Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

MIS03-01 Room:104 Time:May 27 09:00-09:45

Volcanic islands as model systems to quantify pedogenic thresholds and determine their impact on Polynesian land-use

CHADWICK, Oliver[1*]

[1]University of California, USA

Soils and weathering profiles are complex emergent features at the surface of terrestrial Earth. They form a boundary layer hosting the chemical and physical interaction of biology and hydrology with rock. Soil development derives from the dissipation of chemical energy through reaction with rock minerals; few of the original reactants survive, but they are replaced by secondary products unique to the weathering environment. Soil processes filter and transform gasses and liquids passing through them, which in turn leads to chemical and mineralogical evolution of the fabric of soil itself. Soil chemical reactions are controlled by a number of feedbacks that buffer the system from rapid changes in external inputs, however there are limits beyond which the chemical system rapidly shifts into a new chemical domain governed by different buffer reactions. Globally soil distribution patterns are underlain by specific soil process domains that are separated by pedogenic thresholds at points of domain failure. Considering how soil process domains and thresholds determine the global distribution of properties, which control everything from agricultural productivity to carbon sequestration is a primary research focus for modern biogeochemistry. Soils are complex systems, which makes it difficult to develop clear understanding of how specific driving factors control soil process domains. It is common therefore to develop model systems that allow us to tackle specific questions with fewer complications. Here I discuss the use of volcanic islands in the Pacific Ocean as a model system to study how pedogenic thresholds control phosphorus and calcium availability to plants. I then combine that knowledge with archeological information to understand how the geographic constraints imposed by these thresholds determined Polynesian land use and agricultural productivity. As Polynesians radiated across the Pacific they encountered islands that presented many different local environments ranging from reef protected lagoons and minimal high island terrain to high volcanic islands with still active volcanoes. They brought with them an agricultural starter kit, but from there on they needed to adapt to their new surroundings. They practiced two major types of intensive agriculture: non-irrigated dryland and flooded-field irrigated farming. Typically young islands had soils with rich nutrient stores, whereas older islands had depleted soils that were not productive. By contrast, young islands had few large valleys to support irrigated agriculture, whereas the older ones had broad valleys allowing development of highly productive irrigation systems. Thus cultivators in rainfed systems brought their crops to areas where near-surface rocks were still weathering and supplying nutrients such as calcium and phosphorus, whereas in irrigated systems flowing water brought the products of weathering to crops. The contrast had profound implications for the development of culture across Polynesia. Behind these anthropological observations lies an equally fascinating story about how dramatically different soil properties are produced by non-linear responses to environmental forcing. In this talk I will explore the pedology of volcanic islands and relate it to pre-industrial human land-use decisions.

Keywords: Soil Chemistry, Biogeochemistry, Andisols, Soils

Japan Geoscience Union Meeting 2015
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MIS03-02 Room:104 Time:May 27 10:00-10:30

Can soil properties alone predict ecosystem processes?

KITAYAMA, Kanehiro[1*]

[1]Forest Ecology, Kyoto University

Soils are a reservoir of nutrients, which supplies plants with essential elements. Soil chemical properties can change spatially and temporary in relation to parent materials, climate and pedogenesis as a function of time. In places, the concentrations of essential elements in soils are extremely impoverished, which can eventually limit the net primary productivity of terrestrial ecosystems. Accounts by Elser et al. (2007), Vitousek et al. (2010) and many others indicate that available P is depleted in deeply weathered soils in the tropics due to a long process of geochemical occlusion and losses without substrate rejuvenation and that P limits the productivity of many tropical rain forests.

Colleagues and I have been extensively studying soil P fractions and productivity in Bornean tropical rain forests. Indeed, the concentrations of soil total P or labile P fraction are generally impoverished in comparison to temperate ecosystems but can still vary greatly reflecting parent materials or the status of pedogenesis. For instance, the concentrations of soil total P in seven tropical rain forests below 700 m asl in north Borneo are generally low, but range from 66 to 512 (μg/g). That of Bray-1 extractable P ranges from 0.2 to 4.2 (μg/g). Yet, above-ground net primary productivities of these forests are remarkably high and converge to a narrow range. Therefore, soil chemical properties do not correlate with productivity in plausibly P-limited tropical rain forests. Why soil P fractions cannot explain productivity?

We ecologists consider net primary productivity as a fundamental ecosystem process, which is expressed as the rate of net carbon fixation in an ecosystem context. Trees invest P for carbon fixation and the efficiency of the carbon fixation is expressed by the ratio of C flux to P flux, i.e. P-use efficiency in productivity. In these forests, P-use efficiencies greatly vary by 5-fold from 800 to 4000 (gC/gP) indicating that trees can adjust to the magnitude of P deficiency to maintain productivity. This is the major reason why soil P fractions cannot explain productivity.

Biological mechanisms to explain the enhancement of P-use efficiencies are two fold, one is the efficiency of photosynthetic C fixation per unit P in leaves and the other is the residence time of P in tree bodies. Colleagues and I investigated relative importance of these two mechanisms and found that the variation of residence time of P can much better explain the variation of P-use efficiency. Tropical trees increase the residence time of P in their bodies by increasing leaf life span and also by increasing P resorption from senescing leaves when facing to increasing P deficiency. We consider these are the two important plant traits which plants have acquired as adaptation. Our studies imply that understanding adaptive mechanisms as well as soil chemical properties is essential to understand ecosystem processes.

Keywords: Adaptation, Biogeochemistry, Net primary productivity, Nutrient-use efficiency, Soil P fractions, Tropical rain forest

Japan Geoscience Union Meeting 2015
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MIS03-03 Room:104 Time:May 27 10:30-10:45

Linkage of root physiology and morphology as an adaptation to soil phosphorus impoverishment in tropical montane forests

USHIO, Masayuki[1*] ; FUJIKI, Yasuto[2] ; HIDAKA, Amane[3] ; KITAYAMA, Kanehiro[4]

[1]Ryukoku Univ., [2]MURC, [3]Hokkaido Univ., [4]Grad. Sch. Agric., Kyoto Univ.

Tropical forests in Borneo maintain a high level of productivity/biomass even under phosphorus (P)-limited conditions. The P-acquisition properties of roots may be an important factor that contributes to forest productivity, but they have not been well evaluated compared with aboveground properties of plants. In the present study, we analyzed root acid phosphatase activity and morphological properties (surface area, diameter and tissue density of roots) of dominant tree species in three tropical montane forests on Mt. Kinabalu, Borneo, to investigate changes in root properties along a soil P availability gradient.

We found at the community level that root phosphatase activity and specific root surface area (root surface area per gram root biomass) increased, and root diameter decreased, with decreasing soil P availability at the community level, and the relationship was not changed in general even if we focused on a single tree species distributed across multiple study sites that differ in soil P availability. Root acid phosphatase was significantly positively correlated with specific root surface area, and negatively correlated with root diameter, suggesting that finer roots have higher phosphatase activities. Furthermore, we compared root acid phosphatase activity with leaf P concentration of a given tree species, and found a significant negative correlation between them. The significant correlation suggested that root P-acquisition properties could influence leaf P concentration, and/or vice versa. Belowground properties (i.e., root P-acquisition properties) might be directly/indirectly linked to aboveground properties (i.e., leaf P concentration) of a tree individual.

In conclusion, the root physiological and morphological properties change along a gradient of soil P availability in the tropical montane forests. In addition, the changes in the root properties are coordinated with the changes in leaf P concentrations. The adaptive changes in the aboveground and belowground properties along the soil P gradient could contribute to the maintenance of forest productivity in the tropical montane forest in Borneo.

Keywords: Phosphatase activity, Plant-soil interactions, Tree roots, Root surface area, Soil phosphorus availability, Tropical montane forests

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MIS03-04 Room:104 Time:May 27 11:00-11:15

Distinctive pools and chemical species of phosphorus among density fractions of allophanic and non-allophanic Andisols

TAKAMOTO, Akira[1] ; HASHIMOTO, Yohey[1*] ; WAGAI, Rota[2] ; ASANO, Maki[3]

[1]Tokyo University of Agriculture and Technology, [2]National Institute for Agro-Environmental Sciences, [3]University of Tsukuba

Andisols with abundant aluminum (Al) and iron (Fe) oxyhydroxides are characterized by a high phosphorus (P) retention capacity. Such property leads to a significant inhibition of plant growth in Andisols unless properly managed. Andisols are classified into two types in accordance with the difference in the clay mineral compositions. One type is referred to as allophanic Andisols, in which allophane and imogolite are present in the clay fraction. The other type is referred to as non-allophanic Andisols, in which Al- and Fe- humus complexes and 2:1 phyllosillicates are predominant. Based on the result of chemical extraction, it has been suggested that these clay minerals appear to contribute to P retention capacity of Andisols. Separating the different soil minerals in accordance with their density can limit the number of P-bearing phases, facilitating characterization of species and accumulating pools of P. The objective of this study was to characterize the species and distinctive pools of P in allophanic and non-allophanic Andisols using density separations in combination with sequential extraction and solution ^{31}P nuclear magnetic resonance (NMR) spectroscopy.

Allophanic and non-allophanic Andisols collected from Tsukuba and Osaki, respectively, were fractionated by sodium polytungstate into five density levels including 1.6-1.8, 1.8-2.0, 2.0-2.25, 2.25-2.5, and $>$2.5 g cm^{-3}. Phosphorus in each density fraction was extracted sequentially by deionized water, 0.5 M $NaHCO_3$, 0.1 M NaOH and 1.0 M HCl. After the extracts were filtered, the concentration of inorganic P (P_i) in all fractions was determined colorimetrically with a molybdenum blue method. The concentration of total P (P_t) in each fraction was determined by the same method after the solution was treated using H_2SO_4-persulphate digestion. The concentration of organic P (P_o) was calculated as the difference between P_t and P_i of each fraction.

The total concentration of P was similar in the allophanic and non-allophanic Andisols (6.2 g kg^{-1}). A large proportion of P_i and P_o in the bulk and each density fraction was extracted by NaOH, indicating that P in both Andisols was mainly associated with Al and Fe (oxy)hydroxides. The density fraction that accumulates P was contrastingly different between allophanic and non-allophanic Andisols where over 90% of P_i and P_o in the former was accumulated in the $>$2.0 g cm^{-3} fraction, whereas about 70% of P_i and P_o in the latter was found in the $<$2.0 g cm^{-3} fraction. According to the ^{31}P-NMR analysis, ortho-P monoesters were the primary organic P species for the allophanic and non-allophanic Andisols, although it was 2-folds more abundant in the latter than the former. In the non-allophanic Andisols, myo-inositol hexakisphosphate, an ortho-P monoester, was accumulated in the 1.8-2.25 cm^{-3} fraction.

Keywords: phosphorus, NMR, chemical speciation

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MIS03-05 Room:104 Time:May 27 11:15-11:30

Influence of feral goat and seabird activities on chemical properties of surface soils on an oceanic island in Japan

HIRADATE, Syuntaro[1*] ; MORITA, Sayaka[1] ; HATA, Kenji[2] ; OSAWA, Takeshi[1] ; SUGAI, Kyoko[2] ; KACHI, Naoki[2]

[1]National Institute for Agro-Environmental Sciences, [2]Tokyo Metropolitan University

Ogasawara Islands, subtropical oceanic islands in north-western Pacific of Japan, have been listed as Natural World Heritage by UNESCO since 2011 because of their valuable ecosystems sustaining many indigenous spices including plants and snails. Nakoudojima Island and its peripheral reefs are the important components of the heritage, but the island has been exposed to the serious influence of soil erosion damaging the indigenous ecosystems. Many areas on the island have been covered with native forests before the introduction of goats (*Capra hircus*) of ca. 200 years ago. The introduced goats had been naturalized on the island since 1945 at the latest, and they had destroyed the native vegetation by grazing and trampling, resulting in a shift of the native forests into grasslands and loss of the surface soils. To fix the problem, all the feral goats on the island had been eradicated in 1999. Although the recovery of seabird nesting for brown booby (*Sula leucogaster*) and wedge-tailed shearwater (*Puffinus pacificus*) has been observed, the soil erosion has still been serious and plant biomass has been very low in some places on the island at least in 2014.

To conserve the indigenous natural ecosystem and help the recovery of the natural vegetation, we conducted field survey and investigated the chemical properties of surface soil (0 – 5 cm) and aboveground plant biomass in relation to the topography of this island. Under grassland vegetation where influence of feral goat would have been severe, the chemical properties of surface soils, such as soil pH value, total C and N contents, exchangeable acidity, and plant-available phosphate (Bray II P), were highly variable even in a small area. By comparing soil profile characteristics under natural and disturbed vegetation and distribution patterns of these soils on the island, the changes in the soil chemical properties were reasonably assigned to the effect of soil erosion caused by feral goats for increased soil acidity (mainly found in inland valley area) and to the effect of seabird activities for increased Bray II P and soil acidity (mainly found in outer rim area with high altitude). It was also clarified that the high soil acidity was significantly related to the low productivity of plant biomass. Soil erosion would have removed surface soils having weak acidity and exposed subsoils having strong acidity to the ground surface, resulting in inhibition of plant growth and delay of vegetation recovery. Based on the findings obtained in the present study, several options were proposed to stop soil erosion and to recover the vegetation, although careful preliminary examination would be necessary for applying them.

Keywords: Nakoudojima Island, natural world heritage, plant-available phosphate in soils, soil exchangeable acidity, exotic species, soil erosion

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MIS03-06 Room:104 Time:May 27 11:30-11:45

Pedogenesis of tephra-derived soils in Japan

INOUE, Yudzuru[1*]

[1]Graduate School of Science and Engineering, Saitama University

In Japan, there are still 110 active volcanoes today, which occupy approximately 7 percent of those in the world. Some volcanoes in Japan are erupting now and continuing deposition of tephras on the land surface. They will become the parent material of the soils. Of the soils in Japan, tephra-derived soils 'Kuroboku soils (Andosols/Andisols)' are the second-most common group under the main classification scheme in usage, *the Unified soil classification system of Japan* (FCSCN, 2003). Many tephra-derived soils are distributed near and around numerous volcanoes in Japan. Tephra-derived soils composed of black soils (abundant humic soils), brown soils (mainly brown loamy soils: including tephric loess and loess), and Regosols (Tephric) (FAO, 2006) (very weakly developed mineral soils). It has been suggested that the black soils develop when the supply of organic matter by Gramineae grass exceeds the rate of addition of tephra parent materials (Inoue, 2002). It is usually stabilized by the formation of allophane and Al- (or Fe-) humus complexes. Origin of the abundant humus is confirmed by the high correlation between organic carbon content and phytolith content of Gramineae grass (Inoue et al., 2000; 2001 etc.). Most of the Japanese Holocene tephra-derived soils are rich in humus. Older buried humic-rich soils can also be observed in Late Pleistocene tephra-soil sequence in Japan (Inoue et al, 2011a). One of the tephra-derived soils 'brown soils' having poor in humus include an aeolian-reworked tephras (tephric loess; Pullar and Pollok, 1973) as main parent material. Tephric loess occurs in tephra-soil sequences in Japan and is also interlayered with 'background' loess derived from long-term (continuously-deposited) loess (aeolian dust) deposition from Gobi, Taklamakan desert, and the loess plateau in central Asia (Inoue and Naruse, 1987). This loess is barely observed in Japan. Sase and Hosono (1996) shows that pedogenesis of brown soils occurs under the forest vegetation by using vegetation changes from phytolith composition in tephra-soil sequence.

Pedogenesis includes both 'topdown' and 'upbuilding' models (Almond and Tonkin, 1999; Lowe, 2000; Inoue, 2001). Topdown pedogenesis is 'classical' soil formation that occurs by leaching, illuviation, and other processes that form andic materials with horizons developing in a downward-moving front. Upbuilding pedogenesis operates where the soil forms while additions to the soil surface of such materials as tephra or loess occur. If additions are sufficiently slow — typically as thin incremental deposits in distal areas — then topdown pedogenesis continues while the land surface slowly rises (referred to as 'developmental upbuilding'). If additions are thick or frequent, as typically occurs nearer volcanic sources, then the antecedent soil is buried and isolated, and soil formation begins again on the new materials at the land surface ('retardant upbuilding') (Inoue et al., 2011b; Lowe et al., 2008). The profile character is thus determined by the interplay between the rate at which tephras are added to the land surface and topdown processes. Understanding Andosol/Andisol genesis thus often requires a stratigraphic approach combined with an appreciation of buried soil horizons and polygenesis (Lowe and Tonkin, 2010). The terms 'developmental upbuilding' and 'retardant upbuilding' were first used by Johnson and Watson-Stenger (1987) and Johnson et al. (1990) as part of their dynamic-rate model whereby soils evolve by 'ebb and flow' through time (Schaetzl and Anderson, 2005). As mentioned above, most of the tephra-derived soils in Japan are formed by upbuilding pedogenesis and may be described as multisequal soils.

At the present day, theories concerning pedogenesis of tephra-derived soils in Japan are changing from long-established theories. The soils in the regions having numerous active volcanoes occur distinctive pedogenesis unlike in non-volcanic regions.

Keywords: soil, tephra, pedogenesis, tephra-derived soil, Andosols/Andisols, phytolith

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MIS03-07 Room:104 Time:May 27 11:45-12:00

Effect of climate on vegetation-soil system after volcanic ash deposition 7300 years ago on Yakushima Island

MUKAI, Mana[1*] ; AIBA, Shin-ichiro[2] ; KITAYAMA, Kanehiro[1]

[1]Graduate School of Agriculture, Kyoto University, [2]Guraduate School of Science and Engineering, Kagoshima University

Today's vegetation on Yakushima Island varies across elevations. Yakushima Island is covered with the Akahoya volcanic ash being derived from the Kikai Caldera about 7300 years ago. The eruption was so destructive that today's vegetation was established through primary succession after the volcanic eruption. The five independent state factors, which are climate, topography, organism, parent material and time, must have intricately affected the formation of the current soil-vegetation system. Among five factors, Climate including precipitation and temperature must have strongly affected the formation of today's vegetation. The purpose of this study is to clarify how climate has influenced the vertical distribution of the vegetation during 7300 years by investigating the relationships between soil mineral nutrients and nutrient-use efficiencies of the vegetation.

In this study, seven permanent study plots were set up along the elevation gradient. Soil samples (0-10, 10-20 cm depth) were randomly collected from each forest. We determined phosphorus (P) fraction in the soils following the method of Tiessen & Moir (1993). Inorganic nitrogen (N) and exchangeable cations were determined by using the extract with 1.5N KCl. P and N in collected fresh litter were determined by using Kjeldahl digests with concentrated H_2SO_4 and H_2O_2. We calculated mean values of soil elements in each forest and examined the relationships with temperature and precipitation. Temperature and precipitation data were cited from the publicized national numerical average data. Both data do not correlate with each other.

Soil total P (Pt) and inorganic N had a significant positive correlation with temperature but not with precipitation. Occluded-P (Occl-P) had a strongest negative correlation with temperature among P fractions. On the other hand, exchangeable cation had a stronger negative correlation with precipitation than with temperature. Pt and inorganic N had a negative correlation with each nutrient-use efficiency.

P is an essential element whose primary source is the weathering of minerals in parent materials. Considering that the pedogenesis on Yakushima Island is merely 7300 years, P in current topsoil must be derived primarily from the Akahoya volcanic ash. According to Walker & Syers (1976), Pt and acid extractable Ca-P in soils decrease along a pedogenesis chronosequence. In addition, Occl-P being unavailable to plants, increases with the progress of weathering. However, our results indicate that Occl-P is higher at lower elevations and that Pt is lower at higher altitudes where the intensity of weathering is low because of low temperature. Moreover, Ca-P, which is a primary mineral P in parent materials, decreases with increasing elevation. These results are not in accordance with the model of Walker & Syers (1976). We suggest that temperature and precipitation have intricately affected the weathering and leaching of nutrients, and influenced the formation of P fractions.

At higher elevation sites, annual rainfall exceeds annual evapotranspiration. As soil organic matter is decomposed, soils will be reduced by respiration of microbes and soil pH will be lower. Consequently, at higher elevation, acid extractable Ca-P and aluminum (Al) and iron (Fe) are dissolved and then P bound to Al and Fe are leached from topsoil. At lower elevation sites, Occl-P is formed but Pt is also kept and soil inorganic P as a plant available form is higher. Soil inorganic N is also higher at lower elevations probably due to the direct effects of temperature as well as the indirect effects via P availability; the two effects are, however, inseparable in this study.

In conclusion, the availability of P and N varied across elevations primarily due to temperature, which in turn determined P- and N-use efficiencies of the forests. Today's vegetation is, thus, formed via the effects of soils as a function of temperature in addition to the direct effects of temperature on plants.

Keywords: Phosphorus, Volcanic Ash, Nutrient-use efficiency, Climate, Pedogenesis

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MIS03-08 Room:104 Time:May 27 12:00-12:15

Origin of mica in Allophanic Andosols in Japan and its role as a radiocesium fixing material

NAKAO, Atsushi[1*] ; NAKAO, Aya[2] ; TANAKA, Ryoji[3] ; YANAI, Junta[1]

[1]Graduate School of Life and Environmental Sciences, Kyoto Prefectural University, [2]Faculty of Life and Environmental Sciences, Kyoto Prefectural University, [3]Institute for Study of the Earth's interior, Okayama University

The accident at the Fukushima Daiichi Nuclear Power Plant in March 2011 has turned attention to the fate of radiocesium (RCs) in soils in Japan. Allophanic Andosols are common soils in Japan, which generally have clay mineralogy rich in low crystalline minerals such as allophane and imogolite. Since RCs is not adsorbed strongly on these minerals, Allophanic Andosols are assumed to have very low RCs retention ability. The objective of this study is to elucidate the relationship between RCs retention ability and mineralogical properties of Allophanic Andosols in Japan. We hypothesized that trace amount of micas are deposited as a loess component even in Allophanic Andosols, which control the RCs retention ability.

Twenty-three soil samples were collected from a plow layer (0-15 cm) of either paddy or upland fields distributing at alluvial plains in Hokkaido, Tohoku, Kanto, and Kyusyu districts, representative areas of Allophanic Andosols. Particles with a size of 2-20 μm and $<$2.0 μm were fractionated from the soils by sedimentation method. RCs retention ability for each particle was represented by the Radiocesium intereception potential (RIP). Quartz content was estimated by random powder X-ray diffraction analysis for 2-20 μm particles with adding α-Al_2O_3 as an internal standard. Mica content in 2-20 μm particles was estimated by the amount of potassium extracted by fusion with $NaHSO_4$, whereas that in $<$2.0 μm particles was estimated by K extracted by digestion with HF-$HClO_4$. Quartz was isolated from 2-20 μm particles by the selective dissolution with H_2SiF_6, and then $\delta^{18}O$ value for the isolated quartz was determined to estimate the origin.

The RIP value for 2-20 μm and $<$2 μm fractions was 1.7$\pm$0.8 mol kg^{-1} and 2.6$\pm$1.3 mol kg^{-1}, respectively. Mica-K content in the respective fractions was 3.2$\pm$1.3 g kg^{-1} and 3.4$\pm$1.7 g kg^{-1}. These values are considerably small compared with those for fine particles in non-volcanic soils. The RIP positively correlated with mica-K content for each fraction, indicating that RCs retention ability is mainly controlled by the amount of micas, in spite of its minority as a mineral component. The mica-K content is proportional to the quartz content, suggesting that the origin of these minerals would be the same. Furthermore, $\delta^{18}O$ value for the isolated quartz was +14.8 ‰ on average with a range of +10.8 to +16.1 ‰, which is clearly higher than those of volcanic materials while similar to those of Chinese loess. Thus, this study strongly indicated that the RCs retention ability of Allophanic Andosols is largely controlled by loess-derived micas.

Keywords: loess, oxygen isotopic analysis, Radiocesium Interception Potential, Allophanic Andosol, mica

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MIS03-09 Room:104 Time:May 27 14:15-14:30

Relevant approaches and strategies for investigation on the nitrogen saturation in forested catchments

OHTE, Nobuhito[1*] ; ISOBE, Kazuo[2] ; TOKUCHI, Naoko[1]

[1]Kyoto University, [2]University of Tokyo

After the Industrial Revolution, global scale nitrogen (N) cycle has drastically been altered by increase of anthropogenic N emissions to the atmosphere. Inorganic N concentration in atmosphere and their depositions reached unprecedented level in Europe, northeast United States and northeast Asia. These have caused ”Nitrogen Saturation” in the forested areas within the high N deposition regions of Europe, North America, China and Japan. Mechanisms of nitrogen saturation have previously been studied from biogeochemical point of view. N dynamics in catchment-scale, however, could not be described sufficiently, because geographical variations of catchment characteristics such as climatic and hydrologic properties are generally large and their effects provide various aspects of responses in high nitrogen depositions. We propose new strategies based on multi-aspects approach combining microbial ecology and catchment hydrology to reconstruct the mechanistic understandings on previously reported ecosystem level biogeochemical responses to the environmental changes such as high N inputs. Combined applications of novel isotopic tracer techniques and newly advanced functional gene analysis onto the multiple forest landscapes will provide us insightful information on spatiotemporal heterogeneity and non-linear responses of N dynamics related to the N saturation phenomena in forest catchments.

Keywords: forested catchment, nitrogen saturation, microbial ecology, isotope tracer, hydrological processes

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MIS03-10 Room:104 Time:May 27 14:30-14:45

Carbon and nitrogen transformation and their driving microorganisms in paddy soil, as assessed by meta-transcriptomics

TABUSHI, Yoko[1*] ; ITOH, Hideomi[2] ; SHIRATORI, Yutaka[3] ; ISOBE, Kazuo[1] ; OTSUKA, Shigeto[1] ; SENOO, Keishi[1]

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, [2]National Institute of Advanced Industrial Science and Technology (AIST) Hokkaido, [3]Niigata Agricultural Research Institute

Paddy soil undergoes drastic change in redox potential along water management during rice cultivation period. After water-logging, various reductive biochemical processes, including denitrification, metal and sulfate reduction, and methanogenesis can occur in the soil, leading to generation of reduced soil layer. On the other hand, thin oxidized layer is present at soil surface, where oxidative biochemical processes such as nitrification and methane oxidation can occur. These oxidative and reductive reactions play central role in material transformation in paddy soil and are closely related to soil fertility, rice growth and surrounding environment.

We carried out meta-transcriptomic analysis of oxidized and reduced soils collected from Niigata paddy field during rice cultivation period. Whole microbial communities, quantity and diversity of transcriptome involved in carbon and nitrogen transformation in the soils were investigated by rRNA and mRNA analyses. Active microbial communities, possible carbon and nitrogen transformation, microbial players involved in the transformation, and their temporal transition in the paddy soil will be reported.

Keywords: soil microbial communities, metatranscriptome, bioinformatics, paddy soil, CN cycle

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MIS03-11 Room:104 Time:May 27 14:45-15:00

Agricultural abandonment influences the ecosystem carbon pools

SHIMODA, Seiji[1*] ; WAGAI, Rota[2]

[1]NARO Hokkaido Agricultural Research Center Memuro, [2]National Institute for Agro-Environmental Sciences

Land abandonment, which is increasing globally, has significant impact on terrestrial carbon (C) budget, vegetation, and biodiversity. Invasive alien plants often outcompete native plants after agricultural abandonment, which can lead to the alteration in ecosystem C and nutrient balance. Perennial plants have been an exceptionally successful invader in agricultural abandoned fields around the world. Irrespective of soil nutrient status, alien plants rapidly dominates abandoned agricultural fields in the temperate regions. While negative impact of alien plants on local and regional biodiversity is well established in conservation ecology, its impact on C sequestration potential is much less studied. Paddy fields used for rice (Oryza sativa L.) production are the dominant human land-use systems for a long time throughout Japan. Japan has increased to nearly 10% of the total cultivated land area. The aim of the present study was to investigate how the rice paddy abandonment influenced the storage of C in ecosystem components during the secondary succession over decadal time scale.

If paddy fields, the typical agricultural land in Japan, are left abandoned, the amount of soil C in the abandoned fields up to 20 years after being abandoned is lower than that of paddy fields under cultivation. If the field is abandoned for a long time, the amount of soil C increases due to organic matter from weeds, but it is considered that the process will take more than 20 years. We hypothesize that the invasion of alien plants to the abandoned paddy fields enhances ecosystem C storage by their high N use efficiency and high productivity. As results, the temporal change in soil C was similar among vegetation type through amount of input C was similar in present study.

Keywords: land use change, paddy, grassland, invasive alien plants, litter

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MIS03-12 Room:104 Time:May 27 15:00-15:15

Responses of organic carbon in a variety of soils controlled by temperature and cellulose supply

IIMURA, Yasuo[1*]

[1]The University of Shiga Prefecture

Carbon stored in the upper meter of mineral soils is estimated to be 2500 Gt, which is approximately 3.3 times the size of the atmosphere and 4.5 times the size of the vegetation. Therefore, soil organic matter is often considered as a significant carbon reservoir on the earth′s surface. Although changes in soil organic carbon contents (by natural or anthropogenic causes) have a significant impact on the global carbon cycle, the mechanisms of soil organic carbon stabilization and destabilization and the factors controlling these mechanisms are not very well understood. We thus focused on the response of organic carbon in a variety of soils (black soil, brown soil, and red-yellow soil, etc.) controlled by temperature and fresh carbon (cellulose) supply. In addition, we considered the factors controlling the temperature sensitivity and priming effect.

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MIS03-13 Room:104 Time:May 27 15:15-15:30

Organic matter stabilization in Andisol and Ultisol revealed by isotopic tracer experiment and density fractionation

HAYAKAWA, Chie[1*] ; WAGAI, Rota[2] ; INAGAKI, Yoshiyuki[3] ; ASANO, Maki[2]

[1]Univ. Tokyo, [2]NIAES, [3]FFPRI

For predicting C cycling in terrestrial ecosystem, dynamics of organic matter (OM) in soil can be a large component that increases uncertainty. Once OM is supplied into soil system mainly as plant detritus and root exudates, OM is decomposed by microorganisms and a proportion of OM is stabilized through association with soil mineral particles. The OM in soils has a wide range of size, density, and chemical reactivity. Organo-mineral particles of heavy-density fraction are highly resistant against microbial degradation compared to mineral-free OM (i.e., plant detritus and low-density fraction). The high C sequestration capacities of soils (e.g., Andisol) are hypothesized to be regulated by incorporation rates of microbial-processed OM into heavier fraction. To test this hypothesis, we conducted incubation experiment using tracer to quantify the pool sizes, influx and efflux rates, and mean residence times (MRTs) of different density classes.

Different types of soils were sampled from two agricultural lands; a volcanic-ash soil (Andisol) from Japan and a highly-weathered tropical soil (Ultisol) from Indonesia. The incubation experiments were carried out after addition of ^{13}C-labelled glucose (99 ^{13}C atom%, 0.1915 mmol ^{13}C g 1soil as solution) or ^{13}C, ^{15}N-labeled glutamic acid to the soils (2-mm sieved, 5 g dry weight). The soils were incubated for 276 d at 30oC and 50% water holding capacity. After the incubation, soil was separated into three fractions according to its density using sodium polytungstate as heavy liquid: low ($<$1.8 g cm^{-3}), middle (1.8-2.25 g cm^{-3} for Andisol, 1.8-2.5 g cm^{-3} for Ultisol), high ($>$2.25 g cm^{-3} for Andisol, $>$2.5 g cm^{-3} for Ultisol) density fractions. We measured the mass, isotopic ratios (^{13}C/^{12}C, ^{15}N/^{14}N) and total C and N concentrations of the density fractions as well as the amount of CO_2 respired during the incubation by alkali trap method. We also measured the specific surface areas (SSA) of soil minerals and the concentrations of Al, Fe oxides/hydroxides.

For both soils, ca. 70 to 80 % of added ^{13}C were mineralized to CO_2 within 1 month after substrate addition. The density fractionation showed that 13C recovery in the low-density fraction was low (0.5 - 3.8%) throughout the incubation period. The ^{13}C recovery within the mid- and high-density fractions was greater than 20%. This indicates that labile substrates were immediately incorporated into the mid- and high-density fractions through microbial processing in the both soils. The highest ^{13}C recovery was observed in the mid-density fraction of Andisol and in the high-density fraction of Ultisol, respectively. MRTs of ^{13}C in the density fractions positively correlated with SSAs for respective soil types. This can be explained by differences in mineralogy which contribute to OM stabilization through sorption; short-range-order minerals (e.g., allophane and imogolite) in Andisol and iron oxides in Ultisol, respectively. Our results support the hypothesis that newly-added OM is stabilized through association of microbial metabolites with mineral particles. However, dominant density class and turnover of stabilized OM could be variable depending on soil types and clay mineralogy with high specific surface areas.

Keywords: 13C-glucose, 13C, 15N-glutamic acid, Andisol, Ultisol, organo-mineral particle

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Changes in the structure and function of tannins in natural environments

MAIE, Nagamitsu[1*]

[1]School of Veterinary Medicine, Kitasato University

Tannins are polyphenols that are contained in plants where they can account to 20% of the plant dry weight depending on its species and organs. Tannins are known to bind to proteins, making insoluble complexes that are resistant to microbial degradation. While tannins are considered to play various roles in ecosystems, we are not fully understand the dynamics and functions of tannins in them. Here, I would like to present the changes in the structure and function of tannins in water and soil environments. Furthermore, their possible influence on nitrogen cycling in mangrove ecosystems will be proposed.

Molecular structure and protein binding ability of CT changes during the decomposition of foliage (Maie et al. 2003)
Tannins are classified into two subgroups, condensed tannins (CT) and hydrolysable tannins (HT). CT are mixtures of polymers of flavan-3-ol units with different degrees of polymerization and mostly hydroxyl substitutions. Molecular structure of CT in foliage changes during the decomposition of foliage. CT molecules composed of prodelphinidin unit (PD), which has more hydroxyl groups than procyanidin (PC), are more susceptible to structural changes. Structural change of CT accompanied with the decrease of protein-binding ability.

Tannins are important source of DOM leached from litter, especially at the early stage of decomposition (Nishimura et al. 2012)
Dissolved organic matter (DOM) leached from litter may contain tannin-derived materials. Since tannins are water-soluble and has wide structural variety among different species, DOM composition in leachate is most diverse at the early stage of the decomposition, but converge into relatively similar composition by time when lignin-degradation products become a major source of DOM.

Tannins-protein complex may contribute to nitrogen cycling in mangrove ecosystem, acting as a delayed release fertilizer (Maie et al., 2008)
Fate of CT leached into water environments can be variable. They may aggregate in saline water, adsorb to sediment, and complex with proteins. CT change their chemical structure quickly in water, becoming ”invisible” to analytical window. CT-protein complexes are refractory to microbial degradation, but photo-reactive. By exposing CT-protein complexes to sun light, proteins can be released into water. In mangrove estuary, a large amount of tannins and proteins could be released into water in a relatively short period when leaves fall into water. CT might be contributing to preserve N in mangrove ecosystem, by acting as a delayed release fertilizer.

References
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Keywords: dissolved organic matter, forest ecosystem, mangrove estuary, nitrogen cycling, protein binding ability, structural change

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Nutrient release during biodegradation of organic horizons in the Siberian taiga underlain by continuous permafrost

KAWAHIGASHI, Masayuki[1*] ; PROKUSHKIN, Anatoly[2] ; SUMIDA, Hiroaki[3]

[1]Graduate School of Urban Environmental Sciences, [2]Sukachev Institute of Forest, Rossia Academy of Science, [3]College of Bioresource Sciences, Nihon University

Organic horizons under the Siberian taiga forest have a significant role of nutrient supply for plants through their biodegradation processes and of heat insulation for permafrost table underneath shallow mineral soil layer. Lower weathering stages of mineral soils underlain by permafrost have lower potential of soil nutrient retention and release, indicating that summer growing vegetation can expect to fill their nutrient requirements released by organic matter degradation. Decomposed organic matter can supply mineral and biogenic nutrients to plants and microorganisms. Organic horizons often suffer from frequent forest fire in the Siberian forest. Forest fire moves through organic horizon on the ground because of low tree density in the forest stands. Relatively low burning temperature can leave organic residue on the forest ground. Ground temperature during forest fire is a key variable for changes in properties of organic horizons. Solutes release potential and biodegradability of organic horizons was evaluated in this study along with heating temperature gradient. To estimate the effect of forest fire on the biodegradation processes of organic horizons, we prepared organic horizon samples heated between 65^{o}C and 550^{o}C under a relatively oxygen limited atmospheric condition.

A sampling site located in the Evenkia province in the central Siberia. Soils are classified as Oxyaquic Cryosols or Gelic Cambisols according to the WRB classification system. Organic horizon samples were taken depending on hummock topography. Air-dried and powdered samples were heated in a muffle furnace between 105 and 550^{o}C for 15minites. Organic residues were applied to incubation experiment to evaluate biodegradation and solutes release. Biodegradation was evaluated from mineralization rates being calculated using temporal changes in CO_2 concentration during an incubation experiment and total organic carbon content in heated solid samples. During the same incubation time course, biogenic elements released from the heated samples were determined after water extraction by ICP-AES, Ion-chromatography and TOC-L with total nitrogen module unit.

Solutes release from heated organic horizon samples by water saturation was different between samples depending on the heating temperature. Larger amount of nutrient elements were released from organic horizons taken from trough points on the hummock. Samples heated at 250^{o}C released the highest amount of solutes mainly dominated by dissolved organic C. Basic cations and major anions including phosphate, nitrate and chloride were also largely released from the sample heated at 250^{o}C. Higher the heating temperature was, solutes concentration was lower. Solution pH was higher with increasing the heating temperature. The ratios of carbon to nitrogen in solid samples were decreased with increasing the heating temperature. The temperature dependence of solutes release was different along with hummock topography.

The maximum mineralization (%) was approximately 4% of total C in samples heated at lower temperature below 180^{o}C. The mineralization rate was not largely different between samples, indicating that the biodegradation process in all heated samples mainly depends on the amounts of easily decomposable carbon source, such as DOC. There are significant correlations between the maximum mineralization rate and DOC or inorganic N. Solutes mainly consisting of nutrients and energy source for microorganisms can be a significant controlling factor for the biodegradation process of organic horizons. The difference in solutes composition and the biodegradation were mainly depending on heating temperature of organic horizons. Heating temperature during a forest fire is an important parameter controlling the further degradation of organic matter in organic horizons and the fate of carbon dynamics in the boreal permafrost affected forest region.

Keywords: Forest fire, Biodegradation, Continuous permafrost terrain, plant nutrition, burned temprature, humic substances

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Variation in physical composition of soil organic matter in black spruce forests within a slope in Interior Alaska

TORIYAMA, Jumpei[1*] ; TANAKA, Ayumi O.[1] ; MORISHITA, Tomoaki[1] ; MATSUURA, Yojiro[1] ; HINZMAN, Larry D.[2]

[1]Forestry and Forest Products Research Institute, [2]International Arctic Research Center

In boreal region, rapid climate warming compared to lower latitude region can accelerate decomposition of soil organic matter (SOM) and, together with an increase in active layer depth, shift patterns of nutrient use and growth of boreal forests. In discontinuous permafrost region of Interior Alaska, black spruce (*Picea mariana*) grows in environments with various active layer depths and different degree of nutrient limitation. These environmental gradients can also be obtained from different positions in a single slope where climatic condition and fire history are similar. To clarify accumulation pattern of SOM and its relationship to tree growth and slope position, we set a transect plot of 1.5km-long in black spruce forests in Caribou Poker Creek Research Watershed. Tree growth rate at lower altitude (250 m) with shallow active layer in growing season is low compared to that at higher altitude (450 m) with deep active layer. We collected samples from organic layers and mineral soil horizons in 14 soil profiles. The thickness of organic layer ranged 7 to 45 cm and was not correlated with altitude. Soil samples are separated into light and heavy fractions by density fractionation approach. The light fraction of topsoil (surface horizon of mineral soil) accounted for 269 g kg^{-1} of soil mass and 598 g kg^{-1} of soil organic carbon in average. The relationship between light fraction content of topsoil and slope position was unclear. In the session, we focus on the ^{15}N natural abundance of SOM and other components in the forest ecosystem and discuss the nitrogen cycling in black spruce forests with different growth rates.

Keywords: black spruce, soil organic matter, density fractionation

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Controls over turnover of organic matter and nutrients in permafrost soils

FUJII, Kazumichi[1*] ; MATSUURA, Yojiro[1] ; FUJII, Soichiro[2] ; INAGAKI, Yoshiyuki[1] ; OSAWA, Akira[2]

[1]Forestry and Forest Products Research Institute, [2]Graduate School of Agriculture, Kyoto University

Introduction: Plant productivity on permafrost soils is limited by nutrient supply from organic matter. Organic matter decomposition and nutrient release can be limited by cold climate, flooding, and recalcitrance of bryophytes (lichen and moss). Plant-soil association (white spruce on mineral soil, black spruce on organic soil, and shrub tundra on lowland soil) suggests the hypothesis that plant acquisition strategies for nutrient (esp., amino acids/inorganic N) can be matched by nutrient supply from soil organic matter. To test this, turnover of organic matter and nutrient release was investigated for three types of ecosystems in Northwest Territory, Canada; white spruce forest (WSF) on the upland soil derived from glaciofluvial sands, black spruce forest (BSF) and tundra (TND) in lower position on fluvial sediments.

Methods: We measured soil organic carbon (SOC) storage [organic and mineral soil layers (0 to 30 cm)], soil temperature and moisture, aeration index [Eh, free Fe oxides (oxalate-extractable Fe)] of soils, and the decomposition rates of litter (lichen, moss, and root litter) and cellulose filter paper buried in the soils. Regarding soil N dynamics, the concentrations of organic and inorganic N in soil solution (zero-tension lysimeter) were measured. Root uptake of dual-labeled (^{13}C, ^{15}N) glutamic acid, ^{15}N-labeled ammonium, and ^{15}N-labeled nitrate was measured 24 h after spike of mixture solution.

Water dynamics: Episodic flooding events were observed following spring snowmelt at all sites. Rapid snowmelt and water percolation enhanced aeration in the sandy soil profile of WSF, while the BSF and TND soils were saturated by water flooding on impermeable permafrost layer (30 cm deep) even in summer. The seasonal cycles of reducing- and oxidizing- conditions were recorded as accumulation of free Fe oxides in the soils.

C dynamics: The C stocks in the organic and mineral soil layers were greater in TND (188 Mg C ha^{-1}) and BSF (207-237 Mg C ha^{-1}) than in WSF (37 Mg C ha^{-1}). When the regression analysis was conducted for 15 soil profiles, there was a positive correlation between SOC storage and free Fe oxide concentration. The high concentrations of free Fe oxides in soils appeared to be an index of poor drainage and high SOC storage. Mass loss rates of cellulose filter paper, lichenous litter, and root litter followed the order: WSF>TND>BSF. Water flooding and cold climate retarded decomposition of organic matter in BSF and TND. The development of hummocky micro-topography, which was recorded as the tilting of drunken forest, resulted in accumulation of sparingly-decomposable lichen and moss debris in BSF. The warmer and aeration conditions in sandy upland soil of WSF enhanced turnover of organic matter.

N dynamics: Dissolved organic N is abundant in soil solution at all sites. Nitrogen species in soil solution was dominated by nitrate and ammonium ions in TND soil, while it was ammonium in WSF and BSF soils. Regarding N uptake by plants, TND plants (shrub birch and grasses) preferentially absorb inorganic N (ammonium and nitrate), while white spruce and black spruce could also utilize amino acid-N. Both C and N of amino acids were assimilated by white spruce roots, while only ammonium was transferred to roots of black spruce probably after rapid mineralization by mycorrhizae or roots. N preference of plants is consistent with the dominant N species in soil solution.

Conclusions:Water flooding as well as cold climate retarded turnover of organic matter in black spruce forest. Despite slow turnover of organic matter, black spruce can utilize amino acids as well as ammonium. In warmer and aerated sandy soil, white spruce can absorb both amino acids and inorganic N. In the lowland tundra soil rich in inorganic N, plants can absorb inorganic N. This highlights the importance of considering plant-soil association to predict responses of ”sensitive” ecosystem to future changes in flooding, fires, and climate.

Keywords: permafrost, soil organic matter, dissolved organic matter, amino acids, microorganism

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Possible future directions in soil and ecosystem research

WAGAI, Rota[1*] ; KOSAKI, Takashi[2]

[1]National Institute for Agro-Environmental Science, [2]Tokyo Metropolitan University

Better understanding of soil is fundamental to enhance sustainability of humankind, to conserve natural environment, and to predict/manage future earth environment. Thus, soil scientists can and should play bigger role beyond the field of agricultural science and collaborate more with the scientists of other disciplines. We will discuss possible future directions that we could take to better understand soil processes in earth system's context.

Keywords: soil process, biogeochemistry, ecosystem, ecology, environmental science, earth surface processe