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Monitoring of dynamic subsurface activities: My past and present researches

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The two biggest issues for CO_2 capture and storage (CCS) are (1) risk of CO_2 leakage from storage reservoir and (2) cost for CO_2 injection. The monitoring of injected CO_2 is the most important technique for solving these issues. It is obvious that the monitoring methods can be used for (1) prediction of CO2 leakage. In addition to the risk management, the monitoring of injected CO_2 has a key role in (2) cost evaluation. CCS projects inject large amounts of CO_2 (e.g., one million tons/year) and continue over several ten years. Because such a long-term, large-amount CO_2 injection could change reservoir characteristics, the injection speed and amount should be controlled by considering the injected CO_2 distribution as well as *in situ* status derived from monitoring. Furthermore, because reservoir size is not large in many geologic settings especially near from emission source (e.g. power plant), we need to optimize effective injection procedure by controlling CO_2 injection and designing multiple wells.

In I2CNER, I try to develop effective method of CO_2 monitoring in order to ensure effective injection well controls, verify quantity of injected CO_2, optimize the efficiency of the storage project, mitigate or detect CO_2 leakage from storage reservoir, and estimate future distribution of injected CO_2. We mainly use change in seismic velocity for the CO_2 monitoring, because P-wave velocity decreases dramatically as the CO_2 starts to invade the pore space of a rock initially saturated with brine. Furthermore, I have recently studied Biological-CCS, which converts the injected CO2 into CH4. This technique provides us hydrocarbon even around Japanese Island, when CO2 is injected in the low-maturity coaled sequence. To move toward the bio-CCS, I try to establish a new monitoring method for the Bio-CCS, because the elastic response in Bio-CCS is much different from that in the conventional CCS.

In this IISS seminar, I introduce my previous studies of geophysical monitoring, in addition to the ongoing CCS studies. I mainly explain the huge-tsunami mechanisms in the 2011 Tohoku earthquake revealed from the geophysical monitoring data. This study shows the effectiveness of geophysical monitoring for the estimation of dynamic subsurface activities. I identify a series of faults on reflection seismic profiles and examine dynamic changes of fault system by comparing observations made before and after the 2011 earthquake. Because the survey area includes the region of largest vertical displacement, these shallow faults most likely relate directly to the tsunami characteristics. The geophysical monitoring and seafloor observations in the tsunami induced region demonstrate that significant extension was generated within the geological unit above the plate interface. These extensional features caused acceleration of displacement along the plate interface during the earthquake, contributing to the huge tsunami generation.