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The potential of Vp and Vs monitoring for MVA program of offshore CCS project

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For the safe operation of CCS, we are required to monitor the CO_2 behavior and to accurately account for the storage volume of CO_2 in deep reservoirs. It is well-known that the P-wave velocity measurements (Vp) can be used for monitoring the CO_2 behavior in deep reservoirs. However, it is difficult to accurately estimate the storage volume of CO_2 by only using Vp. Takahashi (2000) indicated the potential of S-wave velocity for monitoring of fluid behavior and accounting for the storage volume of natural gas in deep reservoirs. S-wave monitoring can be achieved by deploying a permenent ocean bottom cable(OBC) system at the off-shore CCS sites. In our own study, we conducted a simultaneous measurement of Vp and Vs of porous sandstone by injecting various types of fluids under set in-situ pressure and temperature conditions. For this study, we use the Tako sandstone, which is an early Miocene marine sandstone, mainly composed of quartz and plagioclase. Tako sandstone has near 10mDarcy of permeability and almost 24% porosity. The sample was cut into a column shape (5cm in diameter and 10cm in length), and polished on both ends (1PV=47 ml). In this study, we tried to estimate CO_2 saturation, and to monitor the CO_2 behavior in porous sandstone by measuring Vp and Vs. First, we injected near 1.3PV water into the vacuumed specimen (Water injection). After this process, over 2.2PV CO_2 is injected into the water saturated specimen (Drainage). Finally, CO_2-saturated water over 2.3 PV is re-injected into the CO_2-injected specimen (Imbibition). We illustrated the Vp-Vs relationships of all the processes. This Vp-Vs relationship diagram clearly illustrates the obvious differences between water injection and drainage. On the other hand, drainage and imbibition show the similar tendency of Vp-Vs change with injecting CO_2 and CO_2-saturated water. These changes indicate the changes of CO_2 saturation during drainage and imbibition stage. This result suggests the potential to estimate CO_2 saturation by using the Vp-Vs relationship. Additionally, Vp does not recover to pre-drainage levels after end of imbibition process. This Vp difference is considered to be the effect of residual trapped CO_2. This result also indicates the potential of monitoring the residual trapped CO_2 from seismic wave velocities.

Keywords: P-wave velocity, S-wave velocity, Porous sandstone, CO_2 saturation, MVA