Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-01 Room:105 Time:May 23 09:00-09:15

Reconstruction of snow algal variations from an ice core drilled on an ice cap in Kyrgyz Tien Shan

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Snow algae are photosynthetic microorganisms and are living on the surfase of glaciers. They grow on melting surface from spring to summer and their biomass and community structure are changed with physical and chemical conditions on glaciers. Ice cores drilled from glaciers also contain snow algae that grew in the past. Studying biomass and community structure of snow algae in ice cores could reveal the temporal variation in snow algae in the past, and also environmental conditions relating propagation of snow algae. In this study, we anlalyzed snow algae preserved in an ice core of Grigoriev Ice cap located in eastern Kyrgyzstan of the central Asia, and to describe their temporal variations for the last 200 years.

Microscopy revealed that the ice core contained three taxa of filamentous cyanobacteria, an unicellular cyanobacterium, and two green algae. They were also found on the ice or snow surface of the ice cap.

The quantitative analyses of the algae in the part of upper 64 m of the ice core revealed that the algal biomass varied significantly and showed many peaks. Furthermore, the biomass profile differed among the taxa.

Annal variation of the algal biomass was found to be significantly correlated with air temperature at the nearest observing station from the ice cap and hydrogen stable isotope in the ice core. The results suggest that the algal growth is more preferable in warmer year.

Keywords: ice core, glacier, snow algae, microbes, climate warming

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-02 Room:105 Time:May 23 09:15-09:30

Reconstructions of past flora using DNA analysis from ice core samples on Gregoriev Glacier, Kyrgyz Tienshan

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Analyses of ice cores have often been used as a means to reconstruct past environments. The species composition of the organism such as microorganism and plant in the ice cores could reflect the environmental condition at that time. Thus, organisms in ice cores could be useful to reconstruct past environments. However, analysis of the biological contents in ice cores is still highly limited.

We report results of metagenomic analyses of genomic DNA collected from the ice core sample (about 8,000 and 12,500 years old) collected on Gregoriev Glacier, Kyrgyz Tienshan. The ice core samples were melted using a device that enabled us to obtain water only from the inner portion of the cores. Complete separation of the inner and outer cores is required to avoid contamination by bacteria that can adhere to the cores during drilling and storage. We carried out taxonomic and functional binning of the metagenomic DNA by utilizing sequences generated by the 454 FLX sequencer, and attempted to reconstruct the organisms and their interactions within the community and with the environment on the sampled sites. The results implied genomic information used as an environmental marker for past environmental studies.

Keywords: ice core, genome analysis, metagenome, past environmental study, microoganisms

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-03 Room:105 Time:May 23 09:30-09:45

Variations in pollens, dissolved ions,Oxygen isotopes, and Snow algaes in a shallow ice core of No.31 Glacier, Suntar-Kh

Masaya miyairi[1*], Nozomu Takeuchi[1], Sota Tanaka[1], Tsutomu Kadota[2], Tatsuo Shirakawa[3], Ryo KUSAKA[3], Alexander Fedorov[5], Pavel Konstantinov[5], Shuhei Takahashi[3], Tetsuo Ohata[2], Hironori Yabuki[2], Keiko Konya[2], Hiroyuki Enomoto[4]

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We investigated glaciers in the Suntar-khayata mountain range located in far east Russia from July to September, 2012, and drilled two shallow ice core on the glaciers.

We analyzed pollens, dissolved ions, oxygen isotopes and sonw algaes to examine posibilities of dating of the ice core and of reconstraction ofpast environment.

There was no clear seasonal change in stable isotope. The chemical analysis showed that there was a positive correlations among Cl,Na, NH4,K and Mg and between NO3 and SO4. This suggested that there is two different sources of the chemical species.

Pollen analysis showed that the ice core contained the grains of Betulaceae ,Pinaceae and Artemisia, which agreed with the vagitation around the region.Their variation seemed to show annual layers, indicating that they are possble to use dating of the ice core.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-04 Room:105 Time:May 23 09:45-10:00

Causes of Greenland temperature variability over the past 4000 years: Implications for Northern Hemispheric temperature

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A new Greenland temperature record reconstructed from argon and nitrogen isotopes from trapped air in a GISP2 ice core, provides high resolution (less than 20 years) and precise annual average temperature estimates for the past 4000 years. Due to tight age controls and abundant paleoclimatic information from the ice core, the temperature record provides an exceptional opportunity to investigate the late Holocene climate in a multidecadal to millennial time scale. To investigate causes of Greenland temperature variability over the past 4000 years, we calculated high latitude (70 to 80N) temperature change using a one dimensional energy balance model with reconstructed climate forcings including orbital, solar, volcanic, and greenhouse gas forcings. Greenland temperature was calculated from the high latitude temperature, considering Greenland negative temperature responses to solar variability due to associated changes in atmospheric and oceanic circulations. The calculated Greenland temperature was significantly correlated with the ice core derived Greenland temperatures with the 97 percent confidence level. Therefore, the past variability of climate forcings can explain at least 10 percent of the multidecadal to millennial variability in Greenland temperature over the past 4000 years. An average temperature trend for the Northern Hemisphere (NH) over the past 4000 years was also inferred from the ice core derived Greenland temperatures. Lines of evidence indicate that the current decadal average temperature of NH is likely warmer than at any time over the past 4000 years. Sequential cooling events starting around 800 B.C.E. (the 2.8ka event), which were induced by several large volcanic eruptions as well as low solar activity, had similar magnitude with the Little Ice Age cooling.

Keywords: Greenland, Temperaure, Paleoclimate, Climate change, Ice core

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-05 Room:105 Time:May 23 10:00-10:15

Climate and environment in north Greenland during the last interglacial reconstructed from the NEEM ice core

Kumiko Goto-Azuma[1*], Nobuhiko Azuma[2], Motohiro Hirabayashi[1], Kenji Kawamura[1], Takayuki Kuramoto[3], Atsushi Miyamoto[4], Jun Uetake[1]

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A 2540m-long ice core was drilled during 2008-2012 by an international ice coring project NEEM (North Greenland Eemian Ice Drilling). Though the ice below 2206m was disturbed and folded, the international team has successfully reconstructed the climate and ice sheet elevation during the Eemian interglacial (130.000 to 115.000 years ago). The climate around 126.000 years ago in North Greenland was about 8 degrees Celsius warmer than at present, which led to extensive surface melt as was observed in July 2012. Despite the strong warming during the Eemian, the surface in the vicinity of NEEM was only a few hundred meters lower than its present level. These results have been published in Nature as the first NEEM community paper. Here we report the results described in this paper, introduce the NEEM core analyses carried out by the Japanese team, and discuss the future direction of the analyses.

Keywords: Greenland, NEEM, last interglacial, ice core, climate and environment

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-06 Room:105 Time:May 23 10:15-10:30

Non-destructive magnetic detection of thin ash layers in ice cores

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We will make a presentation on the results of non-destructive magnetic detection of ash layers in ice core samples with an LTS-SQUID gradiometer developed for non-destructive evalusation. The LTS-SQUID gradiometer have a planar pickup coil with 1.5 mm x 1.5 mm area and the baseline of 3 mm. Volcanic ash sample collected from 2008 eruption of Sakurajima volcano at Sakurajima and AT tephra sample collected in Hokkaido were used to imitate ash layers in ice cores. Both of the model ice core samples gave reasonable signals by artificial magnetization. Preliminary estimate of the detection limit for the current system and configuration is of the order of ˜1x10ˆ-4 A/m. The sensitivity is very much enhanced when the magnetic sensor is lowered just above the model ice cores. High sensitivity non-destructive magnetic detection of ash layers will be an important method to identify stratigraphic horizons of volcanic activities combined with electrical conductivity signals related to sulfate supplied at the time of volcanic eruptions.

Keywords: ice core, tephra, nondestructive measurement, SQUID gradiometer, magnetic mineral, age model

Japan Geoscience Union Meeting 2013
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ACC33-07 Room:105 Time:May 23 10:30-10:45

SO2 photoexcitation mechanism links sulfur MIF in polar sulfate to climate-impacting volcanism

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Natural climate variation such as that due to volcanoes is the basis for identifying anthropogenic climate change. However, knowledge of the history of volcanic activity is inadequate, in particular concerning the explosivity of specific events. Stable sulfur isotope abundances contain additional information and recent studies show a correlation between volcanic plumes that reach the stratosphere and mass-independent anomalies in sulfur isotopes in glacial sulfate. We describe a new mechanism, photoexcitation of SO_2, links the two yielding a useful metric of explosivity of historic volcanic events. A plume model of SO_2 to sulfate conversion was constructed including photochemistry, entrainment of background air and sulfate deposition. Isotopologue-specific photoexcitation rates were calculated based on the UV absorption cross sections of $^{32}SO_2$, $^{32}SO_2$, $^{32}SO_2$ and $^{32}SO_2$ from 250 to 320 nm. The model demonstrates that UV photoexcitation is enhanced by altitude while mass-dependent oxidation such as SO_2 + OH is suppressed by in situ plume chemistry, allowing the production and preservation of a mass-independent sulfur isotope anomaly in the sulfate product. The model accounts for the amplitude, phases and time development of Delta^{33}S / delta^{34}S and Delta^{36}S / Delta^{33}S found in glacial samples. For the first time we are able to identify the process controlling mass-independent sulfur isotope anomalies in the modern atmosphere. This mechanism is the basis of identifying the magnitude of historic volcanic events.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-08 Room:105 Time:May 23 11:00-11:15

Sulfate-climate coupling over the past 300,000 years in inland Antarctica

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Sulfate aerosols, particularly micrometer-sized particles of sulfate salt and sulfate-adhered dust, can act as cloud condensation nuclei, leading to increased solar scattering that cools Earth's climate. Evidence for such a coupling may lie in the sulfate record from polar ice cores, but previous analyses of melted ice-core samples have provided only sulfate ion concentrations, which may be due to sulfuric acid. Here we present profiles of sulfate salt and sulfate-adhered dust fluxes over the past 300,000 years from the Dome Fuji ice core in inland Antarctica. Our results show a nearly constant flux of sulfate-adhered dust through glacial and interglacial periods despite the large increases in total dust flux during glacial maxima. The sulfate salt flux, however, correlates inversely with temperature, suggesting a climatic coupling between particulate sulfur and temperature. For example, the total sulfate salt flux during the Last Glacial Maximum averages 5.78mgm^{-2} yr^{-1}, which is almost twice the Holocene value. Although it is based on a modern analogue with considerable uncertainties when applied to the ice-core record, this analysis indicates that the glacial-to-interglacial decrease in sulfate would lessen the aerosol indirect effects on cloud lifetime and albedo, leading to an Antarctic warming of 0.1 to 5 kelvin.

Keywords: sulphate aerosols, cloud condensation nuclei, polar ice core, ice sublimation method

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-09 Room:105 Time:May 23 11:15-11:30

Reconstruction of Blake excursion using the cosmogenic radio nuclide Beryllium-10 in Antarctic Dome Fuji ice core

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An important development in the field of geomagnetism is the recognition of excursions that serve as chronostratigraphic tools for the dating and correlation of marine and lacustrine sediment cores. Here, we reconstruct the Blake excursion from 127ka to 101ka by analyzing 10Be in the second Dome Fuji deep ice core. We focus attentin on the Blake excursion because it occurs during Marine Isotope Stage (MIS) 5, during the last interglaciation, beyond the range of radiocarbon dating. 10Be and other cosmogenic radionuclides, such as 14C, 26Al, and 36Cl are good proxies for geomagnetic field intensity because atmospheric production increases during periods of low intensity during excursions, and 10Be is particularly well suited due to its long half life, high production rate, and well understood fallout process. While the accumulation of 10Be in sediments is complicated due to enrichment from sources other than direct atmospheric fallout, polar ice cores are remarkable archives of 10Be, especially those from Antarctica, which is isolated from other continents. Ice cores drilled at Dome Fuji also have the advantage of a well dated chronology using the O2/N2 ratios (Kawamura, et al., 2007). Results indicate there are five discrete peaks in 10Be flux during the Blake excursion that will allow export of the Dome Fuji chronology to the MIS5 intervals of sediment cores.

Keywords: ice core, cosmogenic radio nuclide, Blake excursion, Dome Fuji

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-10 Room:105 Time:May 23 11:30-11:45

Measurement of nitrogen and oxygen isotope ratios of nitrate in a shallow ice core drilled in the vicinity of Dome Fuji

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Knowledge of the variability of solar activity is important for astrophysics and geoscience. Ice core samples have been considered that they preserve astronomical events as well as various information on the history of the earth involving climate change and so on. In previous studies, it is reported that nitrate concentration in Antarctic ice core can be a proxy of solar activity [*Traversi et al.*, 2012]. We have focused on nitrogen and oxygen isotope ratios of nitrate expected to be used as archives of isotope fractionations by photochemical reaction in the stratosphere.

In 2010, a shallow ice core was obtained in the vicinity of Dome Fuji station, Antarctica. Dome Fuji is regarded as an ideal site for research of atmospheric reactions because chemical components are directly transported from the stratosphere. In this study, we analyzed nitrogen and oxygen isotope ratios in or near nitrate spikes by using a denitrifier method [*Casciotti et al.*, 2002]. The denitrifier method is based on the isotopic analysis of nitrous oxide generated from nitrate by denitrifying bacteria (*Pseudomonas aureofaciens*).

The fluctuations of nitrogen and oxygen isotope ratios are lager than that of nitrate concentration. The range of nitrogen isotope ratio is similar to that found in previous studies of snow pit samples from Dome C. The changes of nitrogen and oxygen isotope ratios are different in each spike. Precious studies inferred that nitrogen isotope ratio contains NOx signature and oxygen isotope ratios is dependent upon the oxidation pathway that produces nitrate from NOx in the atmosphere [e.g. *Hastings et al.*, 2003]. Our results suggest that it is possible to reveal hidden signature of solar activity with considering chemical reactions in the stratosphere.

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Keywords: ice core, nitrate isotopes, solar activity

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-11 Room:105 Time:May 23 11:45-12:00

A new dating method for Dome Fuji ice core using data assimilation]

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Using Data Assimilation, we try to make a new dating method but based on the glaciological dynamics of Parrenin et al. (2004, 2007). Trough filtering and smoothing method, we could gain a better tacking of the age of ice using high-resolution age makers for the deep part. It is still in the experimental stage but we will introduce the method and indicate the results using Kalman Filtering method. We gained similar results of estimated ages of ice and optimized parameters for dating model as well as Parrenin et al.(2007). Moreover, our calculation method has a substantial advantage for the calculating cost. In the future, we plan to make an improved dating model with other data assimilation method which could carry out a detailed ice chronology.

Keywords: Data Assimilation, Ice Core

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-12 Room:105 Time:May 23 12:00-12:15

An updated chronology and inference of climate evolution for the GISP2 ice core from Summit, Greenland

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Accurate chronologies are paramount for properly assessing the timing of past climate events. The GISP2 ice core has been updated to the Greenland Ice Core Chronology (GICC05) for 840 sparse volcanic tie points. Using the thickness evolution for the GISP2 site from the three-dimensional dynamic/thermodynamic ice sheet model SICOPOLIS (sicopolis.greveweb.net), we determine a more continuous GISP2 chronology. The associated accumulation-rate history is determined for a suite of thickness reconstructions. The implications of this work include aligning the GISP2 ice core chronology and climate record with other Greenland ice cores (NEEM, NGRIP, and GRIP), improving our understanding of the Arctic climate from a suite of deep ice cores. Improving the GISP2 Greenland chronology has implications for both polar regions. Antarctic ice cores (Byrd, Siple) have been dated from the GISP2 record through inflection points in the well-mixed methane record.

Keywords: Greenland, Ice sheet, Ice core, Climate change, Modeling

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-13 Room:105 Time:May 23 12:15-12:30

The topographic and albedo effect of ice sheets on surface wind stress with implications for glacial ocean circulation

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In the previous presentation of Abe-Ouchi et al. (2012, JpGU), they pointed out that the Atlantic meridional overturning circulation (AMOC) was strongly controlled by the ice sheet and greenhouse gases (GHGs). By comparing the results from a coupled atmosphere ocean general circulation model (AOGCM) with and without glacial ice sheets, they showed that the ice sheets had a large influence on the glacial AMOC. The process behind this is not fully understood, but may be related to atmospheric circulation change due to the presence of huge ice sheets. Some studies have shown that during the Last Glacial Maximum (LGM), the atmospheric circulation was very different to that of today mainly due to the presence of the huge ice sheet, especially in the North Atlantic. These atmospheric circulation differences would cause some changes in wind stress and should therefore affect AMOC. Thus in this study, we investigate the potential/possible influence of the ice sheets on glacial AMOC through wind stress. Here we use an atmosphere general circulation model (AGCM), which is the atmospheric part of MIROC climate model for sensitivity experiments. As ice sheet has two effects (topography effect and albedo effect) on atmospheric circulation, we separate each effect as well. In the North Atlantic, consistent with previous studies, differences between the wind stresses of the modern climate and LGM were mainly explained by the presence of the LGM ice sheets, i.e., Laurentide and Fenno-Scandian ice sheets. Anomalies induced by the ice sheets were a southward wind stress anomaly in the Greenland Sea and the Baffin Bay, and anti-cyclonic wind stress anomaly at mid and low latitudes. It was also found that at high latitudes, the topography effect was dominant and the albedo effect played a secondary role. On the other hand, at mid-latitudes, the albedo effect was dominant and the topography effect played an opposite role compared to the total ice sheet effect. In the zonal mean, there were also net westward and eastward anomalies at mid and low latitudes, respectively.

Keywords: Ice sheet, LGM, wind stress, AMOC

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-P01 Room:Convention Hall Time:May 23 18:15-19:30

modelled response of the volume and thickness of the Antarctic ice sheets to transient retreat of the grounding lines

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The volume of Antarctic ice sheet is about 60 meters equivalent sea level.
besides of climate change, interaction between ice shelves and ocean may be significant to Antarctic ice sheet.
The grounding line shift is a important factor in considering interaction between ice shelf and ocean. The position of grou nding line is thought to be governed by ice flow and mass balance between ice shelves and ocean. Last retreat of grounding l ine (20ka to present) is reconstructed from marine data.
To simulate evolution of Antarctic ice sheet, explicit treatment of grounding line movement also should be included. Howeve r, simulation of transient behavior of the grounding line is still difficult using a numerical large-area ice sheet model. I nstead, grounding line is prescribed as a boundary condition.
According to Saito and Abe-Ouchi (2010) , grounding line position is a most important factor of Antarctic Ice Volume while climate factor is relatively small.

In this study, Antarctic ice sheet volume at prescribed grounding line patterns and Antarctic ice sheet volume change since last glacial maximum by retreat of grounding line is tested. Results show that Antarctic ice sheet volume has high sensitiv ity to grounding line in a term of deglaciation.

Keywords: Antarctica, Ice sheet, Ice shelf, Grounding Line, Sea level, Ice shelf-Ocean Interaction

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-P02 Room:Convention Hall Time:May 23 18:15-19:30

The relationship between metal composition and climate change derived from the Dome Fuji ice core

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Aerosol was deposited into the surface of the ice sheet and preserved in the ice layer. The study of particulate matters in the ice sheet is important in understanding for the past climatic change because aerosol originated from various sources on the Earth, this chemical composition reflects the environmental change. Previously, several studies have reported about the physical and chemical properties of Dome Fuji ice core. Significant parts of the metallic elements in the ice core are insoluble particle. However, the study of metallic elements of insoluble particle is not sufficiently achieved, because previous studies have focused on dissolved components. In this research, we measured total (particulate + dissolved) concentration of metallic elements in the Dome Fuji ice core by applying a full-digestion analysis, and clarified the climate change.

The composition of metal components is close to the average of the crustal composition during the glacial, and close to the average of the ocean composition during the interglacial. Metal elements can be divide into two categories, (1) Group of elements composition between the crust and the ocean, and (2) Group of elements that is large variation range and unstable. These results suggest that response to change in source is different for each element. In addition, it was found that the fluctuation pattern of Sr and Ba were different boundary about 340 kyr. In this report, we discuss the relationship of these metal composition and environmental change.

Keywords: ice core, aerosol, climate change

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-P03 Room:Convention Hall Time:May 23 18:15-19:30

SP2 analysis of black carbon in snow at NEEM, Greenland

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We measured concentrations of black carbon particles (BC) in snow at NEEM, Greenland. These samples were collected in 2010 from a 3.4m deep pit. BC in melted snow was analyzed with the SP2 (Single Particle Soot Photometer) method developed by Ohata et al. (2011). BC particles in water were aerosolized by an ultrasonic nebulizer and then masses of individual BC particles were measured by SP2, which is based on the laser-induced incandescence technique. Calibration of incandescence signal was carried out with fullerene soot. In order to correcting for the loss of BC during aerosolizing, we calculated nebulizer efficiencies using five different sizes of PSLs (polystyrene latex spheres) standard solutions. We evaluated seasonal variations of BC concentrations with respect to those of stable isotopes. We also compared seasonal variations of BC and ionic species.

Keywords: black carbon, NEEM, Greenland

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-P04 Room:Convention Hall Time:May 23 18:15-19:30

Kinetic fractionation of gases by deep air convection in polar firn

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A previously unrecognized type of gas fractionation occurs in firn air columns subjected to intense convection. It is a form of kinetic fractionation that depends on the fact that different gases have different molecular diffusivities. Convective mixing continually disturbs diffusive equilibrium, and gases diffuse back toward diffusive equilibrium under the influence of gravity and thermal gradients. In near-surface firn where convection and diffusion compete as gas transport mechanisms, slow-diffusing gases such as krypton and xenon are more heavily impacted by convection than fast diffusing gases such as nitrogen and argon, and the signals are preserved in deep firn and ice. We show a simple theory that predicts this kinetic effect, and the theory is confirmed by observations of stable gas isotopes from the Megadunes field site on the East Antarctic plateau. Numerical simulations confirm the effect's magnitude at this site. A main purpose of this work is to support the development of a proxy indicator of past convection in firn, for use in ice-core gas records. To this aim, we also show with the simulations that the magnitude of kinetic effect is fairly insensitive to the exact profile of convective strength, if the overall thickness of convective zone is kept constant.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-P05 Room:Convention Hall Time:May 23 18:15-19:30

Evolution of the anisotropic structure of ice and pore spaces in firn at NEEM

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The evolution of the structure of firn core recovered at NEEM camp was investigated in order to improve our understanding of firn densification and bubble formation processes. The relative dielectric permittivities in both the vertical and horizontal planes were measured at ˜35 GHz. The results were compared with those of firn at Dome Fuji in East Antarctica. Results are summarized as follows. Down to ˜20 m, permittivity exhibited a positive correlation with the strength of dielectric anisotropy along the vertical. In contrast, the correlation is negative in deeper firn. This is a feature of the density crossover. We found that the crossover density is almost the same at NEEM and at Dome Fuji, confirming earlier studies of the polar firn. A remarkable difference between two sites is that strength of dielectric anisotropy at NEEM is only two thirds of that at Dome Fuji. In addition, negative correlation between permittivity and dielectric anisotropy is much more developed at NEEM. This fact suggests that the 3-D vertical anisotropic structure decreases rapidly in firn at NEEM and that limited layers deform rapidly by some factor. In contrast, at Dome Fuji, 3-D vertical anisotropic structure is preserved much longer period of time than NEEM. We speculate that at NEEM impurity plays a major role for selective deformation and that at Dome Fuji texture plays a major role for selective deformation.

Keywords: Greenland, ice sheet, firn, metamorphism, densification, NEEM

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC33-P06 Room:Convention Hall Time:May 23 18:15-19:30

Limit of the ice-sheet thickness and the subglacial lake

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It is said that there is the water at the bottom of thick ice-sheet, there is a water cycle of freezing and melting and re-freezing in there. In this study, I explored basic structure of the ice under high pressure at the bottom of the ice-sheet, and I discussed the limits of the ice-sheet thickness.

1) Formation of the subglacial lake

The subglacial lakes were found over a wide range under East Antarctica ice-sheet by the permeable radar on ICESat satellite, and to be confirmed the water is present. It is considered that the water temperature of the subglacial lakes are about -2˜-3’C. The subglacial lakes have keeping the liquid for high pressure by the ice load, and that is the temperature at which melting point of the ice and temperature gradient crosses. Lake Vostok is largest the subglacial lake in the Antarctica, there are about 3,800m under the ice-sheet, total area is 14,000km2, and average depth of the lake is 125m.

2) Ice transition under high pressure

Inside pressure of the ice-sheet is going to increase gradually due to snow load. This pressure reaches about 30MPa at the bottom of the Antarctica ice-sheet. The air of the earth’s surface is captured between the snow particles in this consolidation course, and the air bubbles isolate about 200m depth (Ice-Gas phase region). Reaches about 1,000m depth, this high-pressure air bubbles constitute a new crystal due to reacts with the ice, and Clathrate-hydrate is generated (Ice-Hydrate phase region). In addition, going to the higher pressure into the ice sheet, reach the region where Hydrate-water is produced by melting ice (Water-Hydrate phase region). Thereby, I think the water of the ice-sheet bottom is generated in the state of pressure melting under the ice-sheet.

3) Fracture strength of the ice and limit of the ice-sheet thickness

According to pressurization experiments of the ice under hydrostatic pressure, hydrostatic pressure was increased, which increased fracture strength. But, to compare hydrostatic pressure of 55MPa and 30MPa, fracture strength was reversed, because 30MPa was higher than 55MPa. From this fact, maximum fracture strength is expected to be about 35MPa (Thick of ice-sheet is 4,100m). Therefore, in high-pressure portion under the ice-sheet over about 4,000m occurs ductile fracture that continued plastic deformation without brittle fracture beyond the yield point. And, the state of pressure melting under the ice-sheet increase liquidity by the generated water, further, the strength is reduced

It is said that thickness of the Antarctic ice-sheet is maximum 4,000m for the ice-snow. Maximum depth of digging in the Antarctic ice-sheet is 3,800m at Vostok base, by adding depth of the subglacial lake under the ice-sheet, it will be about 4,000m. Therefore, limit of the ice-sheet thickness is about 4,000m, and by exceeding the limit thickness, the water is generated by plastic flow occurs under the ice-sheet. I think that a space to generated water has become the subglacial lake.

Keywords: Ice-sheet thickness, Subglacial lake, Pressure melting