Carbon Capture and Storage (CCS) and its potential in Taiwan

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Carbon dioxide capture and storage (CCS) is considered as one of the most effective ways of reducing green-house gases in the future. Basic researches and large-scale pilot experiments have been conducted in Europe, North America, Japan and other countries, in order to realize CCS in practice in about 10 years from now. Taiwan seems to have great CCS potential because thick Tertiary to Quaternary sediments are distributed all along west coast. The second oldest gas field in northwestern Taiwan provides with precious information on underground permeability/porosity structures, both essential for the evaluation of CCS potential.

This talk will focus on geological storage, rather than CO_2 capture in power plants, and will summarize geological tasks towards such a goal. Current status of CCS is summarized well in "*IPCC special report on Carbon Dioxide Capture and Storage*" (Cambridge Univ. Press, 2005; an electric form can be downloaded free from IPCC homepage). I will introduce large-scale experiments in Sleipner Norway since 1996, In Salah in Algeria since 2004 and Weyburn in Canada since 2000, to illustrate current status of CCS. In those three stations combined, about 2 million tons of CO_2 has been injected every year, enough to eliminate CO_2 from one moderate-size power station. Technologies already exist to conduct CCS. Porous sandstone provides enormous underground space, and it is estimated that Utsuira formation in Sleipner alone can accommodate CO_2 from entire EU countries for more than 100 years. Thus CCS potential is powerful, but care must be taken to select suitable geological sites.

IPCC Report proposes four trapping mechanisms; (1) structural and stratigraphic trapping, (2) residual trapping, (3) solubility trapping and (4) mineral trapping. Among those (1) is by far the most important and we have to make sure that injected CO_2 remains underground for the time periods of several hundred years or longer so that more stable trapping mechanisms, (2) to (4), becomes effective. Thus site selection should be done based on the determination of underground transport properties (permeability, porosity and storage capacity, etc.) and on detailed analyses of two-phase fluid flow. Porosity is needed to estimate the potential amount of CO_2 storage. To determine permeability and porosity structures on a scale of sedimentary basin, we need to analyze basin evolution, i.e., sedimentation, compaction and fluid-flow processes, because sediments cannot compact unless pore fluid escape to surface. I will summarize an example of such study in the gas field in northwestern Taiwan based on laboratory-measured transport properties of surface rocks (Tanikawa and Shimamoto, 2008, JGR). A difficult problem is how to evaluate the effects of faults and fractures on fluid flow. In other words, it is uncertain whether one can use laboratory measurements to determine transport properties using small specimens. I will introduce our ongoing researches in collaboration with Horonobe Underground Research Center (JAEA) on late Tertiary to Quaternary sediments where more than 50 in-situ permeability measurements were conducted. We have shown that in-situ permeability is bound by permeability of fault breccia zone on the upper side and by intact host-rock permeability on the lower side. I propose a practical way of evaluating seal capacity of sedimentary rocks which will be useful in the initial phase of CCS studies in Korea.

Injection of massive water-resolvable gas can create potential danger for eruption of CO_2-rich water or mud. Gas solubility in water decreases with decreasing pressure, so that upward movement of water rich in gas releases lots of gas which can act as gas pumping. Crystal geyser in Utah and formidable mud eruption in East Java are such examples, the latter can be the worst scenario of CCS and has to be carefully avoided.