Interwell Calculation of Permeability in Vuggy Pores Using Ground-Penetrating Radar and Cross-Hole Tomography within Albian Carbonates Reservoir Analogs, Pipe Creek, Texas

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ABSTRACT

Touching vugs are fast permeability pathways and permeability calculations are scale dependent and represent a significant challenge for flow property characterization in subsurface reservoirs. We used surface and down-hole ground-penetrating radar (GPR) to constrain the shape of a gravity-injected water plume at the Cretaceous (Albian) Pipe Creek site in Central Texas. Five wells were drilled to collect core for facies description and were completed ithin a facies with complex vuggy pores. As part of a pilot study, water levels within the wells were used to monitor pressure changes in a thin, perched aquifer during the injection of 1,300 gallons of water in one well that was completed open hole from 1.5 to 7.6 meters depth below surface. Water pressure changes were monitored in the four other wells that were all spaced greater than 7.8 meters away from the injection well. A 2D GPR grid was acquired prior to and near completion of the water injection. This grid was interpreted and processed for amplitude anomalies created by the water injection. Mapping the amplitude anomaly in the surface GPR reveals the areal extent of the water injection front. Downhole GPR was acquired in incremented time steps during injection. Zero offset profiles were processed to determine the lag time effect created by the injected water into the vuggy facies. From the cross-hole tomography we were able to determine the cross-sectional area that was affected during water injection. Integrating the surface and cross-hole GPR data, along with the water injection rate, allows us to calculate a more precise effective permeability of 1.2 darcies for the rudist rudstone facies. This value is consistent with other measurements of this facies from conventional core analysis, but represents a three-fold increase from gas tracer experiments conducted within twinned wells spaced 1.5 meters apart.

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