J253-P015 **Room: Poster Session Hall** **Time: May 19**

Experimental study on the coal matrix swelling and gas permeability during adsorption of super critical CO_2

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In this study, we evaluated the coal matrix swelling during the adsorption of super critical CO_2 under hydrostatic pressure. It is inferred that CO_2 injected into the coal seams change to a liquid or the super critical condition under in-situ temperatures and pressures. Therefore, we measured the time change of the elastic wave velocity and swelling strain injecting liquid or super critical CO_2 into the coal sample, and discussed the availability of the elastic wave about the monitoring technique of CO_2 injected into the coal seams. In the experiments, we used the Bibai coal sample of the Sanbi Coal Mine in Hokkaido, Japan, and monitored the migration of pore fluid in the coal sample measuring compressional wave velocity, strain and fluid flow rate in the confining pressure conditions of 12 MPa. The pore pressure conditions were set to 10 MPa in the temperature conditions of 25 deg.C (liquid) and 40 deg.C (super critical). A sample length was cut into about 50 mm diameter core and doubly polished to a length of about 125 mm. The injection of liquid CO_2 into the coal sample at pore pressure of 10 MPa were carried out by the displacement from water to CO_2. After coal sample was saturated with liquid CO_2, temperature condition in the pressure vessel was set to 40 deg.C in order to make CO_2 into super critical condition. In the CO_2 injecting-side of coal sample, the compressional wave velocity nearly constant until about 10 hours passed, and remarkably decreased until about 30 hours passed accompanied with the migration and saturation of pore CO_2 injected into the coal sample. Then, it became nearly constant. In the CO_2 ejecting-side, the compressional wave velocity also gradually decreased after about 10 hours passed, but the degree of velocity reduction rate of ejecting-side was smaller than that of injecting-side. And then, the compressional wave velocity became nearly constant after about 50 hours passed. The strain values also remarkably increased accompanied with CO_2 injection. After temperature condition in the pressure vessel was set to 40 deg.C and liquid CO_2 became super critical CO_2, the compressional wave velocity became faster than that of water saturated condition. The permeability of coal sample in the liquid and super critical condition was measured at a differential pore pressure of 0.2 MPa intervals between the injecting- and ejecting-side. The permeability of coal sample was estimated by flow-pump technique. At a differential pore pressure of 0.2 MPa, the permeability of liquid CO_2 remarkably showed about 1.4 x 10^{-5} darcy. At a differential pore pressure of 0.4 MPa, it showed about 5.8 x 10^{-5} darcy. At differential pore pressures of 0.6, 0.8 and 1.0 MPa, the permeability of liquid CO_2 in the coal sample showed about 7.0 x 10^{-5} darcy. During the liquid CO_2 flooding, the permeability showed nearly constant at each differential pore pressure condition. On the other hand, the permeability during super critical CO_2 flooding in the coal sample gradually increased except for differential pore pressures of 0.2 and 0.4 MPa. At differential pore pressures of 0.2 and 0.4 MPa, the permeability of super critical CO_2 in the coal sample showed about 8.9 x 10^{-5} darcy and they were nearly constant during flooding. At differential pore pressures of 0.6 - 1.0 MPa, the permeability during super critical CO_2 flooding remarkably increased from 1.7 x 10^{-5} to 2.6 x 10^{-5}. These result suggested that the permeability of super critical CO_2 in the coal sample at high differential pore pressures showed higher than that of liquid CO_2.