Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

HCG36-01 Room:411 Time:April 29 15:15-15:30

Relationship between progress of borehole investigations and the geometric data of fractures at the crystalline rocks

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In order to evaluate deep geological environment for geological disposal of high level radioactive waste (HLW) and underground storage of liquefied petroleum gas, understanding of the geometry of water conducting features such as fractures is essential. Geometric data of fractures are obtained by borehole investigations. But, methodology to understand the geometry of fractures has not been established in terms of planning borehole investigation such as number and total length of boreholes. Thus, relationship between progress of borehole investigation and increase of the geometric data of fractures is studied.

In this study, discrete fracture network models with the size of 100×100×100m cube were used as virtual fractured rock mass, and virtual boreholes were drilled in the virtual rock mass. Five boreholes with the length of 100m each were located in four directions. One dimensional fracture intensity (as the number of fractures per unit length; P10) of virtual boreholes is calculated. The P10 is depending on the relationships borehole directions and fracture orientations. In addition, The P10 is become constant at each direction of borehole as investigations progressed.

These results suggest that in order to obtain the geometric data of fracture, the borehole investigation should be planned in consideration of distribution of the fracture orientations.

Keywords: Borehole investigation, DFN model, Methdology, Fracture intensity

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HCG36-02 Room:411 Time:April 29 15:30-15:45

Characterization of the fracture zone on the basis of fracture spacing, case study at the Toki granite, central Japan

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In order to evaluate deep geological environment for geological disposal of high level radioactive waste, understanding of the geometry of water conducting features such as fractures is essential. The fracture zones have been divided based on the fracture intensity that has been obtained deep boreholes. But fracture intensity could be changeable in different portion of the rock body. The method to divide the fracture zones based on fracture spacing is studied. In this study, cumulative frequency curve of fracture spacing based on fifteen deep borehole with the total length of ca.12,000 meters was used. Cumulative frequency curve shows that half of fracture spacing is lower than 1m. Thus, fracture could exist in fracture zones. The fractures with the dip of middle to high angle are needed to divide into fracture zones based on the fracture spacing. In the future, we will establish the methodology to divides the fracture zones coupled with spatial distribution of fracture spaces.

Keywords: fracture zone, fracture spacing, Toki granite

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HCG36-03 Room:411 Time:April 29 15:45-16:00

Examination of realistic conceptual model of near-field process in HLW repository

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Since 2000, data of deep underground has been accumulated through the URLs in-situ studies and related underground investigation. Based on these data, here we show the result on the examination of realistic conceptual model of near-field process in HLW repository.

Keywords: Geological Disposal of Radioactive Waste, Near filed processes

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HCG36-04 Room:411 Time:April 29 16:15-16:30

An approach to establish information basis of Weathered zone for the Safety Assessment to HLW Disposal over long-term.

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The consideration of evolution on geological environment is required in the safety assessment of geological disposal for the high level radioactive waste (HLW). The HLW repository can be expected to come close to ground surface assuming a continuous uplift and erosion for a long-term period. Therefore, the consideration of shallow zone (weathered zone) environment is also required. Since the geological condition in the near-surface underground is different from that in the deep underground due to weathering, the basic information and understanding for the near-surface condition are essential for the scenario development. Therefore, information regarding weathered zone is surveyed and arranged based on available literatures.

As a result, 37data of depth (thickness) of weathered zone were extracted. Then the data distribution and these characteristics for the thickness of weathered zone were discussed. In order to understand the formation process of weathered zone, the relation between weathered zone and landform was also discussed and categorized into four patterns. The key factors which account for the patterns are also analyzed in a qualitative manner.

Regarding the geological property/condition in the weathered zone, although information on hydraulic and chemical conditions are very limited, information on tensile strength and porosity are available.

For the sake of condition setting for near-surface underground in the long-term safety assessment, continuous research and development for the characterization on weathered zone are important.

Keywords: HLW, Long-term, Safety Assessment, Weathered Zone, Landform, Geological Environmental Conditions

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HCG36-05 Room:411 Time:April 29 16:30-16:45

A Bayesian approach to assess the probability of concealed active faults existing using helium isotope ratios

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In Japan, numerous studies have been carried out to assess the stability of the geological environment including in particular, the spatio-temporal distribution of active faulting in the context of site selection of a radioactive waste repository and/or assessing the safety of current nuclear facilities etc. One key concern is the existance of active faults that do not show any surface rupture.

High He-3/He-4 ratios which tend to be found in volcanic regions have also been measured in non-volcanic regions. This has been attributed to degassing from the mantle with faults potentially acting as conduits (e.g., Kennedy et al., 1997). Studies carried out in the western Tottori district have shown the potential of using He-3/He-4 ratios as a means of providing indirect evidence of the existence of source fault(s) that caused the 6 Oct 2000 Tottori earthquake (Mw 6.8), but which had no apparent surface indication prior to the earthquake (Umeda and Ninomiya, 2009).

Here we introduce a new technique based on Bayesian inference in an effort to quantify this theory. In the Bayesian paradigm, we make *a priori* assumptions based on the tectonic setting of the study area as a starting point. 'Known' active faults are divided into equal distant fault segments. The *a prior* assumption here is that 'unknown' fault segments do not exist far from 'known' fault segments. It is also assumed that the probability of 'unknown' faults existing decreases with distance from the 'known' faults.

2D *a priori* probability distributions of unknown fault(s) existing are then calculated using kernel functions (Martin et al., 2003) centered over the known fault segments. A Cauchy probability density function (PDF) is assigned here conservatively as the *a priori* distribution in the first step so that probability is never zero.

In the second step, the method developed by Martin et al. (2004, 2012), is adapted to remap He-3/He-4 ratios into a PDF, called a likelihood function based on Kolmogorov-Smirnov statistical tests. The *a prior* PDF from the first step above is then combined with the likelihood PDF using Bayes's rule to produce a *a posteriori* PDF.

Carrying out the calculation using data from before the Tottori 2000 earthquake, the *a posterior* 2D probability maps showed increased probability of unknown active fault(s) existing in the region above the source zone of the 2000 earthquake. Thus, in the case of the Tottori region, the *a posterior* probabilities corraborate the theory that faults could be acting as conduits for mantle helium.

The potential of the methodology to incorporate other information such as gravity and crustal strain rates will also be presented and discussed.

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Keywords: Active fault, Bayesian, Helium isotope ratio

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An active shear zone, southwest Japan: electromagnetic geophysics and noble gas geochemistry

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In 1997, the Kagoshima earthquake doublet with two Mw ˜6 strike-slip events struck 5 km and 48 days apart in southwest Japan, where an E-W trending discontinuity along 32 degree N latitude in GPS velocities across southern Kyushu Island is clearly defined, indicating a highly active left-lateral shear zone. However, there was no obvious prefaulting indication at surface (active fault) in relation to the shear zone. Three-dimensional inversion of magnetotelluric sounding data observed in the source region of the the earthquake doublet reveals a near-vertical conductive zone with a width of 20 km, extending down to the base of the crust and perhaps into the upper mantle. The prominent conductor corresponds to the western edge of the active shear zone. Elevated 3He/4He ratios of groundwaters sampled around the seismic source region suggest the emission of mantle-derived helium from the electrical conductor. The geophysical and geochemical observations provide significant evidence that the invasion of mantle fluids into the crust, driven by upwelling asthenosphere from the Okinawa trough, triggers off the notable left-lateral shear zone in the present-day subduction system. In addition, the conductive fluids enhance stress concentration in the seismogenic layers leading to mechanical failure of strong asperities, resulting in the occurrence of the 1997 earthquake doublet.

Keywords: 1997 Kagoshima earthquake doublet, active shear zone, magnetotelluric sounding, helium isotope

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HCG36-07 Room:411 Time:April 29 17:00-17:15

Predominant process for transport of radiocaesium released by the TEPCO's Fukushima Daiichi Nuclear Power Plant Accident

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Understanding the environmental dynamics of the radiocaesium (particularly Cs-134 and 137) released from the Fukushima Daiichi Nuclear Power Plant provides the firm foundation for a remediation of the Fukushima environment because it is the main radionuclide to radiological dose within the contaminated area. One of the main sources of radiocaesium under the current situation is a mountain forest, where the decontamination work has not been carried out as yet. Therefore, transport process, flux and chemical form of the radiocaesium flowing from the mountain forest are crucial issues for an evaluation of a radiation exposure, taking into a dynamics behavior of radiocaesium from the highest contaminated mountain forests down through the river to eventual deposition in the sea. This paper discusses the predominant process of the radiocaesium transport in the mountainous region, Fukushima, Japan.

The four investigation areas, which have different characteristics of vegetation, geomorphology and soil type, were selected in the Abukuma Mountain, eastern part of Fukushima. The soil samples were obtained from ridge, slope, and valley bottom in the areas by soil sampler and scraper plate to the depth about 40 cm and 20 cm, respectively. The observation plots, which have an area of 40 to 60 m2, for a monitoring of surface runoff and soil loss are also installed. The concentration of radiocaesium in the uppermost soil horizon is related to the geomorphological aspects, that is, the concentration trends to be higher in the depositional area than in the erosional area. Additionally, the radiocaesium concentration of solid phases (soil particles and fragmented organic materials) including in surface runoff is one to two orders of magnitude greater than that of a liquid phase (running water).

Therefore, predominant process of the radiocaesium transport is the surface runoff accompanied with a detachment of soil particles from the mountain slope.

Keywords: radiocaesium, environmental dynamics, mountain forest, nuclear accident, Fukushima

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Current State of the additional geological surveys of crush zones at the fast breeder prototype reactor ”Monju” site

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Background: In the fast breeder prototype reactor Monju of the Japan Atomic Energy Agency (JAEA), a report of the additional geological survey regarding the crushed zones at the Monju site was submitted to the Nuclear Regulation Authority (NRA) on April 30, 2013. The NRA instructed to develop a further additional research plan on September 25. Accordingly, JAEA compiled and submitted the plan on October 3, followed by a ”preliminary report” on November 29, and a ”complete report” in March 2014.

Overview of additional research: The instructions from the NRA of September 25, 2013 were as follows:

1. to implement the dating of materials within the crushed zones, to research the displacement markers, and to understand their formation age, etc.,in order to enhance understanding of the activity of crushed zones at the Monju site in the bedrock of the site investigation area; 2. to investigate the distribution of the fracture zones, the relationship of the sediment layer, and the depositional age of the sediment layer (14C dating, tephra analysis, etc.) for data expansion of the extended portion of the L-2 lineament located near the Monju site; and 3. to implement marine seismic surveys in the coastal sea area and geographical and geological surveys ofthe coast, etc., in order to understand the geological structure and activities of the coastal seabed in the extended portion of the Shiraki-nyuu active fault and the L-2 lineament.

JAEA developed a research plan in response to these instructions and conducted the stripping investigation over an expanded area, the additional detailed geographical and geological surveys around the mountains/terrace boundary, and the marine seismic surveys in the coastal waters.

Summary of findings: The basement rock of the northern Tsuruga peninsula where the Monju site is located is composed of the Late Cretaceous-Paleogene granite known as the Kojyaku granite. In the on-site investigation, the stripping area was extended in the northern direction of the longest fracture zone in the reactor building foundation rock. The fracture zones were grouped into 2 systems called α-system and β-system. We examined the cross-cuttingrelationships and displacementsof the fracture zonesand confirmed that the α-system was formed after the β-system. The α-system fracture zones are left-lateral faultsthat have mesh-like clay veinlets, and the width of the α-system fracture zones is several centimeters. The K-Ar ages of the basalt dyke displaced by the α-system fracture zones were about 19Ma. In addition, U-Pb and FT dating of apatite and zircon separated from the fracture zone materials and granite were conducted to reconstruct their thermal histories. The investigation results so far obtained were similar to the survey results of April 30, 2013, offering no clear evidence that the on-site crushed zones are of an active fault. It can be considered that these crushed zones are small-scale older (pre-Quaternary?) geological structures formed under the hydrothermal environment of the deep part before exposure of the granitic body. On the detailed geographical and geological surveys around mountainous/terrace boundary, no fracture zone along the strike of the boundary was observed. From the C-14 dating and tephra analysis of the depositional layer covering the granite, the distribution of sediments from about 40,000-50,000 years ago was confirmed in a few outcrops. The marine seismic surveys in the coastal waters were performed in conjunction with the bathymetric survey in December 2013. Currently, the data are being analyzed.

Upcoming: In order to further enhance the reliability of the investigation results and accumulate further data related to on-site geology and the underground, voluntary investigations are being conducted on a continuous basis. In addition, a basic study is also being carried out on the evaluation method of the activity of the fault zone not applicable to the overburden strata method.

Keywords: fast breeder reactor Monju, survey of crush zone, Kojyaku granite, Nuclear Regulation Authority