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Seismic anisotropy due to CO2 replacing water

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Geological sequestration of Carbon dioxide (CO2) into saline aquifers or other geological structures has been proposed to reduce the volume of CO2 emission to the atmosphere for the purpose of stabilizing the global warming. Monitoring, verification and environmental safety of CO2 storages are important issues must be addressed before the technology can be accepted by the public for wide scale implementation. If mitigation is required at any point, an accurate estimation of CO2 distribution would be necessary. By now, seismic surveys provide the most attractive approach for obtaining the spatial coverage required for mapping the location and movement of CO2 in the subsurface. Sedimentary aquifers are normally characterized as to be seismically anisotropic medium. On one hand, such anisotropy should be considered in the interpretation of seismic method such as velocity tomography (Lei & Xue, 2009). On the other hand, seismic anisotropy is also meaningful for monitoring CO2 distribution because it is sensitive to CO2-saturation in the pore volume of sedimentary aquifers.

This study aims to make clear the elastic response of typical porosity rocks due to CO2 replacing water as well diffusion of pore-pressure. Gaseous, liquid and super critical CO2 were injected into well-prepared porous rock sample under well-controlled conditions in laboratory. During the injection seismic measurements are performed frequently along many paths, from 8 x 8 to 16 x 16. Then both P-wave velocity and attenuation are imaged using difference tomography techniques. The ongoing study has two main issues. Firstly, we focus on modeling the change of the petrologic properties of typical porosity rocks due to displacement between water and CO2 gas. Secondly, we aim to improve the monitoring techniques applicable in fields, particularly the seismic tomography method, for making precise estimation of the CO2-saturation fraction in an aquifer.

Experimental results indicate that the velocity anisotropy shows strong dependence on contains in the pore volume. For example, in a test sample of Tako sandstone (24% porosity), the estimated ? values, a measure of velocity anisotropy, are 0.15 and 0.075 for dry and water saturated conditions, respectively. After the injection of gaseous CO2 in to the water saturated sample, the optimum value of ? is estimated as 0.1. It is verified that taking the seismic anisotropy into consideration is unavoidable for precise monitoring.

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Reference:

Lei X.-L., Z. Xue, 2009. Ultrasonic velocity and attenuation during CO2 injection into water-saturated porous sandstone: Measurements using difference seismic tomography. Phys. Earth Planet. Inter. 176, 224-234.

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