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Effects of CO_2 Injection on the Seismic Velocity of Sandstone Saturated with Saline Water

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ABSTRACT

Geological sequestration (GS) of carbon dioxide (CO_2) is considered as one of the most promising technologies to reduce the amount of anthropogenic CO_2 emission in the atmosphere. To ensure success of CO_2 GS, monitoring is essential on ascertaining movement, volumes and locations of injected CO2 in the sequestration reservoir. One technique is to use time-lapsed seismic survey mapping to provide spatial distribution of seismic wave velocity as an indicator of CO_2 migration and volumes in a storage reservoir with time. To examine the use of time-lapsed seismic survey mapping as a monitoring tool for CO_2 sequestration, this paper presents mathematical and experimental studies of the effects of supercritical CO_2 injection on the seismic velocity of sandstone initially saturated with saline water. The mathematical model is based on poroelasticity theory, particularly the application of the Biot-Gassmann substitution theory in the modeling of the acoustic velocity of porous rocks containing two-phase immiscible pore fluids. The experimental study uses a high pressure and high temperature triaxial cell to clarify the seismic response of a sample of Berea sandstone to supercritical CO_2 injection under deep saline aquifer conditions. Measured ultrasonic wave velocity changes during CO_2 injection in the sandstone sample show the effects of pore fluid distribution in the seismic velocity of porous rocks. CO_2 injection was shown to decrease the P-wave velocity with increasing CO_2 saturation whereas the S-wave velocity was almost constant. The results confirm that the Biot-Gassmann theory can be used to model the changes in the acoustic P-wave velocity of sandstone containing different mixtures of supercritical CO_2 and saline water provided the distribution of the two fluids in the sandstone pore space is accounted for in the calculation of the pore fluid bulk modulus. The empirical relation of Brie et al. for the bulk modulus of mixtures of two-phase immiscible fluids, in combination with the Biot-Gassmann theory, was found to satisfactorily represent the pore-fluid dependent acoustic P-wave velocity of sandstone.

KEYWORDS

Biot-Gassmann Theory; CO_2 Geological Sequestration; Poroelasticity; Porous Rocks; Two-Phase Fluid Flow; Seismic Velocity

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References

[1] IPCC—Intergovernmental Panel on Climate Change, "Special Report on Carbon Dioxide Capture and Storage," Chapter 5, 2005.

[2] S. M. Benson and D. R. Cole, "CO2 Sequestration in Deep Sedimentary Formations," Elements, Vol. 4, No. 5, 2008, pp. 325-331. doi:10.2113/gselements.4.5.325

[3] S. Bachu, "Screening and Ranking of Sedimentary Basins for Sequestration of CO2 in Geological Media in Response to Climate Change," Environmental Geology, Vol. 44, No. 3, 2003, pp. 277-289. doi:10.1007/s00254-003-0762-9

[4] J. Sminchak, N. Gupta, C. Byrer and P. Bergman, "Issues Related to Seismic Activity Induced by the

Injection of CO_2 in Deep Saline Aquifers," Journal of Energy and Environmental Research, Vol. 2, 2002, pp. 32-46.

[5] J. K. Kim, J. Xue and T. Matsuoka, "Experimental Study on CO_2 Monitoring and Saturation with Combined P-Wave Velocity and Resistivity," SPE Journal, 2010, pp. SPE 130284. doi:10.2118/130284-MS

[6] J. Q. Shi, Z. Q. Xue and S. Durucan, "Seismic Monitoring and Modelling of Supercritical CO_2 Injection into a Water-Saturated Sandstone: Interpretation of P-Wave Velocity Data," International Journal of Greenhouse Gas Control, Vol. 1, No. 4, 2007, pp. 473-480.doi:10.1016/S1750-5836(07)00013-8

[7] A. Brie, F. Pampuri, A. F. Marsala and O. Meazza, "Shear Sonic Interpretation in Gas-Bearing Sands," Proceedings of SPE Annual Technical Conference and Exhibition, Dallas, 22-25 October 1995, p. 701. doi:10.2118/30595-MS

[8] A. L. Endres and R. Knight, "The Effects of Pore-Scale Fluid Distribution on the Physical-Properties of Partially Saturated Tight Sandstones," Journal of Applied Physics, Vol. 69, No. 2, 1991, pp. 1091-1098. doi:10.1063/1.347376

[9] M. Biot, "General Theory of Three-Dimensional Consolidation," Journal of Applied Physics, Vol. 12, 1941, pp. 155-164. doi:10.1063/1.1712886