Separation and Quantification of Matrix, Fracture and Vug Porosity in Carbonate Reservoir Rock by Magnetic Resonance Imaging

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ABSTRACT

Techniques that facilitate the measurement of the spatial distribution of pore structure characteristics, particularly if made at the same scale (i.e. over the same representative volume) as other physical measurements, provide crucial insights regarding the interpretation of core analysis data. Of the available techniques, Nuclear Magnetic Resonance (NMR) Imaging or better known as Magnetic Resonance Imaging (MRI) provides data that best address this requirement for carbonates reservoir samples by permitting the separation and quantification of vug, fracture and matrix porosity.

NMR imaging is a non-destructive technique, carried out on brine-saturated samples. Due to their complex pore structures, thin-section MRI methods must be used to avoid the “full moon” effect that has been reported by other operators due to volume averaging the entire core plug. “Thin section” MRI permits the clear delineation of the vug and fracture porosity, which can be quantified, using long echo time imaging and binary segmentation of the image data.

Fracture detection and characterization (fluid filled or mineralized / mud damaged) can be carried out quickly and easily. Fluid filled fractures show up as high signal intensity features (white lines), while mineralized or mud damaged fractures have dark, low intensity features.

Gravimetric porosity values when compared to values obtained by MRI have close agreement. This is due in part to the low magnetic susceptibility of carbonate rock. The low magnetic susceptibility of carbonates also permits the acquisition of relaxation information at high field. Low field NMR relaxation data suffers from diffusion and low relaxivity effects that can make prediction of pore space properties difficult. We believe that high field NMR data more accurately reflects the true nature of pore space, and when combined with the imaging information can be used to improve the manner in which low field NMR and electrical resistivity logging data are interpreted.