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

HTT35-01 Room:311 Time:May 1 09:00-09:15

Review of development of AMS in the past 30 years and future perspective

NAKAMURA, Toshio[1*]

[1]Center for Chronological Research, Nagoya University

One of the main aims of Quaternary research is to understand global environmental changes of the past and to predict the expected changes in the near future. To pursue this aim, high-resolution age estimation is particularly important. Dating methods so far used for Quaternary research can be classified into five categories: (1) age estimation based on the decay procedure of cosmogenic radioisotopes such as radiocarbon (14C) and 10Be, U-series nuclides and a K-Ar pair; (2) age estimation by cumulative dose from natural nuclear radiation and cosmic rays such as TL, OSL, ESR, FT dating methods; (3) age estimation with geological or geochemical evidences of prehistoric events such as paleomagnetic reversals or excursions, oxygen stable-isotope-ratio variations, tephra stratigraphy; (4) age estimation with paleontological records of prehistoric events such as diatom, pollen, nanno-plankton and shellfish assemblages, as well as semi-global fluctuations of tree ring width; (5) age estimation based on archeological evidences. These dating methods are selectively applied dependent on the characters of geological and archeological events to be analyzed. Among the radio-isotopic dating methods, 14C dating is most frequently used because of its applicability to many different types of Quaternary samples, as well as age range covered by this method (a few hundred to 50,000 yr BP).

Developments of accelerator mass spectrometry (AMS) have triggered a wide area of application in radiocarbon (14C) dating. The AMS system requires only 1mg of carbon in precise determination of 14C/12C and 13C/12C isotope ratios, and this advantage has broadened the applicability of 14C measurements. Nowadays, AMS contributes to almost all kinds of research that utilize 14C dating in archeology, cultural property science, geology, and those that employ 14C tracer in environmental sciences, medical sciences and even forensic studies.

For example, a Tandetron AMS system dedicated to 14C measurement was installed at Nagoya University, and its routine operation for 14C measurement was started in 1983 for the first time in Japan. In 1996, another AMS system (HVE-Model-4130-AMS) was purchased and has been used for high precision 14C measurements. By 30 minutes measurement of carbon isotopes repeated for consecutive three days for a sample, one-sigma uncertainty of +-17 to +-30 years is achieved. A reproducibility test for 2000-year-old archeological samples yielded a fluctuation error as small as +-11 years. We also have evaluated accuracy in our 14C measurements by participating in international 14C inter-comparison tests, and confirmed that our14C results were quite consistent with the consensus values by all the participants. After the critical tests, we are sure that our AMS system can be applicable to historical samples that require high precision as well as high accuracy 14C measurements.

Quite frequent applications of 14C dating with AMS to the Quaternary samples in the last bidecade are promoted by the following reasons: (1) a very small amount of carbon (about 1mg of carbon for the final target preparation) is required; (2) uncertainties of 14C ages are from +-17 to +-30 yr, mainly owing to the 14C counting statistics; (3) calibration of 14C age to the calendar age scale become quite popular, for 14C ages up to 50,000 cal BP; (4) marine reservoir effect on 14C age has been recognized and investigated recently, and a realistic correction for the effect is becoming possible partly.

Along with 14C, other cosmogenic radioisotopes such as 10Be, 26Al, 36Cl, 129I are also measured with AMS systems. We briefly describe history of development of domestic AMS groups as well as worldwide AMS groups, along with the research fields of AMS applications and future perspective.

Keywords: accelerator mass spectrometry, cosmogenic nuclides, radionuclide, age measurement, ion nuclide separation, ion particle counting

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HTT35-02 Room:311 Time:May 1 09:15-09:30

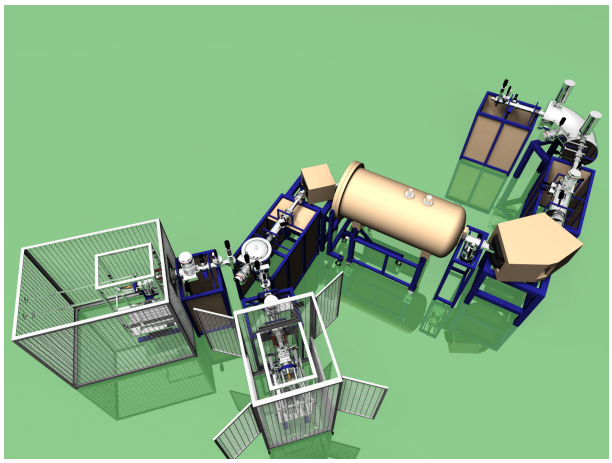
Present status of YU-AMS

TOKANAI, Fuyuki[1*]

[1]Center for YU-AMS

Yamagata University (YU) installed an AMS (YU-AMS) system in the Kaminoyama Research Institute to meet the requirement of ^{14}C AMS for microdosing and medical studies as well as that of radiocarbon dating in the same facility. An automated graphitization line was also installed in the same research institute for sample preparation. This AMS system is the first AMS system installed in a university in north Japan (Tohoku-Hokkaido region). The facility also provides radiocarbon dating for samples from other universities, institutes and public organizations. Currently, we are planning to install a second new ion source and an automated graphitization line until March in 2014. In this paper, we describe the status of the YU-AMS system.

Keywords: AMS, microdose



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HTT35-03 Room:311 Time:May 1 09:30-09:45

Development of isobar suppression system using Laser in Accelerator mass spectrometry

MIYAKE, Yasuto[1*] ; MATSUZAKI, Hiroyuki[1] ; HASEGAWA, Shuichi[2]

[1]Department of Nuclear Engineering and Management, School of Engineering, The University of Tokyo, [2]Nuclear Professional School, The University of Tokyo

For Accelerator mass spectrometry (AMS), isobar separation is quite important to improve measurement accuracy and the background. In order to suppress isobar interference, gas-filled magnet or gas counter have been conventionally used [1,2]. Nuclides of interest are separated from isobars by interaction between ions and materials in these devices.

In the 1980s, Berkovits et al. tried to remove stable isobars before acceleration with laser light[3]. In this method, the difference of the electron affinity (EA) was utilized for isobar suppression. If the EA of the nuclide of interest is higher than the EA of the isobar nuclide, only negative isobar can be selectively neutralized by photodetachment with photons of energy, which is higher than the EA of isobar nuclide but lower than the EA of the nuclide of interest. Consequently, only nuclide of interest can be injected into the accelerator and isobar suppression can be effectively achieved. However, due to the limited laser performance, the laser-ion interaction time was too short to suppress isobar sufficiently at that time. Therefore, this technique has not been in practical use yet.

Recently, as laser improved in quality and the way to increase the laser-ion interaction time effectively was proposed, development of isobar suppression system is going on. For example, Liu et al. developed the RFQ ion cooler to slow ions [4]. This apparatus is filled with a buff gas and ions collide with gas molecules, which results in the deceleration of ions and the long interaction time. This photodetachment system can remove isobar interference in AMS measurements for nuclides, such as Cl-36 (EA=3.62eV) with S-36 (EA=2.08eV), Ni-59 (EA=1.156eV) with Co-59 (EA=0.661eV) [4]. Furthermore, even if the EA of the nuclide of interest is lower than the EA of the isobar nuclide, photodetachment could be useful by converting the nuclides into the molecular ions and reversing these electron affinities.

In order to make laser interact with ion beams effectively, the ion beam optics including the devices like the ion cooler should be optimized. This device will be installed after the electrostatic deflector or after the injection magnet in the beam line. In this study, as a preliminary step, optimization of the ion beam optics including some components to decelerate ion will be dicussed.

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Keywords: AMS, isobar, laser, photodetachment

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HTT35-04 Room:311 Time:May 1 09:45-10:00

Development of C14-free laboratory animals.

KOBAYASHI, Koichi[1*] ; AMS, Dating group[1]

[1]Paleo Labo Co.,Ltd.

In the early stage of pharmaceutical researches, ^{14}C labeled chemicals with very high radioactivity are administrated to laboratory animals to study pharmacokinetics. However, when $^{14}C/^{12}C$ of the laboratory animals could be reduced, the radioactivity level of the chemicals is expected to be reduced lower. Also when ^{14}C-free (DC ; denoted as dead carbon) laboratory animals were developed, the radioactivity level for the study is expected to be reduced down by five orders of magnitude or lower by using AMS technique. That means that we need not the ^{14}C labeled chemicals but natural level chemicals for the study of pharmacokinetics. In this case, it is also expected that we can be free from the hazardous high radioactivity and from the strictly regulated troublesome laboratory to handle the high level radioactive materials.

In Dec. 2010, we started the project to produce ^{14}C-free lives as feed for the ^{14}C-free laboratory animals. This is a preliminary report on the project, and parts of the investigation were already reported at 13th Japanese Symposium on AMS (Kobayashi et al., 2011). Here will be also introduced some recent studies.

When lives were cultivated in DC surroundings they grow up inevitably to be DC lives. For example, photosynthetic lives like vegetables or some kinds of microbes with chloroplast like euglena (midorimushi ; in Japanese) can easily be DC lives when they were cultivated in DC surroundings.

For the first step, we cultivated some plants and euglena using ^{14}C free water set in a glove box that was filled with artificial air (N_2, O_2 and dead carbon CO_2 with proper concentration) irradiating with some artificial lights. ^{14}C concentrations in the plants and the microbes were measured by AMS. Since the modern carbon (natural carbon) CO_2 could not be perfectly removed from the air and the water and air tightness of the glove box system was also not perfect, the percentages of dead carbon to modern carbon (DC ratio) in the samples could not be higher than about 80 %.(Kobayashi et al., 2011a ; Kobayashi et al., 2011b)

While investigating the cause of the imperfect DC ratio, we got 96% DC Euglena by using a little different way. That is to use a small glass bowl with an airtight lid, in which were set CO_2 tablets, a small amount of chemical fertilizer and Euglena. From outside of the bowl, fluorescent lamps irradiated adequate amount of light to them. One or two months later, the euglena was carefully collected on glass filters in a glove box filled with DC air. $^{14}C/^{12}C$ of the euglena was measured by AMS and the ^{14}C concentration was 3.71 ± 0.02 pMC (percent Modern Carbon) which leads to DC ratio as 96% (Kobayashi et.al., 2012).

In order to make sure that mice really eat the euglena tablets, we fed the mice with euglena tablets which were mixed with chlorella powder by 20%. The tablet is on the market for people as a health food. After three months feeding on three mice, there were no large differences compared to the other three mice which were fed by ordinary food for comparison. The experiment concluded that mice will grow up healthy by eating the euglena tablet.

Those two above data show the possibility to realize the DC animals.

Recently, we have started to extend the project to realize for business, supported by a grant.

References:

Kobayashi, K. et al. (2011a), Production of ^{14}C-free plants and animals (in Japanese) ; Kobayashi, K. et al. (2011b), Production of ^{14}C-free plants and animals ; Kobayashi, K. et al. (2012), Production of dead carbon lives (in Japanese)

Keywords: Pharmacokinetics by AMS, C14-free lives, Euglena

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HTT35-05 Room:311 Time:May 1 10:00-10:15

^{14}C measurement of the Southern Japanese tree by the AMS method for high-precision radiocarbon calibration

HAKOZAKI, Masataka[1*] ; NAKAMURA, Toshio[1]

[1]Center for Chronological Research, Nagoya University

Radiocarbon (^{14}C) dating method has contributed to the age determination of samples of the past 50,000 years in geology and archaeology. However, since ^{14}C date is not in agreement with the calendar year, the calibration using a dataset which consists of ^{14}C data of calendar year known samples is required for it. Moreover, since there is regional difference of ^{14}C concentration in the atmosphere (regional ^{14}C offset; Hogg et al. 2002), in order to be high-precision calibration, the dataset for each area needs to be established.

The Center for Chronological Research (CCR), Nagoya University has measured ^{14}C data of tree-rings of a Yaku cedar from the Southern Japan, in order to establish a calibration dataset for Japan. Previous measurement has shown that the cedar shows 14C date older than global standard calibration dataset IntCal13 (Reimer et al. 2013) in various times for the past 2000 years (Nakamura et al. 2013). This report shows the measurement result of the tree-rings formed in the 5th century.

Sample is a Japanese cedar from Yaku Island, Kagoshima prefecture (sample code: Yaku_A). Dendrochronological analysis with a master-chronology (Kimura unpublished) has carried out, and the calendar year of this sample is known. After exfoliating the annual rings of AD434-502 of a sample in one year respectively, only even-numbered years was measured (n = 35). The tandetron AMS II of CCR was used for this measurement. Measuring only even-numbered years in order to understand a whole tendency previously, it also measures the samples of odd-numbered years in the future.

Thirty five ^{14}C dates of tree-ring samples showed that it will be older than IntCal13 for an average of 28 $\pm$ 22 years, a maximum of 76 $\pm$ 21 years (in AD488). These ^{14}C dates were mostly located in the middle of IntCal13 and SHCal13 (the calibration dataset for the Southern Hemisphere; Hogg et al. 2013).

Since Yaku Island touch the northernmost end of the Intertropical Convergence Zone in a summer, it is thought that the Southern Hemisphere atmosphere with regularly low ^{14}C concentration is easy to be supplied (Nakamura et al. 2012). This measurement result might suggest that ^{14}C concentration in the atmosphere of the Japanese neighborhood fell in the 5th century, and the atmospheric supply from the Southern Hemisphere may have become strong. Sakamoto et al. (2013) measured the tree-ring samples in the 5th to 6th century of the Japanese cedar from Nagano Prefecture Central Japan, and they has reported that the data is older than a IntCal13. Our result harmonizes with the measurement result of the trees from Nagano, and this time can consider a possibility that the influence of the Southern Hemisphere atmosphere had reached to central Japan. From now on, the tree-rings of Yaku cedar in formed the 6th century will measure, and it will compare with the result of Sakamoto et al. (2013).

Keywords: radiocarbon calibration, regional ^{14}C offset, Southern Japan, tree-ring, Yaku cedar

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HTT35-06 Room:311 Time:May 1 10:15-10:30

C-14 dating and geochemical analyses of the tsunami sediments in continuous soil deposits from Tohoku area, Japan

WATANABE, Takahiro[1*] ; HOSODA, Norihiro[1] ; TSUCHIYA, Noriyoshi[1] ; NAKAMURA, Toshio[2] ; YAMASAKI, Shin-ichi[1] ; NARA, Fumiko[1]

[1]Graduate School of Environmental Studies, Tohoku University, [2]Center for Chronological Research, Nagoya University

Past tsunami sediments preserved in continuous soil and lake sediments are crucial and unique clues to reconstruct the past tsunami invasion area. Generally, the tsunami sediments originated from sea floor, sandy beach and/or coastal land soils containing gravels, sands, muds, shells and microfossils. In particular, muddy tsunami sediments should be found to detect the limit of tsunami invasion areas, because relative small particles move to more inland area with tsunami in comparison with sand deposits. Additionally, dating of tsunami sediments is indispensable to refer for historical disaster events. Therefore, we have to make age models of continuous soil deposits with tsunami sediments and new techniques for detection of invisible muddy tsunami sediment in strata. In this study, we performed the nine radiocarbon measurements of plant residues in continuous soil deposits as well as geochemical characteristics of tsunami sediments. 2m-continuous soil deposits were taken by the handy geoslicer (Fukkenn co. ltd.) from the Pacific coast of Tohoku area in northeast Japan. The samples were composed of cultivated surface soils, peaty clay, silt and sub-rounded medium sands. The sandy deposits were found between the peaty clay layers. To show the sedimentary ages of sandy deposits, plant residues were taken from the sandy and peaty clay layers in the continuous soil sediments. The plant residues were washed with ultra pure water using ultra sonic cleaner to remove soil particles containing relative old carbon. Then, the samples were treated sequentially with 1.2M-HCl, 1.2M-NaOH and 1.2M-HCl at 60 degrees of Celsius for 3 hours. After neutralization and freeze-drying, the samples were combusted in evacuated quartz tubes. Then, the purified carbon dioxide was reduced to graphite using Hydrogen gas with iron catalysts. Radiocarbon measurements were performed by the Tandetron AMS system (Model-4130, HVEE) in Center for Chronological Research, Nagoya University. Total organic carbon contents of the plant residues were from 45.9 to 54.5 wt.% (50.4 wt.% in average) and stable carbon isotope ratios of the plant residues ranged between -26.7 and -30.1 permil (vs. PDB), which consist with those of modern terrestrial C3 plants. As a result of this study, part of the calibrated ages of plant residues taken from just above the sandy tsunami sediments was about 1000-1300 cal BP, and these ages were agreed well with those of the Jogan earthquake and tsunami in the Sendai plain.

Keywords: Radiocarbon dating, Tsunami deposits, Jogan tsunami, Geochemistry, EDXRF

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HTT35-07 Room:311 Time:May 1 10:30-10:45

AMS radiocarbon dating of tephra layers on Adak Island, central Aleutian

OKUNO, Mitsuru[1*] ; NAKAMURA, Toshio[2]

[1]Fac. Sci., Fukuoka Univ., [2]CCR, Nagoya Univ.

The Holocene tephra layers distribute on Adak Island located in the central part of the Aleutian Islands. Radiocarbon (ˆ{14} C) age determination of charcoal fragments in the soil layer has been performed. Moreover, tephra is intercalated with sand layer of dune. Since sand dune has high depositional rate and low contamination of organic matter, a possibility of polluted charcoal sample from below and above tephra is low. Thus reliable age was able to be obtained by the AMS method to these small samples. We report those results.

Keywords: Adak Island, Holocene, tephra, radiocarbon date

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HTT35-08 Room:311 Time:May 1 11:00-11:15

Radiocarbon dating of stalagmites from the Ryugashi Cave, Shizuoka

KATO, Tomomi[1] ; MINAMI, Masayo[2*] ; HORIKAWA, Keiji[3] ; NAKAMURA, Toshio[2]

[1]Graduate School of Environmental Studies, Nagoya University, [2]Center for Chronological Research, Nagoya University, [3]Graduate School of Science and Engineering for Research, University of Toyama

Stalagmites are cave deposits precipitated from drip water. Drip water consists of carbon derived from soil CO_2, which has atmospheric ^{14}C values in isotopic equilibrium with atmosphere, and carbonate-dissolved CO_2, which has ^{14}C-free (dead) carbon through interaction with cave host bedrock. As a result, drip water contains a percentage of dead carbon, which will make the ^{14}C ages of the stalagmite older. Therefore, a correction of the dead carbon fraction is needed for ^{14}C dating of stalagmites. In recent years, young stalagmites of 10-20 ka have been ^{14}C dated by comparing the ^{14}C on samples of known calendar age with the tree ring record of atmospheric ^{14}C during a period of overlap (Hoffmann *et al*., 2010; Southon *et al*., 2012). This procedure involves the implicit assumption that dead carbon fraction in stalagmite remained constant through its growth time. In this study, therefore, we examined dead carbon fraction in two stalagmites from the Ryugashi Cave in Hamamatsu, Shizuoka by investigating seasonal variation in ^{14}C concentrations of drop water coupled with soil CO_2, atmospheric CO_2, and host limestone, in order to reveal possibility of accurate and precise ^{14}C dating on stalagmite in Japan.

The drip water samples showed ^{14}C of 1130 BP to 980 BP and $\delta^{13}C$ of -10.1 ‰ to -9.1 ‰, which are lower in fall and winter, and higher in spring and summer, and have the annual means of ^{14}C of 1025±140 BP and $\delta^{13}C$ of -9.4±0.4 ‰. The RYGS12 stalagmite of 7 cm in length showed 945±30 BP at its top and 2150±40 BP at its bottom, and had a growth rate of about 60 μm/yr. The calibrated age of RYGS12 was estimated by comparing the ^{14}C with the IntCal13 calibration curve, resulting that the stalagmite had a constant dead carbon fraction through its growth time and gives ^{14}C ages of 1050 years older than the true age. The carbon isotopic fractionation between drip water and stalagmite was negligible. The results indicate that high-resolution ^{14}C measurement can be performed on stalagmites in the Ryugashi Cave.

The RYGS12 sample showed rapid decrease of $\delta^{13}C$ from -8.3 ‰ to -11.8 ‰ at around AD1450 The decrease suggests an increase of soil input to the stalagmite, since soil CO_2 has low $\delta^{13}C$ of -22.0 ‰. It is reported that there was a great earthquake of magnitude 8.6 (Meio earthquake) accompanied by a catastrophic tsunami in this study area in AD1498. Therefore, the $\delta^{13}C$ decrease might be caused by the Meio earthquake. In the presentation, we will present ^{14}C result on another stalagmite sample RYG08 of 30 cm in length.

Keywords: stalagmite, radiocarbon age, carbon isotope ratio, oxygen isotope ratio

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HTT35-09 Room:311 Time:May 1 11:15-11:30

14C-based source apportionment of carbonaceous component in PM2.5 in Nagoya city

IKEMORI, Fumikazu[1*] ; YAMAGAMI, Makiko[2] ; HONJYO, Koji[3] ; NAKAMURA, Toshio[4]

[1]Graduate School of Environmental Studies, Nagoya University, Nagoya City Institute for Environmental, [2]Nagoya University, Nagoya City Institute for Environmental, [3]Graduate School of Environmental Studies, Nagoya University, [4]Center for Chronological Research, Nagoya University

The measurement of radiocarbon (14C) has been used to estimate the relative contributions of fossil and contemporary carbon sources in particulate matter throughout the world. In this study, we use 14C to provide quantitative estimates of carbon origin sources in Nagoya in April 2003 to March 2004. pMC and OC/EC showed similar seasonal variations and high values (range 39.8 to 68.4, 1.0 to 2.0; average 53.4, 1.5, respectively) in May and early June, whereas the values of pMC stayed relatively low values (range 28.3 to 41.9, 0.7 to 1.2; average 34.2, 1.0, respectively) after middle June. To estimate the source region of high pMC values, backward air mass trajectories were calculated during the sampling period in April to June. The air mass appeared to have passed through eastern Siberia when the pMC values showed high values in May and early June which also showed high values of OC/EC ratio and OC concentrations. In 2003, many researchers reported the influence of large forest burning in Siberia. This large forest burning occurred in spring to summer. The smoke from this forest burning had reached to Korea, Japan, and North America. The influences from the Siberian forest fires had an important implication for air quality over East Asian region. We conclude that high pMC values measured in spring are originated from large forest fires in Siberia and transported long distance.

Keywords: atmospheric aerosol, PM2.5, radiocarbon

Japan Geoscience Union Meeting 2014
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HTT35-10 Room:311 Time:May 1 11:30-11:45

Decadal change in bomb-produced radiocarbon in the Pacific Ocean revealed by WHP repeat hydrography

KUMAMOTO, Yuichiro[1*] ; MURATA, Akihiko[1] ; KAWANO, Takeshi[1]

[1]Japan Agency for Marine-Earth Science Technology

Radiocarbon produced by nuclear weapon tests is one of ideal tracers for the air-sea gas exchange and ocean circulation. In the 2000s, radiocarbon in dissolved inorganic carbon was measured during revisit cruises along the WOCE (World Ocean Circulation Experiment) lines of P01 (47N approx., 2007), P03 (24N approx. 2005), P06 (32S approx., 2003), P10 (149E approx., 2005), P13N (165E approx., 2011), P14N/C (179E approx., 2007), P17N (135W approx., 2001), and P21 (17S approx., 2009) conducted in the 1990s in the Pacific Ocean. Comparison of radiocarbon data from the 1990s and 2000s revealed decadal changes of radiocarbon concentration in the thermocline, most of which were due to temporal changes in the bomb-produced radiocarbon. Vertical profiles and vertical-integrated inventories of the bomb radiocarbon in the subarctic and equatorial regions have not changed significantly. In the subtropical regions, radiocarbon decreased in upper thermocline from surface to about 500-m depth. In contrast, radiocarbon increased in lower thermocline from about 500-m to 1500-m depths. In the southern and northeastern subtropical regions, the two opposing directions in radiocarbon change resulted in small temporal changes of the total inventory of the bomb radiocarbon. On the other hand, the water column inventory significantly decreased in the northwestern subtropical region because the radiocarbon decrease in the upper thermocline was larger than the radiocarbon increase in the lower one. These decadal changes are primarily due to the meridional transport of the bomb radiocarbon from high latitude into temperate zone. The decrease in the vertical-integrated radiocarbon in the northwestern subtropical region implies that the turnover time of the thermocline circulation in the region is faster than those in the other subtropical regions in the Pacific Ocean. In addition the loss of the bomb-radiocarbon in the North Pacific Ocean could be explained by its transformation to the Indian Ocean via Indonesian Through Flow. This work was partially supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Number 18310017 and the Common-Use Facility Program of JAEA (2007A-F03, 2007B-F05, 2008A-F02, 2009A-F05, 2010A-F06, and 2011A-F04).

Keywords: bomb-produced radiocarbon, Pacific Ocean, ocean circulation

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HTT35-11 Room:311 Time:May 1 11:45-12:00

Study on property of soil organic matter decomposition by global warming using radiocarbon

ARAMAKI, Takafumi[1*] ; LIANG, Naishen[1] ; TERAMOTO, Munemasa[1] ; TOMITA, Ayako[1]

[1]National Institute for Environmental Studies

Current research indicates that future atmospheric CO_2 concentration may be increased more than predicted value by furthering of soil organic matter decomposition due to global warming. The information on soil organic matter decomposition property in long-term warmer environment has not yet been obtained. We have carried out artificial soil warming experiment in six forest sites having different vegetation in Japan for long time. We planed vertical ^{14}C measurement of soil core at an even-green Japanese oak forest in Setonaikai region (Higashi-Hiroshima). A soil core was collected from both the soil warming and the control plot in December 2011, and was cut into 1cm layers in laboratory. Each sample was hydrolyzed with 1N HCl overnight to remove inorganic carbon in the sample, and then was analyzed particulate organic carbon (POC) and organic nitrogen (PON) by an elemental analyzer. For ^{14}C analysis by an accelerator mass spectrometer (AMS), soil samples adjusted to a weight of approximately 3mg-C were first converted to CO_2 gases by combustion with CuO and Ag foil at 900 ℃, and then purified cryogenically in a vacuum line. The CO_2 gas samples were reduced to graphite with H_2 gas over Fe powder. The $^{14}C/^{12}C$ ratios of the sample graphite were measured at the Tandetron AMS Facility in the Mutsu Office of the Japan Atomic Energy Agency. The ^{14}C results are expressed as $\Delta^{14}C$. The typical analytical error of the $\Delta^{14}C$ values was about $\pm$ 4 ‰ based on the 1σ value of the counting statistics.

Both of POC and PON weight percent in the soil were high above 3cm depth and decreased sharply with depth from 5cm to 15cm. Both of POC and PON of the soil warming plot were 20-30% lower than those of the control plot irrespective of depth above 15cm depth. The result indicates that the soil warming experiment was encouraged the microbial decomposition of soil organic matter up to comparatively deep layer. The $\Delta^{14}C$ profile of the warming plot was unique with a maximum (220 ‰) at 5cm depth, although the $\Delta^{14}C$ of the control plot was approximately constant from surface to 10cm depth. In terms of $\Delta^{14}C$ vertical profile above 10cm depth, although the $\Delta^{14}C$ of the warming plot above the 3cm depth having POC $>$15 wt% were lower than those of the control plot, the $\Delta^{14}C$ of the warming plot below the 3cm depth were obviously higher than those of the control plot. The results indicate that microbes selectively decomposed young POC at surface layer and old POC at intermediate layer by the soil warming experiment.

Keywords: soil carbon, radiocarbon, global warming, organic matter decomposition, forest soil

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HTT35-12 Room:311 Time:May 1 12:00-12:15

Cosmogenic $^{36}Cl/^{10}Be$ ratio in the Antarctic ice core during the last deglaciation and early Holocene

SASA, Kimikazu[1*] ; KUROSUMI, Kazuna[1] ; SUEKI, Keisuke[1] ; TAKAHASHI, Tsutomu[1] ; MATSUSHI, Yuki[2] ; TOSAKI, Yuki[3] ; HORIUCHI, Kazuho[4] ; UCHIDA, Tomoko[5] ; MATSUZAKI, Hiroyuki[6] ; MOTOYAMA, Hideaki[7]

[1]University of Tsukuba, [2]Kyoto University, [3]National Institute of Advanced Industrial Science and Technology, [4]Hirosaki University, [5]Tohoku University, [6]The University of Tokyo, [7]National Institute of Polar Research

^{36}Cl is cosmogenic nuclide (half-life:301 kyr) produced mainly by a reaction of $^{40}Ar(p, n\alpha)^{36}Cl$ in the upper atmosphere. Cosmogenic nuclides fall on the Earth's surface at a rate depending on the nuclide production rates and hence reflecting the cosmic ray intensity. Therefore we can reconstruct fluctuations of cosmic ray intensity, by determining the past ^{36}Cl depositional flux. Such fluctuations of cosmic ray intensity may indicate paleo solar activity and/or variations in the Earth's geomagnetic field.

In this presentation, we report the results of cosmogenic ^{36}Cl measurements during 10.55 - 18.42 kyr b2k in the ice core drilled at the Dome Fuji station, Antarctica (Motoyama et al., 2007). ^{36}Cl in the ice was measured with the accelerator mass spectrometry (AMS) system at the University of Tsukuba (Sasa et al., 2010). The results show that ^{36}Cl conc. is 0.21 - 1.80 $\times$ 10^4 atoms g^{-1} and ^{36}Cl flux is 0.54 - 3.25 $\times$ 10^4 atoms cm^{-2} yr^{-1}. The variation of ^{36}Cl flux in early Holocene shows similar fluctuations of ^{10}Be flux in the same ice core. $^{36}Cl/^{10}Be$ is constant at 0.10 $\pm$ 0.01 in early Holocene. This means that this value can be used for radioactive age dating of the old ice core. $^{36}Cl/^{10}Be$ varies in the last deglaciation. It suggests that the decrease in $^{36}Cl/^{10}Be$ ratio is linked to climate change.

Keywords: $^{36}Cl/^{10}Be$, Cosmogenic nuclide, Accelerator Mass Spectrometry, Radiometric age determination, Ice core

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HTT35-13 Room:311 Time:May 1 12:15-12:30

Correlation between the concentrations of cosmogenic Be-7, Be-10 in atmosphere and solar activities.

YAMAGATA, Takeyasu[1*] ; NARAZAKI, Yukinori[2] ; NAGAI, Hisao[1] ; MATSUZAKI, Hiroyuki[3]

[1]Collage of Humanities and Sciences, Nihon University, [2]Fukuoka Institute of Health and Environmental Science, [3]School of Engineering, the University of Tokyo

The concentrations of ^{7}Be and ^{10}Be were investigated at Dazaifu, Fukuoka (1998-2002), Hachijo-Island (2002-2005) and Tokyo (2002-2008) during 1998 to 2008. The seasonal variations were same each year; high concentrations and high isotopic ratios of ^{10}Be/^{7}Be that was caused by strong stratosphere-troposphere exchange (STE) were appeared in February to June, and various concentrations but constant ^{10}Be/^{7}Be by vertical convection in troposphere were appeared in July to December. The concentrations were reconstructed by the box model formula. The parameters of the mean residence time and STE intensities, and period, were constant. The amplitudes of production rate were higher than the amplitude of cosmic ray neutron flux observed at Moscow near earth's surface by a factor of 4. Since the neutron flux amplitude at polar region that was little influenced by geomagnetic field was only 10% higher than Moscow, the high amplitudes of production rate were assumed that caused by changing of energy spectrum of galactic cosmic ray.

Keywords: Accelerator mass spectrometry, Cosmogenic nuclide, atmosphere, aerosol

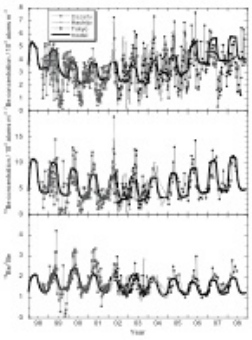

Fig. 1 The decadal variations of ^{7}Be, ^{10}Be concentration and ^{10}Be/^{7}Be in the atmosphere in Dazaifu, Hachijo-Island and Tokyo during 1998 to 2008.

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Distributions of radionuclides Cl-36 and I-129 in surface soils before Fukushima accident

SUEKI, Keisuke[1*] ; KITAGAWA, Jun-ichi[2] ; SASA, Kimikazu[1] ; TAKAHASHI, Tsutomu[1] ; MATSUKURA, Masumi[1] ; KINOSHITA, Norikazu[3] ; TOSAKI, Yuki[4] ; MATSUSHI, Yuki[5] ; MATSUZAKI, Hiroyuki[6]

[1]University of Tsukuba, [2]High energy acclerator research organization, [3]Shimizu corporation, [4]The National Institute of Advanced Industrial Science and Technology, [5]Kyoto University, [6]The University of Tokyo

The long-lived radionuclides ^{36}Cl and ^{129}I are generated by the nuclear tests or interaction with cosmic rays. They have descended to ground or sea level surface, and they have remained ground surface afterward. We have measured amount of ^{36}Cl and ^{129}I by accelerator mass spectrometry (AMS) before nuclear accident at the Fukushima No. 1 nuclear power plant.

We have collected surface soil samples from the Sea of Japan to the Pacific Ocean at the equal-latitude cross-sectional areas (37 ^{o} 20' N - 37 ^{o} 30' N) in the south Tohoku, Japan. Inorganic chlorine in soil developed an improved leaching process that uses diluted HNO3 as an extractant, activated carbon to remove organic matters without decomposition, and H_2O_2 to remove residual organic matters. After leaching from soils, the AgCl samples for AMS-target made from the obtained solutions at ordinary treatment. Isotopic ratios of ^{36}Cl/Cl were determined by AMS at Tandem Accelerator Complex, University of Tsukuba. Preparation of Iodine-129 target was following ordinary method. Isotopic ratios of ^{129}I/I were determined by accelerator mass spectrometry (AMS) at MALT, the University of Tokyo. Moreover, we determined ^{137}Cs concentrations by gamma spectroscopy and LOI (loss on ignition used by an electric furnace) which related to the amount of the organic matter in soil.

We obtained the distributions of radionuclides ^{36}Cl and ^{129}I in surface soils. The measured ^{36}Cl/Cl ratios of 34 surface soil samples which were about 0-10 cm in depth from 6 sites at the equal-latitude cross-sectional areas were between 0.1 x 10^{-13} and 4.1 x 10^{-13}. It was shown that the ^{36}Cl/Cl ratios are lower at both sea sides. The concentrations of ^{129}I and ^{129}I/I ratios in surface soil (0-10 cm) at 28 points were determined to be 0.18 - 1.13 mBq/kg and 4.3 x 10^{-9} - 11.7 x 10^{-9}, respectively.

The depth profiles of ^{36}Cl/Cl, ^{129}I and ^{137}Cs were examined that the difference of distribution. The concentrations are higher at close surface in each nuclide. The results of ^{36}Cl/Cl profiles in soil cores up to 1 m long suggested that bomb-produced ^{36}Cl remains in uppermost sections, typically for ˜20 cm deep, in undisturbed soil layers. The observed close correlation between organic matter content and ^{36}Cl/Cl ratio implies that presence of biological activity contributes the retention of fallout ^{36}Cl in the surface zone. The concentration of ^{129}I is shown the highest in uppermost surface. It is thought that the influence of global fallout has been received until now. In both nuclides, a constant amount exists in deeper than 30 cm. The concentrations of ^{137}Cs are not detection in deeper than 40 cm. It is showed that ^{137}Cs was lower mobility in soils. Therefore, the sampling soils were not a disturbance.

Keywords: AMS, Cl-36, I-129, soil