Japan Geoscience Union Meeting 2015
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HCG34-01 Room:101A Time:May 26 09:00-09:15

Formative process of fracture in granite on the basis of geological history at the Toki Granite, central Japan

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Fractures in the crystalline rock (e.g. granite) can act as groundwater pathways. Therefore, understanding of the fracture characteristics (e.g. frequency distribution and infilling minerals) is an important subject for the disposal of high-level nuclear waste. Geological setting and formation process of the granite can influence the fracture characteristics. Thus, this study discuss the relation between 'the formation of fracture and infilling mineral' and geological history from the emplacement to present in the Toki granite, Tono district, central Japan.

The thermochronology for the Toki granite (Suzuki and Adachi, 1998; Shibata and Ishihara, 1979; Yuguchi et al., 2011) and the age determination for the basal layer of the Mizunami Group overlaying unconformably the Toki granite (Sasao et al., 2006) gave the geological history (especially, cooling history) of the granitic pluton. The Toki granite cooled rapidly during about 20 million years after the emplacement to about 250 ^{o}C, and then the granite underwent exhumation with slowly cooling during about 50-30 million years until the subaerial exposure.

Brittle fractures occurred below the temperature of about 300 to 400 ^{o}C in the cooling granite, and thus the fracture filling minerals also occurred below such temperature. The fracture fillings collected from the Toki granite are hydrothermal minerals such as chlorite and mica clay mineral, hydrothermal and meteoric water-derived calcite. The hydrothermal calcite occurs in accompany with plagioclase sericitization in the country rock, that is, such calcite was produced by supplement of anorthite (Ca) component form plagioclase through the hydrothermal fluid (Ishibashi et al., 2014). Chloritization temperature in the Toki granite ranges from about 200 to 300 ^{o}C (Yuguchi et al., in press), which is indicator of formation temperature of the hydrothermal fracture fillings. The meteoric water-derived calcite was produced during the process in which the meteoric water seeped underground through the fractures in the granite. This phenomenon occurred in a period between the sedimentation of the Mizunami Group (20Ma) and present.

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Keywords: fracture, Toki Granite, geological history

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HCG34-02 Room:101A Time:May 26 09:15-09:30

Significance of the Hydrogeological Compartment Structure in the Geological Disposal Program

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As lots of major faults of low permeable fault core with higher permeable damaged zone on both side of the fault core have been reported in Japan, the fault compartment could generally exists. The existence of the fault core and damage zone could result in permeability contrasts between perpendicular and parallel to the fault zone.

In hydrogeological characterization of a potential disposal site, one of the specific concerns is to understand what happens if an underground facility is constructed in the fault compartment bounded by low permeable faults (hydrogeological compartment structure (HGCS)) within a fractured rock. Groundwater cannot easily flow into such HGCS from its surroundings, causing a huge drawdown in the HGCS. Hydraulic gradient and flow velocity would be lower value in the HGCS.

The existence of HGCS at a regional scale has also been suggested around the Mizunami area. Changes in static pressure heads and pressures in response to earthquake and cross-hole pumping test have been observed within a larger block bounded by the faults and/or lineaments.

If the HGCS could widely be distributed in Japan, site suitability of the HGCS for a high-level radioactive wastes (HLW) repository should be evaluated by the site characterization

In this study we extracted fault compartment in Japan based on the Geomap Navi released by AIST. The extracted compartment structures are about 1,400 from Hokkaido to Kyushu district. Based on the histogram of the size of the compartment structure, the abundant size in Japan is 2.25-9 km^2 except for the Shikoku district. This size is almost correspond to the HLW repository area

Lower hydraulic gradient and flow velocity inside the HGCS could be suitable for the repository from hydrogeological view point, while slow recovery of the groundwater in the structure causing the long duration of the oxidation condition could not be suitable from the hydrochemical view point. Characterization of the bounded fault of the HGCS should be studied in detail in each case. Prediction of the groundwater flow and mass transport by the numerical simulations are also needed.

Keywords: hydrogeological copartment structure, geological disposal, site characterization, high-level radioactive waste, Geomap Navi

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HCG34-03 Room:101A Time:May 26 09:30-09:45

A Bayesian approach to assess the probability of concealed active faults existing from multiple datasets

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Assessing the stability of the geological environment including the spatio-temporal distribution of active faulting is of particular concern in the context of site selection of nuclear facilities such as radioactive waste repositories and nuclear power plants.

In order to assess the spatio-temporal distribution of active faults, one typically starts by looking at mapped active faults (e.g. AIST's active fault database) to estimate spatial frequencies and orientations. However, active faults listed in current databases do not represent a complete picture of active faulting, as not all active faults have a surface rupture, and their existence might be unknown. In this case, additional datasets are needed that may imply the existence of active faulting.

Datasets such as high He-3/He-4 ratios which tend to be found in volcanic regions have been attributed to degassing from the mantle with faults potentially acting as conduits. 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 2000 Western Tottori earthquake, but which had no apparent surface indication prior to the earthquake (e.g., Umeda and Ninomiya, 2009). Other factors that may need to be taken into account when assessing the existence of active faults include horizontal stress orientation, change in stress regimes, regional stresses and so on.

The Bayesian approach can be used to construct probabilistic models from multiple datasets in order to assess the likelihood of given natural phenomena occuring over defined time periods. This method has previously been applied to assessing future new volcano formation (e.g. Martin et al., 2004, 2012) but not to new active fault segment formation. We have thus been developing such a Bayesian model in the Western Tottori district as a case study. In the first step, known active faults are divided into equal fault segments. We assume that unknown fault segments do not exist far from known fault segments. Also, the probability of unknown faults existing decreases with distance from the known faults. 2-D *a priori* probability distributions are calculated using kernel functions centered over the fault segments with varying values of standard deviation depending on the degree of conservation required. A Cauchy probability density function (PDF) is assigned conservatively as the kernel function in the first step so that probability is never zero.

In the second step, Kolmogorov-Smirnov statistical tests are used to remap additional datasets (e.g. He-3/He-4, horizontal stress orientation) into a likelihood PDF. The *a prior* PDF from the first step above is then combined with the likelihood PDF using Bayes' rule to produce a *a posteriori* PDF. In the third and final step, the *a posteriori* PDF is evaluated by comparing probability maps calculated from datasets before and after the 2000 Western Tottori Prefecture earthquake.

The whole procedure can be repeated as new information/data becomes available where the derived *a posteriori* PDF from the first cycle is then used as the starting point, i.e. the *a prior* PDF in the next cycle.

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Keywords: Active fault, Bayesian approach

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HCG34-04 Room:101A Time:May 26 09:45-10:00

Cesium adsorption on redox zone pumice tuff at different geochemical condition

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Non-redox-sensitive element Cesium (Cs) was used to investigate the ionic strength effect on the adsorption behavior on a potential host rock for low and intermediate radioactive wastes. Now-a-days, formation of redox zones in subsurface host rock formation surrounding radioactive disposal facility is a major concern. As such, different geochemical reactions during water-rock interaction around the disposal facility have gained interest to nuclear researchers. The present study attempts to compare the adsorption phenomena, an important geochemical reaction in waste disposal research field, between fresh rock and rock from such redox zone of an underground research facility of Japan. The surrounding rock formation is rhyolitic pumice tuff belong to tuffaceous sandstone which has been affected by redox environment and oxidation to the rock formation has been greatly observed. Physical, mechanical and chemical analyses were carried out to distinguish between fresh and oxidized solid phase. Batch adsorption study was carried out at different geochemical condition including several initial nuclide concentration of Cs, ranging from 10^{-3} mol/dm^3 to 10^{-7} mol/dm^3; wide range of pH from 4-12, and very low to very high ionic strength ranging from 0.001 to 3.0 mol/dm^3. The ionic strength was controlled by Na^+ ion concentration of $NaClO_4$. Based on experimental distribution coefficient values, K_d, ionic strength was found to be the most influential for Cs adsorption on both oxidized and fresh pumice tuff. With increasing salt concentration, the K_d of cesium apparently decreases, reflecting the competition of the electrolyte Na^+ with the sorption of Cs^+. However, such salt concentration effect became minimum at higher nuclide concentration due to its saturation capacity and a threshold concentration has been observed. Oxidation of pumice tuff did not affect the adsorption of Cs significantly even at variable salt concentration, due to being redox inactive element. Simple surface complexation model without considering the electrostatic layer has also been adopted to explain the adsorption mechanism.

Keywords: Cesium, Redox zone, Pumice tuff, Salt concentration, Adsorption coefficient, Surface complexation model

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HCG34-05 Room:101A Time:May 26 10:00-10:15

Preliminary study on the directional statistics of crush zones' strikes in the Kojaku Granite

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Introduction: Geological reports on crush zones in granitic basement rocks holding the FBR "Monju" by JAEA were submitted to the NRA, and they are under examination. In relation to the ensuring safety of important installations, there is a new horizon of open process of examination on practical geological problem between the NRA and electric power utilities. It is important to observe crush zones jointly and discuss objectively. In this preliminary study, more objective discrimination between orientations of small crush zones was carried out by means of directional statistics based on an awareness of field data should be discussed objectively. Then, a simple structural geologic interpretation was presented.

Problem: Intuitive discrimination that there were obvious two systems in crush zone (system alpha-3, strikes ca. 50 deg. ; system beta, strikes ca. 10 deg.) have been outlined from field observations. There should be an objective gauge.

Method: Prepare a sketch map of horizontal outcrop (1:200, ca. 15m squares) showing traces of high-angle crush zones and clay seams. Measure the strike and length of segments. The length is divided by unit length making a list of number of each strike. These strikes (0 - 180 deg.) are doubled for directional statistical approach. Mixture fitting method introduced by García-Portugués (2013) by means of the R version 3.1.2 (R Core Team, 2014) with "movMF" package (Hornik and Grun, 2014) is carried out. Resultant mean directions of each von Mises distribution are divided by two to convert direction to strike.

Result: Fitted number of mixture components of von Mises distribution is eight. Each of them has mean strike in deg., concentration parameter (kappa) and fraction (total = 1) as follows 10/12.5/0.147 (≒ system beta), 14/3.79/0.117, 26/3.22/0.134, 44/15.3/0.145 (≒ system alpha-3), 47/3.55/0.116, 66/2.55/0.110, 132/4.14/0.066, 169/4.63/0.167. The two systems correspond to components with higher kappa. A probability distribution function curve of eight components mixture shows two peaks (fig. 1). Estimations of kappa via directional statistics give a basis of the description that there are principal two systems of crush zone.

Discussion: Crush zones principally depict dextral sense of shear along the system beta, and sinistral one along the system alpha-3. Plastically deformed biotite grains are observed in both crush zones. Deformation temperature of them seems to be higher. Statistically comparable development, nearly orthorhombic symmetry, and cross cutting relationship between the two systems suggest the development of crush zones in conjugate manner. Bisect orientation of acute angle, 30 deg., indicate a shortening axis and elongation normal to it during deformation. This movement picture is inconsistent with continuing E-W shortening during late Quaternary. These lines of evidence suggest that crush zones are old geologic structure which could not be formed near the surface.

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Fig.1 A probability distribution function curve. x: strike in 0-360 deg., y: relative probability (mean=1).

Keywords: directional statistics, crush zone, Kojaku Granite, Monju

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