Digital Rock Physics Reveals Link between Reservoir Quality and Pore Type in Eagle Ford Shale

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Hydrocarbon production from source rocks is dependent on the type, quantity, and connectivity of the pore space within the rock matrix. Loucks (2010) has identified three main pore types in mudstones; kerogen, intra-granular, and intergranular. The objective of this work was to observe and quantify how the predominant pore types affect porosity and permeability and how they vary with facies and depositional sequences. The work was conducted on a whole core from the Eagle Fordformation of southern Texas.

The work was conducted using high resolution focused ion beam scanning electron microscopy (FIB-SEM) and 3D X-ray CT scanning. The whole core was X-ray CT scanned in such a way that bulk density (RhoB) and effective atomic number (Zeff) could be separately quantified. This is a new method that substantially increases the value and information content of X-ray CT data versus older methods that just produce images of X-ray attenuation. Samples used for matrix permeability tests were selected based on the core RhoB and Zeff data. The FIB-SEM method was used to create 3D volumes of pores, kerogen, and solid grains. Digital rock physics (DRP) technology was used to segment these volumes into different pore types and compute connectivity and matrix permeability directly. Density is an indicator of porosity plus kerogen and Zeff is a lithology indicator (similar to the photoelectric or PE log). As with most mudstone formations, Eagle Ford has a distinct pattern of repeating facies and sequences that can be detected in whole core by the combination of RhoB and ZefJ. These changes are caused by depositional trends in quartz, clay, kerogen, and calcite content. Because the resolution is many times finer than open-hole logs (about 0.5 millimeter), these sequences can be accurately defined. The porosity versus matrix permeability behavior is related to the pore types, and the pore types vary depending on their location relative to depositional sequences.

Observations and Conclusions: Fine scale depositional sequences in Eagle Ford shale were detected using a new X-ray CT method that quantifies both bulk density and effective atomic number. This data helps identify the most porous and organic rich zones as opposed to the calcareous, harder streaks. Digital rock physics technology showed thatthe porosity-permea bility trends in these samples are controlled by pore type, with kerogen porosity being critical to good reservoir properties.