Field Investigation of CO_2 Migration Behavior near the Ground Surface for Environmental Impact Evaluation

Background

To gain the public acceptance for CO_2 geological storage, environment impact evaluation in groundwater and atmosphere is necessary in addition to a feasibility demonstration of the geological storage technology. A possible leakage path of CO_2 which was not extracted in storage capability estimation of reservoir aquifer will allow CO_2 to go upwards in the long term and to consequently reach near the ground surface. Therefore, it is necessary to predict CO_2 migration behavior from a lack of seal rock above the aquifer to the surface and atmosphere, and to reflect it into the environmental impact evaluation of CO_2 geological storage.

Objectives

This study aims to propose investigation methodology of CO_2 migration behavior, geochemical influence of CO_2 underground, and concentration distribution of the atmospheric diffusion of CO_2 in cases of leakage of CO_2 stored underground moving upwards to the ground surface (Fig.1);

Principal Results

1. Investigation of gas migration underground

An uprising migration phenomenon of natural gas (mainly consisting of methane, CH_4) from gas fields including dissolved natural gas in groundwater was investigated by taking a natural analogue of CO_2 migration in shallow layers. Geological survey of outcrops and boring cores, hydraulic measurement in boreholes, carbon isotope analysis of underground gas, and numerical analysis of gas migration were conducted in a Pleistocene sedimentary rock region. As a result of the investigation, a gas migration model in which the gas moves upwards from deeper layers, is trapped by low permeability layers and goes up along the fault fracture zones was proposed and was approximately validated by the numerical analysis (Fig. 2).

2. Investigation of CO_2 geochemical influence on groundwater

Methods of quantitative analysis and dissolution rate evaluation were surveyed to clarify the elution phenomenon of trace elements (12 elements including B and As) from rock contacted with groundwater including dissolved CO_2. A concentration analysis technique of the trace element in rock sample directly using high precision X-ray fluorescence analysis (XRF) and a dissolution rate evaluation technique of trace element based on a laboratory or a field survey of carbonate spring were presented. A procedure for the geochemical influence investigation of uprising CO_2 including these techniques was proposed.

3. Investigation of CO_2 atmospheric diffusion after leakage

A modeling method to predict the atmospheric diffusion phenomenon of CO_2 leaked from the ground surface was investigated. Example analyses in which numerical simulation based on DEGADIS model [*1] with attached functions of radiation source calculation and weather data import was performed and yielded an efficiency for the prediction approach of CO_2 atmospheric diffusion discharged from the ground surface (Fig.3).

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Future Developments

The proposed investigation methodology will be applied to the field including CO_2 gas migration in a shallow underground layer.

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Reference

K. Nakagawa, et al., 2008, "Survey on understanding and estimation of CO_2 migration behavior in a shallow layer around geological storage site", CRIEPI Report N990728 (in Japanese)

＊1：One of the models that American environmental protection agency (U.S.EPA) allows to use for an atmospheric diffusion prediction of the high-density gas.

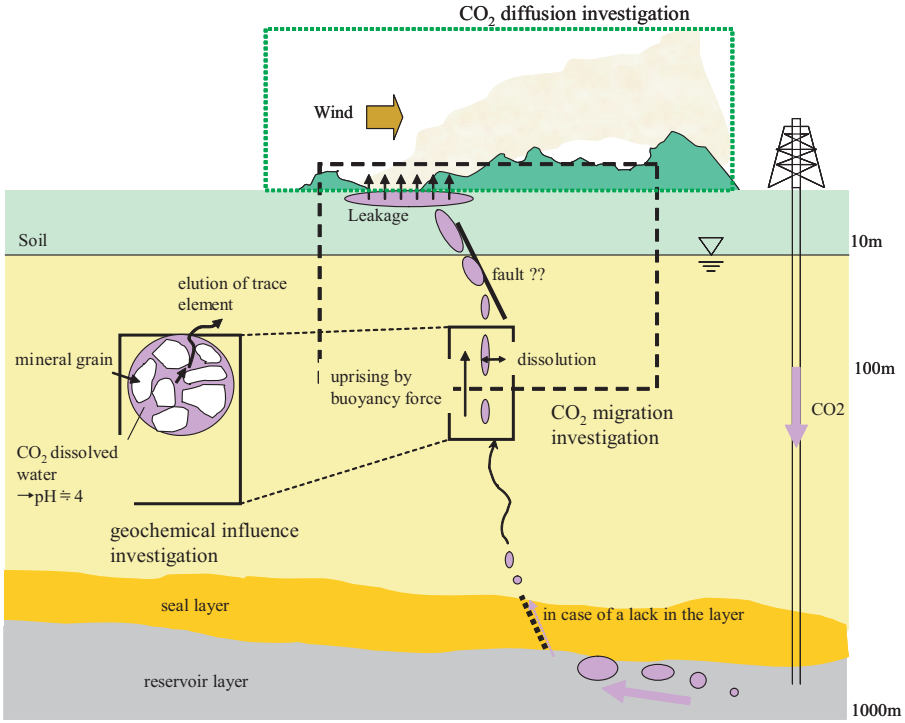

Fig.1 Schematic diagram of this study

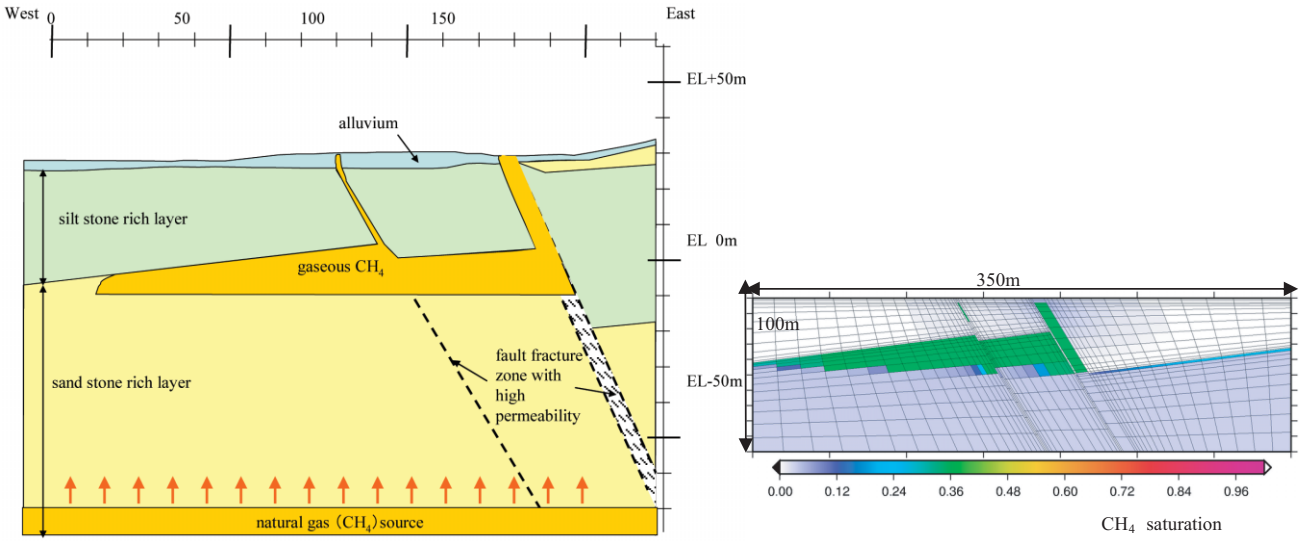

Fig.2 Results of the gas migration investigation (left: gas migration model, right: calculated result of CH_4 gas migration)

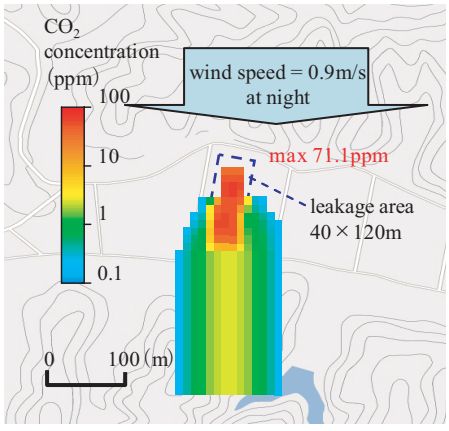

Fig.3 Calculated result of the leakage CO_2 diffusion in atmosphere