Cost-effective seismic imaging of subsurface structures at high-resolution using distributed acoustic sensing

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For successful CO_2 geological storage, imaging and monitoring of subsurface properties in CO_2 storage sites are essential. Although seismic reflection surveys using active seismic sources are usually performed to characterize CO_2 storage sites and monitor injected CO_2, their high cost for each survey prevents frequent monitoring. To overcome this difficulty, development of cost-effective seismic imaging and monitoring methods is required.

Distributed acoustic sensing (DAS) is technology to change fiber optic cables into continuous seismic receivers by measuring axial strain. Because existing dark fibers can be available for DAS data acquisition, dense seismic data along long fiber optic cables can be acquired at low cost. In this talk, we present two seismic approaches for high-resolution subsurface imaging using DAS data in offshore environments. One uses passive seismic sources caused by natural phenomena such as ocean swell, and another uses natural earthquakes occurred around the fiber optic cables. Because both seismic sources do not require installation of any artificial seismic sources, the two approaches can be conducted at a low cost.

Using passive seismic sources, the shallow seismic structure to a depth of several hundreds of meters along the fiber optic cable was estimated at high lateral resolution by the advanced passive seismic processing. Because five days of DAS data were enough for data processing, our approach has the potential to monitor temporal change in the shallow subsurface, which would contribute to identifying CO_2 leaks from the reservoirs. Using natural earthquake data, the seismic reflection profile along the fiber optic cable was estimated. In this approach, reflection signals at each receiver point were extracted by computing autocorrelation of earthquake records based on seismic interferometry. Because the DAS data has high spatial sampling, the resulting reflection image shows various heterogeneities including low velocity zones, lateral variation of the basement, and scattering of seismic signals possibly associated with faults. Thus, our cost-effective approaches using DAS without any artificial seismic sources have the potential to monitor CO_2 leakages and characterize heterogeneities in CO_2 storage sites.