Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

MIS005-09 Room: Function Room B Time: May 24 11:15-11:30

Experimental verification for a principle of CO2 injection into sediments about enhanced recovery of methane hydrate

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Commercialization of methane hydrate resources as next generation of natural gases is expected. CO2-enhanced oil recovery is commercialized by injecting CO2 into oil wells in the U.S. to enlarge oil production. This method mitigates CO2 release into atmosphere. CO2 shows a function to increase temperature of sediments up to 10 degrees Celsius. Then we have proposed an enlarging method of methane hydrate production using exothermic heat of CO2 hydrate formation. However, CO2 hydrate as solid formed from both CO2 and water, when CO2 is injected into sediments. Then CO2 hydrate blocks the pore of sediments, CO2 cannot be injected. It is necessary to show that CO2 can inject into formations continuously for long terms, such as several years.
When pressure is more than or equal to 4.5 mega Pascal, temperature is about 10 degrees Celsius on the boundary of stability zone of CO2 hydrate. It is a state of phase equilibrium on the boundary where formation and dissolving of CO2 hydrate are balanced. Temperature of sediments is therefore kept naturally at 10 degrees Celsius by exothermic heat and endothermic heat of CO2 hydrate formation and CO2 hydrate dissolving respectively. We experimentally verified that CO2 flow through Toyoura sand without blocking the pore by CO2 hydrate formation at the state of phase equilibrium. Toyoura sand is used as an index of sand sediments. This means that CO2 can inject into formations continuously for long terms at the state of phase equilibrium.
Both CO2 and water is necessary to form CO2 hydrate, when temperature is less than or equal to about 10 degrees Celsius and pressure is more than or equal to 4.5 mega Pascal. We have proposed to inject CO2/water emulsion into sediments to disperse CO2 homogeneously. The ratio of CO2 to H2O of CO2/water emulsion can be controlled. We have shown that CO2/water emulsion can be made by spraying liquid CO2 from the top into CO2 gas environment and mix with water at the bottom in a pressure cell. But it is difficult to use this method in injection well or to control flow rate, because the size of well limited. Then we experimentally verified a new method to make CO2/water emulsion using a porous material with pores of 10 micrometer in diameter. It is ensured that the droplets of liquid CO2 are kept sphere in flowing emulsion by taking high-speed photo. This verification shows that CO2/water emulsion can be made in injection wells.
This report uses results obtained by a part of researches of research group for production and modeling in research consortium for methane hydrate resources in Japan.

Keywords: methane hydrate, CO2 hydrate, exothermic heat, enhanced recovery, continuous injection, experiment