Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG61-01 Room:104 Time:May 20 09:00-09:15

The results of groundwater studies and the future plan in the Horonobe coastal area.

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On the new utilization methods of underground space development such as geological disposal of high level radioactive waste (HLW) and CO2 sequestration or carbon capture and storage (CCS) , groundwater study is very important to evaluate the underground environments. It is difficult to obtain physical data in sedimentary rock with low permeability, because the groundwater velocity degradation was caused by a rock pressure increase associated with the depth increases. Geochemical data is significant to understand the groundwater flow conditions, groundwater source, and residence time. However, in situ groundwater sampling is very difficult because of the sampling schedule, cost, and technical requirements. In such a case, it is clearly that the application of pore water with the same chemistry as groundwater is efficient to estimate the groundwater environment. In our study, one thousand meter borehole was drilled in the Hamasato area at Horonobe town, Hokkaido prif, and various groundwater studies by the application of pore water were conducted to understand the groundwater hydrology in a coastal area. As the results of these studies, existence of five hydrological units was confirmed in this area and existence of freshwater under the seabed was also found by geophysical exploration. Furthermore, a number of knowledge for the pore water extraction and water chemistry analytical methods were also obtained.

In the presentation, we will report the result of these groundwater studies and introduce the future plan based on the results of studies.

Keywords: Coastal area, Pore water, Deep groundwater, Low permeability sedimentary rock

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SCG61-02 Room:104 Time:May 20 09:15-09:30

Numerical analysis of groundwater flow system under the seabed accompanying sea level fluctuations

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Coastal area is one of the promising places for geological disposal due to scientific and social aspects. Developments of investigation and evaluation method to interpret coastal environment are needed because there are a lot of uncertainties remaining to understand the hydrogeological environment in there. Long-term geological variations such as climate variation and sea level fluctuations will lead to great changes of groundwater flow environment under the seabed especially in shallow sea area. It is believed that the prediction of future groundwater flow process is necessary for evaluation of geological environment stability.

There is a report that fresh paleo-water under the seabed was discovered on the continental shelf away from a present coastline in many parts of the world (ex. Horonobe coastal area), because recently investigation technology has been improving. That is the proof that a complex mixing and diffusion among seawater and groundwater and meteoric water was happened. Prediction of future groundwater flow environment can be better interpreted by constructing the groundwater flow model of long-term behavior like a natural analog.

The purpose of this study is to find out the long-term groundwater flow processes at Horonobe coastal area and Iwaki coastal area through the sensitivity and scoping analysis using site-scaled numerical modeling. Transient boundary condition is better than static boundary condition for evaluation of the distribution of the groundwater flow under the seabed. Many cases indicated that remnants of fresh groundwater which was infiltrated and became trapped in shelf sediments may be occurred. Groundwater under the seabed may be washed out due to sea level fluctuations with each cycle, so that it is NOT safe for the radioactive waste repository. This method to evaluate groundwater flow system under the seabed contributes effectively research plan such as offshore boring, electromagnetic investigation.

Keywords: under the seabed, groundwater flow, sea level fluctuation, numerical simulation, density flow, groundwater age

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SCG61-03 Room:104 Time:May 20 09:30-09:45

Correlating permeability with fracture property and hydrothermal alteration intensity of Toki granite samples

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Information on spatial distribution of permeability is essential to estimate groundwater flow in rock mass with a high degree of accuracy. Permeability of Toki granite samples was measured using permeameter in this study and space distribution and anisotropy of the permeability in rock core scale was shown. Correlation of permeability with fracture property and alteration intensity was discussed.

Samples are boring cores of Toki granite. Vertical sample is a core collected at borehole MIZ-1, excavated by Japan Atomic Energy Agency (hereafter JAEA) at Mizunami, Gifu prefecture, Japan. Horizontal sample consists of 30 cores collected at borehole 10MI22 and 10MI23, excavated in drift of Mizunami Underground Research Laboratory of JAEA.

Macroscopic fracture separates the vertical sample from contiguous part. To reveal relationship between permeability and distance from the macroscopic fracture, and to reveal relationship between permeability and azimuth direction (anisotropy), air permeability of 16 directions was measured in plane perpendicular to core axis. For the horizontal samples, permeability was measured at three points of 2.0cm from both ends and midpoint along core axis. Nitrogen gas injection type permeameter (TEMCO Inc., MP-401) was used for the measurement.

Image analysis was carried our to characterize fracture property of microcracks and mesocracks. Fracture image was prepared by tracing microcracks observed in thin section. Fracture image for mesocrack was traced from core surface image taken with fluorescent method. Fracture number, length and angle of each fracture, number of crossed point, were collected by image analysis.

The horizontal samples show various degrees of alteration and are classified as intact, fractured part, faulting part, and altered part based on criteria by JAEA. Powder X-ray diffraction analysis (XRD) and fluorescent X-ray analysis were employed to consider relationship between permeability and alteration intensity.

In permeability measurement of the vertical sample, permeability was larger at points near the macroscopic fracture and decreased with increase in the distance from the fracture. Additionally, permeability was larger in NE-SW direction and NW-SE direction.

Image analysis of microcrack showed that longer crack exists near the macroscopic fracture and that the fractures make network considering the number of crossing point. Dominant orientation of microcrack was NE-SW and NW-SE. Similar results were obtained in the mesocrack analysis, and fracture number and number of crossing point increased near the macroscopic fracture plane. Dominant orientations of mesocrack were NE-SW and NW-SE.

Dominant direction of fracture was similar between microcrack and mesocrack, and fractures observed in different scale have similar orientation. This direction is consistent with one where permeability is large, and it means that fracture orientation rules anisotropy of permeability.

Maximum compressive direction in deeper part than 250m beneath the surface around MIZ-1 is known to be NW-SE[1]. Anisotropy in permeability and fracture orientation shown in this study was consistent with the compressive direction in this area. This stress field may cause the fracture orientation and anisotropy of permeability.

Results of XRF analysis showed that Ca concentration varied depending on alteration intensity. Therefore, Ca concentration was used as index of hydrothermal alteration, and correlation with permeability was considered. Intact sample, whose Ca concentration is low, was relatively impermeable, and fractured part sample, whose Ca concentration was high, was relatively permeable. These results indicate that relatively strong hydrothermal alteration proceeded in more permeable part because hydrothermal solution can circulate easily in such permeable part.

[1] Sato et al., Rock stress measurement in 1000m -deep boreholes around Tono area-, JNC technical review, No.5, 1999.

Keywords: Permeability, Permeameter, Toki granite, Fracture property, Hydrothermal alteration, Anisotropy

Japan Geoscience Union Meeting 2012
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SCG61-04 Room:104 Time:May 20 09:45-10:00

Smectitic Alterations in Drill Cores obtained from the campus of Tokai University, Hiratsuka, Kanagawa Prefecture

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In the geological disposal of radioactive waste, cementitious materials and bentonite, which contains smectite as a major mineral component, are to be used as part of the engineered barrier system. Natural analogues of the reactions between cementitious materials and bentonite have been studied to understand reactions on the timescale of tens of thousands of years and longer. Drill cores were obtained from the campus of Tokai University in Hiratsuka, Kanagawa Prefecture, for a natural analogue study of smectitic alterations in the calcium-rich water released by cementitious materials.

A sandy tuff with smectite was observed in drill cores from depths of 239.7 to 250 m, the deepest of the drill cores. Foraminifera microfossils were found in the sandy tuff, suggesting that the tuff was deposited under the sea. Fission-track and uranium-lead dating of the zircon in the sandy tuff were performed to obtain ages of ca. 10 Ma, and thus, it was estimated that the sandy tuff was deposited at or later than ca. 10 Ma. The altitude of the drilling location was assumed to have come above sea level at ca. 0.13 Ma (Oka, 1980), and so the sandy tuff was thought to have been under the sea for a maximum period of ca. tens of millions of years.

Two types of smectite were observed coexisting with zeolite in the sandy tuff, suggesting that two different types of smectite were formed in at least two different periods.
a) Smectite formed as a result of zeolite alteration: Electron probe micro-analysis (EPMA) indicated that the smectite belonged to dioctahedral montmorillonite. The oxygen-isotope geothermometer, obtained from the isotopic equilibrium of stable oxygen isotopes in the smectite and the coexisting zeolite, indicated temperatures ca. 40 degrees C.
b) Smectite with calcite: Both minerals are included in the zeolite crystal, and EPMA indicated that the smectite was trioctahedral saponite. The oxygen-isotope geothermometer indicated temperatures ca. 165 degrees C.

The chemical compositions of smectite and plagioclase in the sandy tuff were analyzed using EPMA. The results show that variations of Ca/(Ca+Na) at different depths were similar in the smectite and the plagioclase, and suggested that a possible source of the calcium in the smectite was from the dissolution of the plagioclase.

A numerical analysis of long-term alteration was performed to examine whether the mineral composition of the sandy tuff could be explained by calculations based on thermodynamic data. In this analysis, a hypothetical mineral composition calculated based on the chemical composition of non-altered rock near the drilling location was used as the starting material, with seawater as the reacting fluid. The deposit of only Na-type montmorillonite was permitted, and the number of sites for ion exchange was decided by the amount of Na-type montmorillonite. Other types of montmorillonite including Ca, K and Mg, were formed in the exchange of ions between the reacting fluid and each type, based on the selectivity coefficient for ion-exchange reactions.

From the numerical analysis, it was found that the mineral composition became stable after ca. 10 000 years. The mineral composition resulting from the analysis included Ca-type montmorillonite and saponite as the dominant smectites, followed by Na-type montmorillonite and saponite. The above sequence of smectites was coincident with the sequence observed in the sandy tuff. The concentrations of each element in the reaction fluid in these results were coincident with the measured concentrations of the water in a hot spring near the drilling location, showing differences within two orders of magnitude.

ACKNOWLEDGMENTS
This research is a part of ”Evaluation Experiments of Long-Term Performance of Engineered Barriers FY2011” under a grant from the Agency of Natural Resources and Energy, the Japanese Ministry of Economy, Trade and Industry.

Reference
Oka, S., 1980, Sagami sedimentary basin, Urban Kubota, no.18, p.26-33, in Japanese

Keywords: radioactive waste, geological disposal, natural analogues, bentonite, smectite, alteration

Japan Geoscience Union Meeting 2012
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SCG61-05 Room:104 Time:May 20 10:00-10:15

Development of new evaluation technique of long term geomechanical interaction between bedrock and buffer in near-field

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The objective of this paper is to evaluate a long term behavior which is a coupled thermo-hydro-mechanical processes in the near-field of a geological repository for high-level radioactive waste (HLW) disposal by the **centrifugal model test**. To clarify the **long term behavior in the near-field**, the researches by the full-scale test and the numerical analysis have been carried out. The numerical study is able to evaluate the long-term behavior in near-field. For a verification of applicability of numerical model, however, it is difficult to conduct a long-term full-scale test due to a place, time, and economic restraint. If the experiment of the small model of near-field based on the centrifugal scaling law that can supplement these problems becomes possible, a long term reliability of the disposal repository can be improved by acquiring the empirical laboratory data.

The model specimen consists of a cylindrical rock mass (Tage tuff) of 180 mm in a diameter and length, bentonite buffer (Kunigel-V1) and model overpack (SUS). The borehole (disposal pit) of 57 mm in a diameter and 127 mm in a height was drilled at the center of the rock mass. These are the size of 1/30 proposed in the report of *CRIEPI & FEPC (1999)*. The model specimen in the study was enclosed with the pressure vessel, and centrifugal model tests were conducted at 30 G of centrifugal force field in isotropic stress-state conditions with confining pressures of 2 to 10 MPa and injecting water from the bottom of model specimen. The centrifugal tests were conducted up to two months (165 equivalent years in conversion time of full-scale).

As results, a slight settlement due to self-weight in the displacement of the model overpack was measured after injecting water. After that, the model overpack heaved rapidly and a maximal was measured, and then, the overpack tended to a gradual settlement. The value of heave was several times as large as the settlement. The soil pressure of buffer did not occur until the buffer absorbed water and began to swell, and increased rapidly swelling begins. Then, it tended to a gradual decrease after a maximal was measured. In terms of the maximal of displacement of overpack and soil pressure of buffer, these value were obviously different depending on the confining pressure (**confining pressure dependency**). In addition, these measured values after the maximal in this study were not converged even after up to two months in test-time (**time dependency**). These behaviors are distinctly different from the results of previous centrifugal model test *(Nakamura & Tanaka, 2009)* in a strain-state condition using a stainless steel test vessel which the values have converged in about 50 to 70 equivalent years. Thus, we first revealed experimentally that **a long term behavior in the near-field was changed by geomechanical interaction between the deformation of bedrock (disposal hole) and swelling behavior of buffer depending on earth pressure**, and **did not converge even in the long term experiments by the interaction**.

Keywords: High-level radioactive waste disposal repository, Near-field, Centrifugal model test, Long term behavior, Geomechanical interaction

Japan Geoscience Union Meeting 2012
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SCG61-06 Room:104 Time:May 20 10:15-10:30

Redox buffering of host rock and its suitable repository depth

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Buffering capacity of underground environment is one of the important function for geological disposal of radioactive waste. This paper will be discuss about the suitable depth in terms of buffering capacity of geological environment.

Keywords: Underground environment, Redox processes, Buffering capacity, disposal depth

Japan Geoscience Union Meeting 2012
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SCG61-07 Room:104 Time:May 20 10:45-11:00

Approaches to quantitative determination of surface erosion rates

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It is needed to evaluate surface erosion rates for landform evolution. However, at present, appropriate methods for quantitative determination of long-term (100000-1000000 yr) erosion rates have not been established in Japan. We will refer problems attributable to previous methods for determination of surface erosion rates and introduce in situ cosmogenic nuclides as a new powerful and useful approach in this presentation.

A part of this research project has been conducted as the regulatory supporting research funded by the Japan Nuclear Energy Safety Organization (JNES), an incorporated administrative agency, Japan.

Keywords: erosion rate, in situ Terrestrial Cosmogenic Nuclide, depth profile

Japan Geoscience Union Meeting 2012
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SCG61-08 Room:104 Time:May 20 11:00-11:15

Uncertainty in the temporal scale on earthquake and fault activity

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It is needed to evaluate stability of landform surfaces for the Geological Disposal of Radioactive Waste. It takes several 10^5-10^6 years for Nuclides indicated as high-level radioactive waste to get into equal to its abundance in nature. Therefore, notably, long-term (10^5-10^6 year) earthquake and fault activity is important consideration in the evaluation of surface stability to prevent radioactive waste from accessing near surfaces. We discuss about the uncertainty in the temporal scale on earthquake and fault activity.

A part of this research project has been conducted as the regulatory supporting research funded by the Japan Nuclear Energy Safety Organization (JNES), an incorporated administrative agency, Japan.

Keywords: Geological disposal, Earthquake, Fault, Stress, Groundwater Flow System

Japan Geoscience Union Meeting 2012
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SCG61-09 Room:104 Time:May 20 11:15-11:30

Stress field analysis around faults for the safety assessment of reactivation of pre-existing faults

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The safety assessment of reactivation of pre-existing faults is necessary for preliminary field investigations of HLW geological disposals (Research Center for Deep Geological Environments, editor, 2007). Slip tendency analysis (Morris et al., 1996) is considered of value for evaluating the likelihood of reactivation of multiple pre-existing planes under a uniform stress state. However, the principal stresses may rotate due to damage zone (Caine et al., 1996) surrounding faults (e.g., Rice, 1992). Thus, understanding stress field around faults are important for slip tendency analysis.

We applied a stress inversion method to the fault-slip data from the Atera fault system in Kawakami area. In this area, about 40 m width damage zone develop around the fault system (Niwa et al., 2009). For calculation, we mainly used fault-slip data reported by Tonai et al. (2011).

The calculation of multiple inverse method (Yamaji, 2000) resulted in a strike-slip faulting stress regime with a E-W (N-S) trending sigma_1 (sigma_3) axis for fault-slip data obtained from near the main fault plane, a strike-slip faulting stress regime with ENE-WSW (NNW-SSE) trending sigma_1 (simga_3) axis for fault-slip data obtained apart from the main fault plane, and a stress regime with NW-SE trending sigma_1 axis for fault-slip data from host rock around the main fault.

The result probably shows that the stress field around the main fault of the Atera fault system is heterogenous. It is possible that the damage zone surrounding faults is affected such stress field. In addition to stress field analysis with high space resolution, comparative consideration between several fault systems is important for the understanding of the role of damage zone for stress field around faults.

A part of this research project has been conducted as the regulatory supporting research funded by the Nuclear and Industrial Safety Agency (NISA), Ministry of Economy, Trade and Industry (METI), Japan.

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Keywords: stress inversion, damage zone, fault, the Atera fault system

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SCG61-10 Room:104 Time:May 20 11:30-11:45

Time-scale of uncertainty on long-term forecasting for volcanic activities in Japan

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In the forecast of volcanic activities for geological disposal, the foundation will be to clarify the trends of the geological history for the activities that occurred in the assessment area, and to extrapolate this into the future. The Quaternary volcanoes are not distributed evenly throughout the Japan Islands, and their presences are determined by the plate arrangements. This means that the Quaternary volcanoes of the Japan Islands are most densely distributed on the volcanic front located 200˜300 km away from the subduction boundary of the plates toward the plates on the landside, and there is no volcano in the fore-arc region. Also there is a significant tendency where the volcano distribution becomes sparse in the area distant from the back-arc side or area opposite the volcanic front. However, the migration history of the volcanic front differs in individual subduction-arc systems. In evaluating the volcanic activities, it is necessary to understand the conditions of magma generation that is the origin of the volcanic front, in accordance to the spatiotemporal changes of the activity region.

Keywords: volcanic activity, geological disposal, long-term forecasting

Japan Geoscience Union Meeting 2012
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SCG61-11 Room:104 Time:May 20 11:45-12:00

Geological prediction and tectonically linear continuity based on geomorphic development model

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Geological prediction and tectonically linear continuity based on geomorphic development model