Radiocesium outflow related to the forest floor conditions in mountainous forest of the Abukuma Mountains,Fukushima

*Tadafumi Niizato[1], Yoshito Sasaki[1], Katsuaki Mitachi[1]

1. Japan Atomic Energy Agency

The outflow of Cs-137 from the mountainous forest floor was estimated in the Abukuma Mountains, Fukushima. The outflow rates are decreased with a cover rate of the forest floor by a litter layer. The result shows the important role of the litter layer and undergrowth on a migration control of the radiocesium outflow from the forest floor.

Keywords: radiocesium, mountainous forest, TEPCO' Fukushima Dai-ichi nuclear power plant accident

Expansion and alteration behaviors of NH_4-montmorillonite

*Ryohei Kawakita[1], Akito Saito[1], Hiroshi Sakuma[2], Sohtaro Anraku[3], Chie Oda[3], Morihiro Mihara[3], Tsutomu Sato[4]

1. Graduate school of engineering, Hokkaido University, 2. National Institute for Material Science, 3. Japan Atomic Energy Agency, 4. Faculty of engineering, Hokkaido University

Bentonite will be used as a buffer material in the geological disposal of radioactive waste due to the high swelling and cation exchange capacity of the main bentonite constituent Na-montmorillonite (Na-MMT). Replacement of the interlayer Na by other cationic species, however, can cause a significant reduction in the swelling behavior of MMT. Nitrate salts found in transuranic wastes can be reduced to form NH_4^+ in deep underground conditions. NH_4^+ ions could replace the interlayer Na cations of Na-MMT to form NH_4-MMT, but the swelling behavior of NH_4-MMT is not well known.
To improve understanding of the swelling behavior of NH_4-MMT, the expandability of a suite of homoionic MMT, including Na-MMT, K-MMT, Cs-MMT, and NH_4-MMT were investigated by XRD under controlled relative humidity (RH) conditions and supported by molecular dynamics (MD) calculations.
Differences in the swelling behavior of the suite of homoionic MMT were observed by XRD and could be largely explained in terms of the valence, the radius and the hydration energy of the interlayer cations. All these properties, however, are very similar for K^+ and NH_4^+ and so could not be used to explain the reduced swelling of K-MMT compared to NH_4-MMT under low RH conditions. Although it has been well known that K-MMT lost expandability by dehydration, it has not been well known whether this process would occur on NH_4-MMT or not.
First-principles MD calculations were conducted in a previous study (Shi et al., 2013) for NH_4-MMT containing only a small number of water molecules (less than 1.25 molecules per NH_4-MMT half unit cell). The hydrogen bonding and the network between the surface oxygen, interlayer NH_4^+ ion and water were reported to be increased by adding more water molecules to the interlayer. The basal spacing measured by XRD under controlled RH in the current study are consistent with the interlayer containing less than one layer of water, although the interlayer charge may be different between samples. It is also difficult to make direct comparisons with Shi et al.'s calculations and experimental results because the number of water molecules in the interlayer cannot be precisely controlled experimentally.
The classical MD simulations in the current study described the mixing enthalpy of MMT / water molecules system by including the number of interlayer water molecules as a variable. The potential functions and parameters of MMT and water molecules proposed by Nakano and Kawamura (2006) and Kawamura (2008) were employed in this study. Parameters on NH_4^+ are determined to reproduce NH_4Cl structure. The mixing enthalpy was used as an index to evaluate the swelling state stability. To consider the RH effect, the mixing enthalpy (H_{mix}) was calculated by: $H_{mix}=H_{(MMT+nH2O)}-(H_{MMT}+n\mu_{H2O})$, where the chemical potential of water, μ_{H2O} includes the effect of RH by: $\mu_{H2O}=\mu^0+RT\ln(P/P_0)$ (μ^0:standard chemical potential, R:gas constant, T:temperature(K), P_0/P:partial pressure of water) The minimum of H_{mix} indicates the stable hydration state of the MMT. In this study, n = 0 to 20 water molecules were added to homoionic MMT to understand the different swelling behavior of K-MMT and NH_4-MMT under each RH condition. It was found that the series of calculated mixing enthalpy was consistent with the XRD results under controlled RH. In the NH_4-MMT system, the hydrogen bond between NH_4^+ and surface oxygen on clay was confirmed from the radial distribution function. These hydrogen bonds make large basal spacing of NH_4-MMT rather than that of K-MMT at 0%RH, which lead to hydration at low RH condition compare to K-MMT because the expansion of smectite occurs when hydration of interlayer cation exceeds the electrostatic attraction between silicate layer and cation. This result indicates that NH_4-MMT is more

difficult to become non-expandable or less expandable mineral than K-MMT.
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Keywords: Expansion, Alteration, Ammonium, Potassium, Montmorillonite, Molecular Dynamics

Formation of magnesium silicates and its geochemical modeling at high alkaline conditions

*Haruko Hase[1], Tsutomu Sato[2]

1. Graduate School of Engineering, Hokkaido University, 2. Faculty of Engineering, Hokkaido University

In geological disposal of waste generated from reprocessing of spent fuel, a large amount of cement material is used for vitrified waste and grout, and the disposal site is predicted to be a high alkaline environment over time. Therefore, it is urgent to understand radionuclides migration and alteration of the barrier materials under high alkaline environment. In general, most mineral surfaces are negatively charged under high alkaline conditions. Therefore, negatively charged anions are poorly adsorbed to the mineral surface. Although the nuclide is considered to be poorly adsorbed in the safety assessment, the nuclide would be delayed by the dynamic processes such as precipitation and solid solution formation without adsorption. For example, layered double hydroxides (LDH), calcium silicate hydrate (C-S-H) and magnesium silicate hydrate (M-S-H) with positively charged surface and a high anion exchange capacity even at a high alkaline environment (Goh, Lim, and Dong 2008)，(Evans 2008). In this context, the objective in this study is to clarify the Mg-bearing phases produced by mixing the interstitial water of cement (high alkaline) and the groundwater of Mg-HCO_3 system in the geological disposal environment. For formation of LDHs, 50 mM of each of Mg ion solution ($Mg(NO_3)_2 \cdot 6H_2O$), Al or Fe ion solution ($Al(NO_3)_3 \cdot 9H_2O$ or $Fe(NO_3)_3 \cdot 9H_2O$), and silicate anion solution(Na_2SiO_3) as an initial solution was mixed with different ratios. After the mixing, these mixed solutions were adjusted to pH 9 or pH 12 and left at 25 ℃ for 24 hours. The reason for paying attention to silicate ions is that they are concerned about dissolution from cement materials and vitrified bodies used in waste disposal and considered to be analogues of ^{79}Se and ^{99}Tc.

In Mg-Al system, at pH 9, in the case of adding above 15 mM silicate ions, M-S-H and amorphous aluminium (with Al ion), or M-S-H and smectite (without Al ion) were precipitated. On the other hand, in the case of below 15 mM silicate ions, LDH (Mg/Al 0.5) and gibbsite or boehmite (Mg/Al 0.5) were precipitated At pH 12, in the case without Al ion and with Mg ion, brucite was confirmed. Moreover, M-S-H (Mg/Al 0.1) or LDH (Mg/Al 0.3) instead of gibbsite and boehmite were generated. In other systems, no change was observed with the precipitates at pH 9.

In Mg-Fe system, formation of LDH was confirmed in a system containing less silicate ion and much Mg ion, but ferrihydrite or M-S-H was precipitated in other systems containing Fe ion.

In order to investigate these results thermodynamically, by calculating and incorporating M-S-H and LDH database based on previous study(Hase et al. 2017), we could represent thermodynamically precipitated mineral species.

Keywords: magnesium silicate, layered double hydroxide

Background of assessing geological materials for a potential low and intermediate level radioactive waste repository in Bangladesh

*Mohammad Rajib[1], Chiaki T. Oguchi[2], Md. Golam Rasul[1], Ratan Kumar Majumder[1], Md. Ibrahim Khalil[1], Mohammad Zafrul Kabir[1], Farah Deeba[1], Md. Moniruzzaman[1]

1. Bangladesh Atomic Energy Commission, 2. Department of Civil and Environmental Engineering, Saitama University

Low and Intermediate level wastes (LILW) in Bangladesh are being generated from operation, repair and maintenance of 3MW TRIGA MARK-II research reactor (RR), 14 MeV Neutron Generator and research & commercial irradiators such as Co-60 and isotope production for medical purposes. The wastes arising from these sources are generally spent ion exchange resins, graphite, lead and polythene plugs, contaminated vials, hand gloves, plastic syringes, tissue papers, shoe-covers, protective cloths, plastic and metallic wares, spent and disused sources (SRS), activated carbon, gaseous discharges, etc. The radionuclides involved with these wastes are- Co-60, Cs- 134 & 137, Sr-90, Ir-192, Tc-99m, I-131, I-125, C-14, H-3, Ra-226, Am-Be neutron sources, Cm-244, Am-241, Cr-51, Mn-54, Zn-65, P-32, Sc-46, etc. Solid radioactive wastes are collected, segregated at the place of generation and stored in interim-storage rooms of the Central Radioactive Waste Processing and Storage Facility (CWPSF), developed by Bangladesh Atomic Energy Commission (BAEC) in cooperation with International Atomic Energy Agency (IAEA). Short lived radionuclides containing solid wastes are managed by delay-and-decay storage and released into the environment. Others are safely transported & stored in shielded enclosures within CWPSF. Besides, Bangladesh is implementing Nuclear Power Plant (NPP) projects by constructing two reactors of 1000 MW each. It is expected to have more LILW from this NPP which needs to be disposed safely. For safe disposal of LILW, a National Radioactive Waste Management Plan (NRWMP) has been formulated by BAEC where site investigations and processes for site selection for waste disposal facilities is one of the key issues.

For selecting a potential site for safe disposal of radioactive waste, Bangladesh have several apparently suitable geological formations, such as basement hard rock at more than 100 m depth and clay formations exposed at many locations to few meters only. The basement hard rocks of Bangladesh are tonalitic and granodioritic rocks, variously deformed to granitic gneiss and intruded by younger monzogranite having mineralogical composition of plagioclase, quartz and hornblende, with lesser amounts of biotite and potash feldsparand trace amounts of clinopyroxene, titanite and iron oxides. (Ameen et al., 2007). On the other hand, the tropical clays of the central part of the country, called Madhupur Clay Formations are typically highly weathered and reddish brown color. They are mainly composed of kaolinite, illite, chlorite and illite-smectite mixed layer minerals along with some non-clay minerals like quartz, crystobalite, orthoclase, microcline, plagioclase, calcite, siderite and dolomite and of intermediate to high plasticity inorganic clay (Haque et al., 2013; Hossain and Toll, 2006). Physical and engineering properties of these two types of geological materials have been studied by various researchers to some extent. However, their detail geochemical characteristics, specially the migration behavior for radionuclides and associated studies have yet to be investigated. The present study will review these two materials' properties for potentiality of hosting LILW repository with suggestions for future investigations.

Keywords: Basement hard rock, Madhupur Clay, Radioactive waste repository, Bangladesh

Backfilling test in the groundwater recovery experiment (2) Effective factors on saturation of backfilling material

*Yusuke Ozaki[1], Hironori Onoe[1], Yusuke Takayama[1], Kentaro Takayasu[1], Ryuji Takeuchi[1]

1. Japan Atomic Energy Agency

The purpose of this study is to identify effective factors that dominate the saturation process of backfill material for drift closure by numerical simulation of the Groundwater REcovery Experiment in Tunnel (GREET). The GREET, where a part of experiment gallery is filled with in-situ groundwater, is being currently performed at 500m depth of Mizunami Underground Research Laboratory. The backfill test is conducted in the experiment gallery using drilling pits filled with backfill material to obtain fundamental data of its hydro-mechanical behavior during the GREET.
In this study, sensitivity analysis focused on the effect of swelling deformation, hydraulic conductivity and unsaturated characteristics of the backfill material has been carried out. The results showed that the unsaturated characteristics is the sensitive factor for saturation process of backfill material.

Keywords: Backfill material, Saturation process, Numerical simulation

Estimation of hydrogeological properties of a fault by geochemical analysis of groundwater and mass transport analysis

*Junya Okajima[1], Koki Kashiwaya[1], Yohei Tada[1], Katsuaki Koike[1]

1. Kyoto University

Geological disposal is investigated for disposal of high-level radioactive waste. In geological disposal, it is required that radionuclides in the waste does not affect the biosphere even if they are transferred by action of groundwater. Therefore, understanding of groundwater flow regime around disposal site is important. Fault acts as conduit and/or barrier dependent on its internal structure and its hydrogeological property is not sufficiently understood. In this study, spatial and temporal variations of groundwater chemistry around a fault was estimated from geochemical analyses of groundwater samples and past data. Groundwater flow and mass transport regimes around the fault was interpreted by comparing the spatial and temporal variations and simulation results using three dimensional hydrogeological model.
Study area is the region around Mizunami Underground Research Laboratory of Japan Atomic Energy Agency (JAEA), Gifu prefecture, Japan. Main shaft of the laboratory is located adjacent to a fault referred to as Main Shaft Fault (MSF) with NW-SE strike and almost vertical dip. Groundwater samples were collected from 12 intervals of 5 boreholes on both sides of the MSF. Concentrations or isotope ratios of dominant dissolved ions, alkalinity, hydrogen and oxygen isotopes, sulfur hexafluoride, tritium were determined, and the spatial distribution and temporal change were considered by combining with geochemical monitoring data conducted by JAEA (Sai et al., 2011; Shingu et al., 2011; Shingu et al., 2012; Omori et al., 2013a; Omori et al., 2013b; Omori et al., 2014). In addition, a three dimensional hydrogeological model was developed, and groundwater flow analysis was carried out. Its results were used as boundary conditions in groundwater flow and mass transport analyses conducted using another model partly refined around the fault. The analytical results were compared with the actually measured values.
The sample analyses and past data revealed that spatial distributions of calcium, chloride, bromide ion concentrations, hydrogen and oxygen isotope ratios, and tritium concentration were different between both sides of the fault. Concentrations of calcium, chloride, and bromide ions similarly decreased with time only on the southwestern side of the fault. The results of the mass transport analysis considering the influence of the water drainage in the shaft excavation also showed decrease of chloride ion concentration only on the southwestern side of the fault. Head calculated in the groundwater flow analysis was different between both sides of the fault. In contrast, the mass transfer analysis of tritium showed infiltration of surficial young groundwater containing tritium along the damage zones on both sides of the fault. Estimated infiltration rate was larger on the southwestern side of the fault. These results indicated that the MSF acts as both of barrier and conduit.
This research was conducted under support of a grant from the Ministry of Economy, Trade and Industry (METI).

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Keywords: groundwater, environmental tracer, mass transport analysis

Estimation of fracture frequency on the basis of Rock Quality Designation

*Eiji Sasao[1]

1. Tono Geoscience Center, Japan Atomic Energy Agency

Introduction
Science Council of Japan mentioned importance of establishment of technology to search rock body with minor fractures. As a first step towards this subject, it is significant to understand the fracture frequency in many rock bodies in Japan.
Therefore the data widely obtained such as by borehole investigation should be available to characterise the fracture frequency. In this study, the speaker discussed the relationship between RQD (Rock Quality Designation) and fracture frequency focused on the Toki granite, central Japan, where a large number of borehole investigations have been carried out and the data on fracture were obtained.

Method
Fracture data used in this study were obtained by investigations in the boreholes drilled from the ground surface (17 vertical and 2 declined holes) and the underground research galleries (1 vertical and 4 horizontal holes). The total length of boreholes drilled in granite is 16,180 meters. Fracture data were obtained by the BTV investigation. The total number of fractures is 43,658 including 24,737 sharply defined fractures which has clear surface with high continuity. RQD values were calculated by sum of the intact lengths that are 10 cm or longer at 1 meter intervals.

Result and Discussion
Average RQD value of each borehole ranges from 79.9 to 98.6 with fracture frequency ranging from 0.7 to 6.6 fractures per one meter (for sharply defined fracture, RQD: 79.9 to 98.6, fracture frequency: 0.5 to 3.8 fractures per one meter). There is a significant correlation between RQD value and fracture frequency. Drilling lengths of boreholes drilled in granite are, from 329 to 1,185 meters in boreholes drilled from ground surface, 331 meters in vertical borehole and from 30 to 106 meters in horizontal borehole drilled from underground galleries.
This implies that correlation between RQD and fracture frequency is not affected by drilling length. The data are then divided into 100 meters length and those RQD values are compared with fracture frequency. Average RQD values at 100 meters intervals ranges from 68.0 to 100.0 (average value: 92.9) and fracture frequencies range from 0 to 9.2 fractures per one meter (average value: 2.8). The RQD value is also associated with fracture frequency.
This result indicates that the method proposed in this study can be ubiquitously applied to various lengths of borehole. Further examination on the additional data from granitic rock besides Toki granite is required.

Keywords: fracture frequency, Rock Quality Designation, Toki granite

Risk management of downward erosion in the coastal area for disposal of radioactive waste

*Ryuta Hataya[1]

1. Central Research Institute of Electric Power Industry

1. Introduction

In the report related to the selection of scientifically preferable areas for geological disposal of HLW in Japan, the coastal area was regarded as a more suitable area. The Research Group on Technical Issues of Geological Disposal at the coastal seafloor said that it was necessary to improve both survey and evaluation methods related to uplift/erosion. Meanwhile, in the deliberation on the regulation of medium-depth disposal, it is discussed that at least 100,000 years avoid the influence of remarkable erosion and securing the depth necessary for isolation even in consideration of erosion effect.
In coastal areas, rivers erode the ground downward. This research discusses the risk management framework of evaluation related to downward erosion in coastal areas, the way of risk-related decision making.

2. Outline of the framework of risk management of downward erosion for geological disposal

(1) Risk management policy
The law of geological disposal in Japan says that the influence of remarkable erosion must be avoided at the site selection. For example, facilities for geological disposal will not be exposed to the ground surface at least 100,000 years.
(2) Risk assessment
Following are conceivable about the amount of downward erosion in the coastal area for future 100,000 years.
[A] The amount of maximum erosion in the future 100,000 years is smaller than the sum of the maximum decrease and uplift of the sea surface for about last 100,000 years.
[B] In Japan, the amount of downward erosion during the glacial / interglacial one cycle is less than that of uplift after late Pleistocene plus 100m (Hataya et al. 2016).
[C] The amount of downward erosion that actually occurred in the past 100,000 years in each area is regarded as the downward erosion in the future 100,000 years.
(3) Risk treatment
In general, risk treatment is classified into four category: avoiding, reducing, sharing, and retaining. For examples, the former three issues are to exclude from the site, deepen the burial depth, select and develop multiple points respectively.

3. Discussion of risk criteria

For smooth decision-making, we often decide on the risk criteria for some risk, and compare it with the results of the survey and evaluation. In the chapter 3, I introduced the idea of risk assessment of three river downwards. From these, we can think about the following three risk criteria for the downward erosion in about 100,000 years in the future.
[A] Less than the sum of the maximum decrease amount and uplift amount of the sea surface for about last 100,000 years
[B] Less than the amount of uplift after late Pleistocene plus 100m
[C] Less than the amount of uplift after late Pleistocene plus depth of bottom of alluvium layer
Criterion-A accepts sea level fluctuation. If the sea level maximum decrease amount is larger than the assumed value in the future, the downward erosion becomes deeper. Furthermore, criterion-B holds the influence of uncertainty related to the depth distribution of the alluvium base. Criterion-C holds not only

the sea level fluctuation but also the uncertainty of the topography/geological survey. When future river channels can't be specified, we can select criteria-A and B, but we can't adopt Criterion-C.

4. Conclusion

This presentation doesn't state which of the risk standards is appropriate. I'd like to say the following. Accepting future projections, determining risk response policies, risk criteria, and risk response are to retain the underlying risks. This is commonplace. In the radioactive waste disposal project, which is required to see the long-term future, I believe that the following will provide effective information in decision making: They are to show the framework of risk management, to express concretely the research of risk analysis which is mostly carried out individually in this framework, and to explain the retaining risks.

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Keywords: geological disposal, coastal area, erosion, risk management

Assessing the probability of concealed active faults existing through Bayesian analysis of known active faults, historical seismicity and helium isotopes

*Andrew Martin[1], Koichi Asamori[2], Tsuneari Ishimaru[2]

1. National Cooperative for the Disposal of Radioactive Waste, 2. Japan Atomic Energy Agency

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 critical facilities such as nuclear power plants, spent fuel reprocessing facities as well as geological repositories or surface storage facilities of radioactive waste etc. Understanding the spatial distribution of active faulting is one of the challenges facing geologists in that not all active faults have surface experessions. This is especially so for active faults that initiated within the last 0.5 Ma due to their smaller cummulative displacements compared with older and more mature active faults (e.g. faults that have been active for 1 –2 Ma or longer) (Doke et al., 2012).

The western Tottori regions is an area where two recent earthquakes occurred along two separate unknown faults; the 2000 Tottori earthquake (6 October 2000; Mw 6.6) and the 2016 Tottori Earthquake (21st October 2016; Mw 6.2).

We present here a probabilistic approach based on Bayesian statistics that can be used to combine multiple datasets (in this case historic seismic data and helium isotopes sampled from wells) to produce hazard maps showing the likelihood of active faults existing or not.

In order to assess the spatio-temporal distribution of active faults, we start by looking at mapped active faults to estimate spatial frequencies and orientations. This data is sporadic as active faults listed in current databases do not necessarily represent all active faulting, as not all active faults have a surface evidence and their existence might be unknown. In this case, additional datasets are needed that may imply the existance 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. 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 and 2016 Tottori earthquakes (e.g., Umeda and Ninomiya, 2009).

We applied our Bayesian model in the Tottori district as a case study. In the first step, present known active faults are divided into equal fault segments. 2-D prior probability distributions are calculated using probability density functions (PDFs) centered over the fault segments with varying values of standard deviation depending on the degree of conservation required. A non-conservative PDF is assigned in the first step so that probability is never zero. In the second step, statistical tests are used to remap additional datasets, here He-3/He-4 and estimated historic seismic souce zones into a likelihood PDF. The prior PDF from the first step above is then combined with the likelihood PDF using Bayes’ rule to produce a posterior PDF. The posterior PDF is then evaluated using recent seismic activity.

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Keywords: Active Fault , Bayesian, Probability

