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Characterization of Gas Permeability in Two Sandstones and Effects of CO2 Flooding on P-wave Velocity

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Seismic cross-well tomography is considered as a promising monitoring method to map the movement of CO2 in the subsurface, establish that the storage volume is being efficiently utilized, and help ensure the CO2 is safely contained within a known region. The effectiveness of seismic tomography in monitoring CO2 migration depends on the velocity and amplitude changes of the seismic waves caused by the process. Seismic wave properties depend on the mineralogical composition of the rock as well as factors such as, porosity, fluid content, and in-situ stress. Previous works on effects of CO2 flooding on seismic wave velocity, show clearly that CO2 flooding caused the compressional wave (P-wave) velocity to substantially decrease, the shear wave velocity either decrease or increase, depending on pore pressure state.

It is clear that CO2 flooding will change the pore fluid pressure state in the subsurface. Because CO2 is injected at a higher pressure compared with the reservoir pore pressure. Effects of the pore pressure changes on seismic wave properties are important as well as CO2 saturation. Interpretation of seismic monitoring of CO2 flooding requires an understanding of the effects of pore pressure buildup and CO2 saturation.

Laboratory experiments were conducted to measure compressional wave velocities under hydrostatic pressure in Shirahama and Tako sandstone with a porosity of 12% and 24%, respectively. In dry samples, hydrostatic pressure increased the compressional wave velocity significantly in Shirahama sandstone, as a result of the closure of micropores with low aspect ratio, while the velocity in Tako sandstone was less affected. The pressure dependence of velocity is ascribed to the difference in micropore structure. Velocities were also measured to map the movement of the injected CO2 within water-saturated samples during CO2 flooding. Velocity changes caused by the CO2 injection, provided at the bottom end of the sample, are typically on the order of -6%. The compressional wave velocities decreased simultaneously along horizontal paths in two orthogonal directions.

Experimental studies, such as converting field measurements of wave velocities and attenuations to CO2 saturation, support the interpretation of the field survey results. We are conducting a series of seismic tomography experiments on porous sandstone samples to demonstrate the use of cross-well seismic profiling for monitoring the migration of CO2 in geological sequestration projects. In this paper, we present a preliminary result of measurements on velocity changes while injecting CO2 into water-saturated Shirahama and Tako sandstone.