Relationship between reservoir properties and NMR measurements: examples from Tirrawarra Sandstone, Cooper Basin, South Australia

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Abstract

The Tirrawarra Sandstone, like most reservoir rocks in the Permian to Triassic succesion in the Cooper Basin of central Australia, is characterized by low porosity and permeability. Ambient core porosity averages 8.96% and ambient permeability 0.9 mD. Most samples having permeabilities less than 3 mD. Despite its overall poor reservoir characteristics, the Tirrawarra Sandstone is one of the major oil and gas targets in the Cooper Basin.

This study investigates the applicability of the NMR technique in the determination of effective porosity in the gas reservoir sandstones in the Cooper Basin. A total of 17 plugs from five wells were examined. Prior to the NMR experiment, the samples were studied petrographically using x-ray diffraction, optical petrography and scanning electron microscopy. These results were integrated with special and routine core analysis data.

The petrographic study revealed that the diagenetic events, including mechanical and chemical compaction, cementation and alteration have modified the reservoir quality. Ductile components such as rock fragments, clay and matrix influence mechanical compaction to be the main cause of reservoir quality reduction. Quartz cementation and clay distribution also affected the porosity but particularly permeability. Mechanical compaction as well as quartz cementation has reduced and blocked pore-throats to isolate intergranular pores. The alteration of feldspar to kaolin has changed intergranular porosity to microporosity. Illite occurs as either cement or alteration of kaolinite. All of these diagenetic events affect fluid movement in the reservoir, which also influences NMR relaxation times.

Laboratory measurement of NMR relaxation measurement determine pore geometry and volume. Petrography, core data and NMR data were used to demonstrate the connection between NMR relaxation time distribution and the fundamental property of pore size in the Tirrawarra Sandstone.

The NMR measurements partially saturated samples determined the water remaining in the sample (known as BVI). This values was most important in gaining reliable estimates of effective porosity and permeability. To obtain an accurate BVI, the samples were calibrated with core volume irreducible water. BVI was influenced by the effectiveness of the pores and pore throats to flow fluid, which in turn is a function of the mineralogy. NMR unable to reliably distinguish clay associated microporosity from macropororosity. Petrographic studies and calibration of the NMR with the core data assisted in interpreting the NMR relaxation time distribution. The integration of NMR and traditional porosity evaluation methods should produce major advances in the understanding and application of NMR measurements, particularly for the borehole NMR.

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