SENSITIVITY OF BOREHOLE NMR MEASUREMENTS TO WELL CONSTRUCTION AND DEVELOPMENT

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Abstract: In this work we investigate the effect of different well construction methods, and well development activities, on borehole NMR measurements and borehole-NMR-derived estimates of hydraulic conductivity. Nuclear magnetic resonance (NMR) measurements provide direct sensitivity to pore fluids enabling estimation of key petrophysical properties including porosity, bound/free fluid content, and permeability. In particular, the observed NMR relaxation time T2 is sensitive to the pore volume to surface ratio. Hence, any differences or changes in the physical pore-scale properties of a water-saturated formation due to well construction and/or development should logically be detectable by borehole NMR. To test this hypothesis, we used a variety of small diameter NMR logging tools at a well-characterized hydrologic test site in Lawrence Kansas. The investigated aquifer is unconsolidated, primarily sand and gravel, with thin discontinuous lenses of silt and clay. A first set of test compared direct push NMR measurements, to NMR measurements performed in PVC-cased wells that were installed by both direct push and augering methods. The results indicate that the direct push NMR measurements, performed in a somewhat compacted and undeveloped formation, exhibited typically shorter T2 decay rates than NMR measurements performed in nearby auger-constructed and developed wells. A direct push machine was then used to install two screened 2" PVC wells. NMR logging measurements in these two wells were conducted prior to development, and after various stages of development. It was observed that at each stage of development, the T2 relaxation rate became significantly longer at certain depth intervals of the aquifer. This effect is apparently due to the removal of fines, which generally increases the volume to surface ratio of the pore space. Thus, NMR logging measurements and derived permeability estimates were shown to be sensitive to both well construction and development. This highlights the need to account for well construction and development in NMR-based permeability estimation, and also indicates other potential applications of the NMR logging tool for inspection and monitoring of the annular space surrounding a well.

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