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Ultrasonic laboratory measurements of the seismic velocity changes due to CO2 injection

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Monitoring the behavior and movement of carbon dioxide (CO2) in the subsurface is a quite important in sequestration of CO2 in geological formation because such information provides a basis for demonstrating the safety of CO2 sequestration. Recent several applications in many commercial and pilot scale projects and researches show that 4D surface or borehole seismic methods are among the most promising techniques for this purpose. However, such information interpreted from the seismic velocity changes can be quite subjective and qualitative without petrophysical characterization for the effect of CO2 saturation on the seismic changes since seismic wave velocity depends on various factors and parameters like mineralogical composition, hydrogeological factors, in-situ conditions. In this respect, we have developed an ultrasonic laboratory measurement system and have carried out measurements for a porous sandstone sample to characterize the effects of CO2 injection to seismic velocity and amplitude. Measurements are done by ultrasonic piezoelectric transducer mounted on both ends of cylindrical core sample under various pressure, temperature, and saturation conditions. According to our fundamental experiments, injected CO2 introduces the decrease of seismic velocity and amplitude. We identified that the velocity decreases about 6% or more until fully saturated by CO2, but the attenuation of seismic amplitude is more drastically than the velocity decrease. We also identified that Vs/Vp or elastic modulus is more sensitive to CO2 saturation. We note that this means seismic amplitude and elastic modulus change can be an alternative target anomaly of seismic techniques in CO2 sequestration monitoring. Thus, we expect that we can estimate more quantitative petrophysical relationships between the changes of seismic attributes and CO2 concentration, which can provide basic relation for the quantitative assessment of CO2 sequestration by further researches.