Hokkaido University IFES-GCOE
"Establishment of Center for Integrated Field Environmental Science"
北大 IFES-GCOE「統合フィールド環境科学の教育拠点形成」

IFES-GCOE Laboratory Short Course on Stable Isotopes

IFES-GCOE ラボ実習　安定同位体実習

(Tentative Version Oct 21th, 2010)

Oct 25th – 29th, 2010

Graduate school of Environment Earth Science
Hokkaido University
北海道大学大学院
地球環境科学研究院

Schedule of the Short Course
全体スケジュール

All of lectures and seminars are held at the room #D101.
After briefing (meeting at #D101) at 8:50 am, labo works begin.
すべての講義とセミナー、および最終日の成果発表は、地球環境科学研究院**D棟101**で行います。毎朝8:50から**D101**でその日の予定を確認後始めます。

Oct 25th, 2010 (Mon)

8:50	Meet at #D101 D101に集合
9:00～10:00	Greeting and explaining about precautions of the research Projects. Professor Sugimoto, Ms. Hoshino ごあいさつと注意事項等の説明　杉本敦子・星野悠美
10:00～12:00	Laboratory works for each confined research project. マイクロ研究プロジェクトごとの作業
12:00～13:00	Lunch break　昼食 Self-introduction 1,　10min/person　自己紹介タイム①
13:00～14:30	講義１．「安定同位体測定と利用の基礎」 (in Japanese) 杉本 敦子 (地球環境科学研究院)
14:30～14:45	Break　休憩
14:45～16:15	Lecture1．”Principles of IRMS and online analyses” Atsuko SUGIMOTO (Faculty of Environment Earth Science)
16:15～	Laboratory works for each confined research project. マイクロ研究プロジェクトごとの作業
18:00ー	A get together meeting　懇親会

Oct 26th, 2010（Tue）

8:50	Meet at #D101 D101に集合
9:00～12:00	Laboratory works for each confined research project. マイクロ研究プロジェクトごとの作業
10:30～12:00	Lecture 2　“Use of stable isotopes of water and materials which record information on water isotopes to investigate material cycling in ecosystem” Atsuko SUGIMOTO (Faculty of Environment Earth Science)
12:00～13:00	Lunchtime　昼食 Self-introduction 2,　10min/person　自己紹介タイム②

13:00～14:30　講義２．「生態系物質循環における水と水の情報を含む物質の安定同位体比の利用」(in Japanese)
杉本 敦子 (地球環境科学研究院)

13:00～　Laboratory works for each confined research project.
マイクロ研究プロジェクトごとの作業

Oct 27th, 2010（Wed）

8:50　Meet at #D101
D101に集合

9:00～10:30　Laboratory works for each confined research project.
マイクロ研究プロジェクトごとの作業

10:30～12:00　Lecture3．”Tracing sources of N in human-impacted watersheds and airsheds“ (On WebEX)
Carol KENDALL (U.S. Geological Survey)

12:00～13:30　Lunch & Lunch seminar 昼食&ランチセミナー
Student Seminar①
”Coalbed Methane Isotope Analysis for $\delta^{13}C$”
Speaker　Anne Marie SABINO
Student Seminar②
”Dendroclimatological investigations in Yakutia”
Speaker　Roman PETROV

13:30～14:30　Student Seminar③
”Carbon isotope $\delta^{13}C$ as an indicator of plant water stress.”
Speaker:　Akemi TSUKUURA
「植物の炭素安定同位体比 $\delta^{13}C$ は水ストレスの指標となる」
津久浦　朱美
Student Seminar④
“Comparison of $\delta^{13}C$ and $\delta^{15}N$ values among plant species in taiga-tundra ecosystem”
Speaker:　LIANG Maochang　梁 茂厂

14:30ー14:35　Break　休憩

14:35～15:05　Student Seminar⑤
”The habitat situation of northern fur seals at the Oshima peninsula in Hokkaido and the presumption of their food　consumption and migration pattern.”
Speaker:　Takanori HORIMOTO
「北海道渡島半島周辺海域におけるキタオットセイの来遊状況と食性・回遊様式の推定」堀本 高矩

15:05ー15:10　Break　休憩

15:10ー15:40　Student Seminar⑥

”Groundwater flow system under a rapidly urbanizing coastal city as determined by hydrogeochemistry.”
Speaker: Makoto KAGABU
「水文化学手法を用いた都市化する沿岸大都市の地下水流動機構」
利部　慎

15:40～ Laboratory works for each confined research project.
マイクロ研究プロジェクトごとの作業

Oct 28th, 2010（Thu）

8:50 Meet at #D101
D101に集合

9:00～10:30 Laboratory works for each confined research project.
マイクロ研究プロジェクトごとの作業

10:30ー12:00 Lecture４. ”Stable isotopes of C and O of atmospheric CO2”
Hisayuki YOSHIKAWA (Faculty of Environmental Earth Scienc
講義４. 「大気中の二酸化炭素とその炭素、酸素安定同位体」
吉川　久幸　（地球環境科学研究院）

12:00～13:00 Lunchtime 昼食
Self-introduction 3, 10min/person 自己紹介タイム③

13:00～14:30 Lecture 5. ”Application of Nitrogen and Carbon Isotope ratios for Marine Material Cycling"
Takeshi NAKATSUKA (Graduate School of Environmental Studies, Nagoya University)
講義５.「海洋物質循環における窒素・炭素同位体比の応用」
中塚　武（名古屋大学大学院 環境学研究科）

14:30～ Laboratory works for each confined research project.
マイクロ研究プロジェクトごとの作業

Oct 29th, 2010 (Fri)

8:50 Meet at #D101
D101に集合

9:00～12:00 Laboratory works for each confined research project.
マイクロ研究プロジェクトごとの作業

12:00～13:00 Lunch break 休憩・昼食

13:00～15:00 Presentations of confined research projects 成果発表会

15:00～16:00 Closing Ceremony, Certificate1 of Completion, Quetionnare
修了証授与式, アンケート記入（終了後解散）

Overview of the Micro Projects
各マイクロ研究プロジェクト概要

Confined research project A; Water group（English）
マイクロ研究プロジェクトA;　水循環（英語）

Project title: Regional characteristics of stable isotopes of water

To seek the difference in regional isotope value of water, we analyze water samples brought from several countries. This project includes not only Japanese but also foreign members, so we will be able to get global information on water isotopes. It has been well known that isotopic composition of precipitation shows clear geographic distribution. We will analyze various water samples, then, consider the reason for the isotopic gradient and isotopic deviation of our water samples from those of precipitation. Evaporation experiment or another additional measurements may be conducted to know the isotope fractionation.

Confined research project B; Animal group (Japanese)
マイクロ研究プロジェクトB;　動物（日本語）

Project title: Do stable isotopes in humpback whale bone show its seasonal movement and age?
ザトウクジラの骨の安定同位体は季節回遊や年齢を反映するか？

Carbon and nitrogen isotope ratios of animals reflect their diet. The objective of this project is to assess the variability of stable isotope ratios in the baleen (whale bone) of humpback whale to determine seasonal changes in migration areas. Additionally, the project aims at searching the possibility of using stable isotope oscillations in the baleen plates to determine age.

動物組織の炭素・窒素安定同位体は彼らの食性を反映する．本プロジェクトの目的はザトウクジラのヒゲ板(鯨骨)中の安定同位体の変動を調べることで，回遊域の季節変動を明らかにする．さらに本プロジェクトでは，安定同位体の変動パターンを調べることでザトウクジラの年齢推定の可能性を探る．

Confined research project C; Plant group (English)
マイクロ研究プロジェクト C; 植物（英語）

Project title: Comparison of $\delta^{13}C$ and $\delta^{15}N$ values among plant species in taiga-tundra ecosystem

Carbon and nitrogen isotope ratios of plant samples reflect the environment of the site where the plants grow. The $\delta^{13}C$ and $\delta^{14}N$ of plant samples are mainly controlled by their physiological condition, and by N dynamics of the site, respectively, which were affected by environmental condition. The purpose of this research project is to know a variability of leaf $\delta^{13}C$ and $\delta^{14}N$ among plant species and sites in this ecosystem. Plant samples (willow, larch, moss) collected at several sites in taiga-tundra ecosystem in Eastern Siberia will be measured.

Confined research project D; Tree ring group (Japanese)
マイクロ研究プロジェクトD； 年輪 （日本語）

Project title: Carbon isotope analysis of tree-ring for estimation of moisture condition in semiarid area
乾燥地樹木の年輪の炭素同位体比による環境の推定

Tree-ring $\delta^{13}C$ shows negative correlation with precipitation and humidity in many cases. One of the main reasons for this relationship is a change in isotope fractionation during photosynthesis due to stomatal close under drought condition. In this confined research project, $\delta^{13}C$ of tree ring samples which were taken in Mongolia will be analyzed, and compared with moisture condition.

多くの研究で年輪炭素同位体比と水分環境とに負の相関があることが示されている。この相関の主な理由の一つは乾燥状態下で起こる気孔閉鎖により、光合成の際に同位体分別が変化することである。この実習ではモンゴル国で採取した樹木年輪サンプルの炭素安定同位体比の分析やそれと水分環境との比較を行う。

Summary of the Lectures and the seminars
講義及びセミナー要旨

講義 1. 安定同位体測定と利用の基礎
杉本敦子

簡便なオンライン分析が可能な質量分析システムが普及し、地球環境科学、地球科学、生態学など、様々な分野で安定同位体比を利用した研究が行われている。講義では、同位体分別、安定同位体利用の原理、質量分析の原理、スタンダードについてなど、質量分析に関する基礎的な内容を解説する。また、実習で使用する質量分析計の構成を紹介し、実習企画内容の概略とねらいを説明する。

Lecture 1: Principles of IRMS and online analyses
Atsuko SUGIMOTO

Online measurement system for C, N, O, H stable isotopes becomes popular and applications have been developed for various scientific fields, such as earth science, environmental science, ecology, hydrology, etc. In this lecture, basics on stable isotopes, including isotope fractionation and standards, and IRMS (isotope ratio mass spectrometry) will be explained.

講義 2. 生態系物質循環における水と水の情報を含む物質の安定同位体比の利用

水の安定同位体比は緯度や高度、および海岸からの距離といった地理的な分布に明瞭な勾配がある。また、水同位体比の違いから水の由来を解明する研究や、地下水と降水の同位体比の違いを用いた河川のハイドログラフの分離など、様々な応用分野がある。水は、また、生態系の生命活動を支えるとともに生態系の物質輸送を担っており、水を構成する水素と酸素は、これらの過程で様々な物質と同位体を交換する。この講義では、水の動きを軸に、その同位体比の情報を含む物質について解説し、環境科学におけるそれらの同位体比利用の応用例を紹介する。

- 降水および表面水の同位体比
- メタンと CO2
- 硝酸
- セルロース

Lecture 2: Use of stable isotopes of water and materials which record information on water isotopes to investigate material cycling in ecosystem
Atsuko SUGIMOTO

Stable isotope ratios of surface water frequently shows correlation with latitude, distance from the coast, or mean air temperature or precipitation. It has been used to identify source or origin of water. In ecosystems, water is essential for maintaining living things, and its flow plays an important role for transport of materials dissolved in it. Oxygen and hydrogen in water exchanges isotopes with various materials in the ecosystems. In this lecture, stable isotopes of various materials which records information on water isotopes and their applications in environmental science will be explained.

- Isotope ratios of precipitation and surface water
- Methane and CO2
- Nitrate
- Cellulose

Lecture 3: Tracing sources of N in human-impacted watersheds and airsheds
Carol Kendall (United States Geological Survey)

Nitrate isotopes ($\delta^{15}N$, $\delta^{18}O$, $\Delta^{17}O$) and ammonium-$\delta^{15}N$ are useful tools for determining sources of nitrogen in rivers, groundwater, and airsheds because N derived from different sources and land uses often have distinctively different isotope compositions, making isotopes a very useful adjunct to standard chemical and hydrological mass balance methods. This seminar will present a "state-of-the-science" overview of how nitrate and ammonium isotopes can be used to estimate the relative contributions of different sources of N to ecosystems, using examples primarily from our multi-isotope investigations in the San Joaquin and Sacramento Rivers, and our national-scale study of nitrate isotopes in rain.

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Lecture 4: Stable isotopes of C and O of atmospheric
CO2大気中の二酸化炭素とその炭素、酸素安定同位体
Hisayuki YOSHIKAWA　吉川 久幸

Lecture 5: Application of Nitrogen and Carbon Isotope ratios for Marine Material Cycling－Variations in Suspended, Sinking and Sedimented Particulate Organic Matter
海洋物質循環における炭素・窒素安定同位体比の応用－懸濁・沈降・堆積粒子有機物の変動
Takeshi NAKATSUKA　中塚 武

By looking back on the history of carbon and nitrogen isotopic studies of marine suspended, sinking and sedimented particulate organic matter, I will explain factors controlling of their temporal and spatial variations in detail and discuss how we can utilize those data for understanding of marine material cycling. Because large amounts of particulate organic matter could be easily collected by water filtrations, sediment traps and/or sediment samplings, those carbon and nitrogen isotopic ratios have been measured for a long time. There are three main factors affecting their temporal and spatial variations as follows. First, isotopic ratios of photosynthetic substances absorbed by phytoplankton and isotopic fractionation during the assimilation. Second, transports and decompositions of organic matter. Third, selective consumptions of organic molecules. Although all of three were important targets in the study of marine material cycling, it was very difficult to analyze them because of the complex influences among them into the particulate organic matter. In this lecture, I will tell some stories of failures and successes in the application of organic carbon and nitrogen isotopic ratios to marine material cycling, such as (1) Some simple discussions using the initial small numbers of data, (2) Complication of the models explaining the increasing filed data, (3) Detailed experimental and observational studies to verify the models, (4) Isotopic measurement of substrates and its coupling to ocean circulation models, (5) Compound specific isotopic measurements to analyze data deeply etc.

海洋の懸濁・沈降・堆積粒子有機物の炭素・窒素安定同位体比を巡る「研究の歩み」を題材にして、その時間的・空間的変動の規定因子を詳細に解説すると共に、それらのデータから海洋物質循環の何が分かるのかについて議論する。懸濁粒子・沈降粒子・堆積粒子の有機物は、それぞれ海水を濾過すること、セジメントトラップを設置すること、堆積物を採取することにより、比較的簡便に大量に採取できたため、当初より、その炭素・窒素同位体比の測定が広く行われてきた。その時空間分布には、第一に、植物プランクトンによる一次生産の際の基質の同位体比とその取り込み時の同位体分別、第二に、生成された有機物の輸送・分解過程、第三に、有機分子の選択的消費過程、等々が影響している。それらは、全て海洋物質

循環における重要な解析対象であるが、一般に懸濁・沈降・堆積粒子有機物には、その全てが複合的に影響するため単純な解析が難しかった。本講義では、(1)初期の限られたフィールドデータを対象にした素朴な考察、(2)フィールドデータ数の増加と説明モデルの複雑化、(3)それらを検証するための詳細な実験的・観測的研究、(4)基質同位体比の測定及びその海洋循環モデルとの結合、(5)個別化合物の安定同位体比の測定による解析技術の深化等々、研究発展の歩みを順に追うことで、有機物の炭素・窒素安定同位体比を海洋物質循環研究に応用しようとした、先人たちの挫折と成功の歴史を紹介したい。

Seminar 1 Dendroclimatological investigations in Yakutia.
Roman PETROV

In the Republic of Sakha (Yakutia) dendrological studies conducted severel years ego. In the beginning it have Forestry character, but recently it have focused on dendroclimatological research for investigate the influence of climatic factors on tree rings growth. At the present time there are very few publications about the using of isotope analysis, like stable isotopes of carbon (C 13), to characterize the influence of climate on tree growth. Basically isotope analysis was used for dating the samples. In my work I investigated the effect of air temperature and annual rainfall on growth of larch (Larix cajanderi Mayr) and pine (Pinus sylvestris) in Central Yakutia.

Seminar 2 Coalbed Methane Isotope Analysis for $\delta^{13}C$
Anne Marie SABINO

Coalbed Methane is an emerging natural gas resource, evolved worldwide as an alternative clean burning fossil fuel. Because of the growing concerns on the environment and fuel sustainability, Coalbed Methane Project was established between Philippine Department of Energy (DOE) and United States Geological Survey (USGS). The DOE laboratory was able to acquire a continuous flow Mass Spectrometer to analyze the $\delta^{13}C$ of coalbed methane gas samples. $\delta^{13}C$ assist in the interpretation of methane sources (biogenic or thermogenic) and other geochemical processes. Currently the laboratory is only limited in analyzing $\delta^{13}C$ in gas samples but addition of Elemental Analyzer will enhance the technical capability of the laboratory to analyze not only gas samples, but also liquid (petroleum) and solid (source rocks) samples.

Seminar 3 Carbon isotope $\delta^{13}C$ as an indicator of plant water stress.
植物の炭素安定同位体比 $\delta^{13}C$ は水ストレスの指標となる
Akemi TSUKUURA

Plant $\delta^{13}C$ depends on the plant type and environmental conditions due to the change in isotope fractionation during photosynthesis. When stomatal conductance is high (stomata open), CO_2 is supplied quickly from atmosphere into the stomata. $\delta^{13}C$ of fixed C is low because light isotope (^{12}C) reacts faster than heavy isotope (^{13}C) with photosynthetic enzyme. On the other hand, when stomatal conductance is low, CO_2 supplied from atmosphere into the stomata is limited. As the result, CO_2 in the stomata is enriched in heavy isotope (^{13}C), thus, $\delta^{13}C$ of fixed C becomes high. Water stress causes a stomatal closure of the plant; therefore, $\delta^{13}C$ increases under dry condition.

The aim of my study is to reconstruct soil moisture variation and history of water stress at forest-grassland boundary in Mongolia, using tree-ring $\delta^{13}C$. Final goal of my research is to assess the possible influence of global warming such as the boreal forest decline at forest-grassland boundary in Mongolia.

植物の $\delta^{13}C$ は光合成の際に起こる同位体分別により変化し、植物タイプや生息環境により異なる。植物は気孔コンダクタンスが高い（開いている）時は、大気から気孔内への CO_2 の供給が多くなり、軽い同位体(^{12}C)が速く光合成酵素に取り込まれていき、光合成産物の $\delta^{13}C$ は低くなる。一方、気孔コンダクタンスが下がる（閉じぎみになる）時は大気から気孔内への CO_2 の供給が遅くなり、気孔内の CO_2 は重い同位体(^{13}C)に富むようになる。このため、気孔コンダクタンスが低下すると光合成産物の $\delta^{13}C$ は高くなる。乾燥地において植物は水ストレスの最初の応答として気孔を閉じるため、水ストレス状態下では $\delta^{13}C$ は高い値を示す。

私の研究は年輪 $\delta^{13}C$ を用いてモンゴルの森林－草原境界域（エコトーン）において樹木（カラマツ）の生息域の水分環境の復元を行い、カラマツの水ストレスの履歴を明らかにすることで、水の涵養地として重要な役割を果たす森林の減少やそれに伴うエコトーンの北への後退が起こる可能性を評価することである。

Seminar 4 Comparison of δ13C and δ15N values among plant species in taiga-tundra ecosystem
LIANG Maochang

Carbon and nitrogen isotope ratios of plant samples reflect the environment of the site. The δ13C and δ14N of plant samples are mainly controlled by their physiological condition, and by N dynamics of the site, respectively, which were affected by environmental condition. The purpose of this research project is to know a variability of leaf δ13C and δ14N among plant species and sites in this ecosystem.
Plant samples were collected at several sites in taiga-tundra ecosystem in Eastern Siberia.

Seminar 5 The habitat situation of northern fur seals at the Oshima peninsula in Hokkaido and the presumption of their food consumption and migration pattern.
北海道渡島半島周辺海域におけるキタオットセイの来遊状況と食性・回遊様式の推定
Takanori HORIMOTO

Marine mammals are consumers of production at most trophic levels. They impact a lot for fishery as well as for their prey community. For run the sustainable fishery, it is necessary to ascertain their ecology and impact for surrounding environments.

Northern fur seal *Callorhinus ursinus* is one of the common marine mammals in the North Pacific Ocean. Most of them breed in northern islands such as the Kurile and the Aleutian islands. In winter, they also migrate to Japan for foraging. In recent years, there are some reports that fur seals appear near the Oshima peninsula, south area of Hokkaido, and they are also causing great harm to the coastal fishing industry. However, effective countermeasures are not adopted because the ecology of fur seal has many unclear points. In this study, there are two objectives: 1) to find out fur seals' impacts for surrounding environments, we will conduct the visual survey on ships, and also conduct stranding research; 2)

to estimate their migration pattern, we will conduct the stable isotope analysis.

Seminar 6　Groundwater flow system under a rapidly urbanizing coastal city as determined by hydrogeochemistry
Makoto KAGABU

In the Jakarta area (Indonesia), excessive groundwater pumping due to the rapidly increasing population has caused groundwater-related problems such as brackish water contamination in coastal areas and land subsidence. In this study, we adopted multiple hydrogeochemical techniques to demonstrate the groundwater flow system in the Jakarta area. Although almost all groundwater existing in the Jakarta basin is recharged at similar elevations, the water quality and residence time demonstrates a clear difference between the shallow and deep aquifers. Due to the rapid decrease in the groundwater potential in urban areas, we found that the seawater intrusion and the shallow and deep groundwaters are mixing, a conclusion confirmed by major ions, Br?:Cl? ratios, and chlorofluorocarbon (CFC)-12 analysis. Spring water and groundwater samples collected from the southern mountainside area show younger age characteristics with high concentrations of 14C and Ca-HCO3 type water chemistry. We estimated the residence times of these groundwaters within 45 years under piston flow conditions by tritium analysis. Also, these groundwater ages can be limited to 20 to 30 years with piston flow evaluated by CFCs. Moreover, due to the magnitude of the CFC-12 concentration, we can use a pseudo age-indicator in this field study, because we found a positive correlation between the major type of water chemistry and the CFC-12 concentration.