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Semi-permanent continuous monitoring of the CO2 sequestration zone using Seismic ACROSS and multi-geophones - Part I

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In order to continuously monitor the physical state of CO2 sequestration zone in the ground, we are developing a new technology to use seismic ACROSS(s) (Accurately Controlled and Routinely Operated Signal System) and multi-geophones by simulation method and field experiments. The seismic ACROSS source is a very stable semi-permanent seismic source developed by the Tono Geosciences Center and Nagoya University in Japan. Six units are now in nearly continuous operation in Japan and the seismic ACROSS source in Tono was continuously operated for 8 years. The newest seismic ACROSS source can generate 10-50 Hz with 40 ton-f at 50 Hz.

In this report, we explain the results obtained by 2D simulation using a single seismic source and multi-geophones. The result of 3D simulation using small model is reported in Part II in this session. We assumed 20% velocity changes associated with the change of reservoir characteristics or sequestration of CO2. We used rectangular shape reservoirs such as 1) 500 m width and 50 m thick, and 2) 50 m width and 10 m thick located at 1 km depth. We included the velocity change in shallow sedimentary layer. As assuming seismic ACROSS which generates single forces by use of clockwise- and anticlockwise-rotation waveforms, we synthesize forces in two perpendicular direction. By use of synthesized full-wave seismograms, the reverse-time (back propagation) method can generate P, S and P-S phases.

If velocity change of the sedimentary layer is $<$ 0.1%, we can clearly obtain the rectangular shape for the reservoirs using before and after change of characteristics. Even if velocity change of the surface layer is 1 %, we can reproduce rectangular shape. However, the extent of knowledge on velocity structure and large change of velocities at the surface strongly affect to the results. Use of a vertical geophone array can reduce the effect of surface velocity change. Considering the results of simulation, we are testing the imaging by single source and multi-receiver method for a small scale CCS test site in Awaji Island, Japan. The 3D field test will be done in Awaji Island in February and March, 2011.

Keywords: CCS, CO2 sequestration, time lapse, ACROSS, back-propagation, time-reversal