. Applications include upscaling micro-pore scale DRA reservoir properties to GRI crushed sample and bulk rock TOC, leading to improved reservoir estimation. The primary goal was to provide an in depth look at porosity-typing at SEM-scale to better evaluate depths for further analysis and “sweet spots”. We observed good agreement between bulk rock data and digital rock analysis with respect to organic matter volume. Multiple resolution imaging was key in matching porosity visible in SEM with porosity from GRI crushed rock analysis. DRA quantifies the effective porosity, which can be used for better reservoir estimation, while the remaining porosity not visible with SEM is primarily occupied by clay-bound water. While the GRI method measures total porosity, only DRA can give separate results for organic porosity and intergranular porosity. The main technical contributions of this work were; 1. Understanding the relationship between different analytical techniques and how each can better contribute to the integration of whole well analysis at multiple scales. 2. Resolved differences between traditional lab core data and DRA data to provide the industry with more comprehensive study on porosity, in particular different pore types and how each can contribute to the reservoir system. 3. Established that while total porosity can be measured with traditional core analysis methods, it is also important to distinguish the effective porosity, and the porosity associated with organic matter, which is a major contributor to oil and gas in-place volumes. 4. Within a small stratigraphic interval the positive correlation between total organic-hosted porosity and total organic content (TOC) was shown to have limits. A smaller pore size and different pore morphology exist in higher TOC intervals and points to relative differences in organic conversion within samples of similar thermal maturity.