Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MIS01-01 Room:302 Time:May 21 13:45-14:00

Snowball Earth and Cambrian explosion

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We propose a new model that can explain the cause of the Neoproterozoic snowball Earth and the consequent rapid evolution of life called the Cambrian explosion. Starburst in our and outer galaxies modulated by the Earth's core dynamo is the primary driver of large fluctuations of the Earth's surface environment including some unusual extreme conditions such as snowball Earth. When the Earth's dynamo turns weaker by about 50% than that of its present intensity, intense cosmic rays originated from starburst in galaxies can easily penetrate through the Earth's magnetosphere to cause extensive cloud formation and increased albedo, thus the Earth's surface will be covered by ice. The repeated glacial periods in the Neoproterozoic, i.e. Kaigas (770-735Ma), Sturtian (715-680Ma), Marinoan (660-635Ma) and Gaskier (585-582Ma), may have been related to the encounter of our solar system with the Galactic Arms, i.e., Scutum-Crux (Kaigas), Sgr-Carina (Sturtian and Marinoan), and Orion spur (Gaskier), respectively. Galactic arms are generally replete with extensive cosmic radiation by relatively frequent starburst.

In addition, penetration of cosmic rays is controlled also by the Earth's geomagnetism. The weaker the geomagnetism becomes, the more cosmic rays penetrate.

Genome sequences of modern animals suggest the timing of genome-level diversification of animals occurred by 1.2-0.9Ga which is definitely earlier than the so-called Cambrian explosion. Such a large time lag between the fossil record and genome clock has been interpreted as the delay of gene-preparation to make body-plans, in spite that all number of gene had been ready by 1.2-0.9 Ga. The delay of body-plan and explosive diversification can be speculated by the preparation of geochemical environments, (1) oxygen level and (2) chemical saturation of nutrients. It began at 635Ma after ending snowball and first metazoan has emerged to the surface at 582Ma in a lake enriched in nutrients such as Ca, P, Fe2+, HCO3 and others, and became possible in the rifted granitic continent through hydrothermal alteration by then. Biomineralization, began first by the inorganic precipitation in the geochemically saturated small lakes, first around the outerwall of lives, thereafter internal such as vertebrates bone followed by the genome coded the process.

Starburst caused not only the genome-level diversification but also the snowball Earth. For the long-lasting fluctuation from snowball state and interglacial warming period from 770Ma (Kaigas) to 582Ma (Gaskier), gene has diversified by the cosmic radiation, and ready to be explosive evolution if geochemical conditions were ready. We predict 1.2-0.9Ga of the molecular clock for the timing of gene-preparation may be too old, and probably to be 0.77-0.635Ga.

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MIS01-02 Room:302 Time:May 21 14:00-14:15

Snowball Earth events driven by a starburst of the Milky Way Galaxy

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Possible origins of the Snowball Earth events have been studied for a decade and still remain as enigma. External forcings from space may be able to reasonably explain the Snowball Earth events. Here we show the starburst hypothesis that the Snowball Earth events are caused by the frequent encounters with dark clouds and supernova remnants during starbursts. The predicted time intervals from the galactic history are consistent with the time intervals decoded from the Earth's history. The substructures of several super-cool/super-warm cycles during a Snowball Earth event can also be explained by the individual encounters of the nebula during a starburst. The important research target is to elucidate the mechanisms of the connection between the Earth and space to suggest specific methodologies to collect evidence from the geological record in the Earth's history.

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MIS01-03 Room:302 Time:May 21 14:15-14:30

Galactic Environment History of the Sun and Paleoclimate

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It is well established that glaciations exhibit a very long period of around 140 Myrs. However, the origin of such a long period is not well understood. One possibility is the encounter with galactic spiral arms, which has been studied under the assumption of stationary spiral pattern (stationary density waves). We have performed fully self-consistent simulation of the galactic disk, which mimics the present-day structure of the Milky Way galaxy, and traced back the orbits of Sun-like stars. We found that local gas density and the local supernova rate around the Sun show large variations, and that the primary cause of these variations is the epicycle motion of the Sun itself. When the Sun is near the perigalacticon, it generally hits the spiral arm, which roughly stays there at least for the last half billion years. These time variations of the local Galactic environments in our model agrees rather well with the periodic glaciation of the Earth in the las 0.5 Gyr.

Keywords: Milky Way galaxy, N-body/SPH simulation, Paleoclimate

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MIS01-04 Room:302 Time:May 21 14:30-14:45

Mass extinction and glactic cosmic radiation

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The possible link between mass extinction and the secular change in galactic cosmic radiation (GCR) is discussed. The biggest mass extinction in the Phanerozoic occurred at the end of the Paleozoic, in particluar, with the first major global change in the surface environments around the Middle-Late Permian (G-L) boundary. Sedimentological, paleontological, and geochemical (isotopic) data suggest the onset of global cooling immediately before the G-LB extinction. Paleomagnetic records demonstrate that a large change took place in geodynamo at the end of middle Middle Permian, in the terms of frequency change in geomagnetic reversals (Illawarra Reversal). The activation of a large mantle plume with respect to the initial breakup of Pangea likely changed the conditions of geodynamo. In order to explain these various phenomena in a single picture, the integrated ”plume winter” scenario was proposed. By weakening the intensity of geomagnetic shield, a larger flux of GCR might drive the surface climate toward cooling. Possible application/analytical methods to much older examples in deep past are discussed.

Keywords: mass extinction, P-T boundary, G-L boundary, galactic cosmic radiation, paleomagnetism, deep-sea sediments

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Triggers and process of macroevolution and mass extinctions

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Two of the most significant events in Earth biotic evolution occurred in the Ediacaran and the early Cambrian periods. The first event is characterized by the appearance of primitive marine animals such as sponges and cnidarians in the Ediacaran, and the second step is the appearance of diverse marine animals in the early Cambrian. Here we show that a two-step rise of oxygen level in shallow seas coincided with the rise of animal life in the Ediacaran and Cambrian. We hypothesize that the two-step rise in dissolved oxygen is related to the two-step evolution of metazoans in the mid-Ediacaran and the Cambrian.

The Late Devonian mass extinction was characterized by stepwise extinctions of marine organisms during the spread of vascular land plants. Here we show that massive soil erosion occurred rapidly in the latest Frasnian, which marks the culmination of the stepwise Late Devonian mass extinction and sea level rise. The Late Devonian is an unique period marked by massive soil production in flood plains by vascular land plants and massive sediment yield in uninhabited hinterland by rapid physical weathering before development of seeds in the Famennian, resulting in the massive accumulation of soil and sediments on plains. Therefore, similar events have not occurred after the Devonian. We hypothesize that flooding due to global sea-level rise eroded the massive soil and sediments, providing abundant nutrients and a massive mud supply to marine ecosystems, which resulted highly selective decimation of shallow-water sedentary organisms.

The largest mass extinction of animals and plants in both the ocean and on land occurred at the end of the Permian, largely coinciding with the largest flood basalt volcanism event in Siberia. Our depth-transect data of organic and isotopic geochemistry show that euxinia frequently developed at 100-m water depth in the Changhsingian, followed by anoxia or disoxia developed in 200- to 40-m water depths during the extinction. This implies that accumulation of hydrogen sulphide in intermediate and deep waters following oxidation of hydrogen sulphide led to dissolved oxygen consumption, surface-water anoxia, and acidification, resulting in the end-Permian mass extinction in the seas. In the case of a coincident massive release of CH4 from the Siberian igneous province and H2S from the euxinic ocean to the atmosphere, our calculations indicate that massive release of CH4 and H2S to the atmosphere did not cause ozone collapse and that an approximately 10% decrease in atmospheric O2 levels would have occurred in the case of a large combined CH4 and H2S flux. The slight decrease in atmospheric O2 levels may also have contributed to the extinction event. Rather than an increase in UV radiation levels and a decrease in atmospheric O2 levels, the direct causes of the end-Permian mass extinction of terrestrial animals were likely significant global warming and an increase in CO2 levels probably induced by the Siberian volcanism.

Triggers of five mass extinctions are probably glaciation for the end-Ordovician, global sea-level rise eroding the massive soil and sediments for Late Devonian, massive volcanism for the end-Permian and end-Triassic, and a bolide impact for the Cretaceous-Palaeogene (K-P) boundary. The mass extinction at the K-P boundary is the only mass extinction caused by an extraterrestrial impact. On the K-P mass extinction, we show that (1) coincidence of tsunami and wildfire by the bolide impact, (2) massive soil erosion at the extinction level, and (3) recovery of woods 10 kyr after the mass extinction using sedimentary organic molecules.

Keywords: macroevolution, mass extinction, oxygen concentration, spread of vascular land plants, massive volcanism, extraterrestrial impact

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MIS01-06 Room:302 Time:May 21 15:00-15:15

An evolutionary story of Porifera: linkage between the most drastic climate change and the animal multicellularity

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Late Neoproterozoic is a period of climatic changes and animal evolution. It is still unknown whether there is a strong crucial link between the two events. However, one can believe the presence of the linkage if any biological evolution has progressed with biological effort to overcome the environmental tribulation. Recent advance in Neoproterozoic earth sciences leads to reliable discussion on this subject.

Currently well-accepted idea is that increased oxygen concentration induced the animal evolution. Here, the accumulated nutrients induced explosive photosynthesis immediately after the Marinoan snowball (635 Ma), and the raised oxygen supported collagen formation and animal respiration. However, traces of more primitive animals have been recently discovered from the period before.

Porifera (sponges) had likely evolved in Cryogenian soon after the Sturtian glaciation (720 Ma). For understanding its evolutionary process, the stratified ocean can be taken into account. Lack of the thermohaline circulation in a hyper-warming Earth and long-lasting production of ice-molten water induced stable stratification in the post-glacial ocean. Huge amount of organic matter was at least partly suspended at the density gradient and provided food for animals. Similar circumstances can be seen in habitat of the modern deep-sea coral reefs. In addition, this hypothesis fits the fact that the primitive multicellular animals are all filter feeders (Kano et al., 2011). Keyword for the evolution existed in food rather than oxygen.

The most primitive multicellular animal, a sponge, was likely originated from choanoflagellate. This filter-feeding protozoa is morphologically similar to the choanocytes of sponges, and genetically encoded for cell adhesion as preadaptation for multicellularity.

Kano, A. et al. (2011) The evolution of animal multicellularity stimulated by dissolved organic carbon in early Ediacaran ocean: DOXAM hypothesis. Island Arc, 20, 280-293.

Keywords: Neoproterozoic, Porifera

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Middle Permian seawater $^{87}Sr/^{86}Sr$ record from mid-Panthalassan paleo-atoll carbonates

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We report a detail secular change of the Late Guadalupian (Permian) seawater $^{87}Sr/^{86}Sr$ ratio with the unique Permian minimum interval detected in mid-Panthalassa (superocean) paleo-atoll carbonates. The analyzed two sections at Akasaka and Kamura (Japan) occur as exotic blocks within the Jurassic accretionary complex. Both sections span across the Guadalupian-Lopingian (G-L) boundary characterized by the major crisis of large-tested fusulines and rugose corals. The two sections are separated from each other for 500 km at present, thus were likely derived from different paleo-seamounts formed in mid-Panthalassa.

The detected intervals of the minimum and the following increase in $^{87}Sr/^{86}Sr$ are common between the two sections. The new data of the lowest ratio (0.706808) in the Capitanian (Late Guadalupian) *Yabeina* (fusuline) Zone at Akasaka give the minimum $^{87}Sr/^{86}Sr$ ratio ever reported not only from the Paleozoic but also from the entire Phanerozoic. The extremely low values lower than 0.70690 were detected from 18 samples in the *Yabeina* Zone and the overlying barren interval. In particular, the extremely low values continued up to the topmost barren interval immediately below the G-L boundary. The newly detected Sr record likely represents the general trend of the Capitanian seawater in mid-Panthalassa. This find suggests that the seawater chemistry at least that related to Sr isotope fluxes changed its general trend from the long-term Paleozoic decrease to the Mesozoic increase, immediately before the G-LB extinction event. The rapid increase during the Late Permian-Early Triassic interval suggests that a large amount of radiogenic terrigenous clastics have been shed into Panthalassa possibly through rift-related new drainage systems in Pangea. The initial breakup of Pangea may have started around the G-L boundary, considerably before the final opening of the Atlantic in the Jurassic.

Keywords: Permian, Sr isotope, limestone

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Bio- and chemostratigraphy (87Sr/86Sr, d13C$_{carb}$) across the Middle-Late Permian boundary: the Akasaka Limestone case

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The end-Permian mass extinction event was double-phased. The first extinction occurred across the Guadalupian-Lopingian boundary (G-LB) recorded as the high biodiversity drop of the Permian fauna. In order to clarify the global environmental change around the G-LB, detailed litho-, bio-stratigraphy and isotope stratigraphy of ^{87}Sr/^{86}Sr and d^{13}C$_{carb}$ were analyzed at Akasaka Fm. in central Japan.

Akasaka Limestone forms a part of a paleo-atoll complex deposited primarily on the top of a mid-Panthalassan seamount. This limestone likely retains the general information of shallow, low latitude Panthalassa, without local continental effects. The study section consists of 3 units; i.e., unit 1 (Middle Permian black limestone, 112 m thick), unit 2 (white-black striped limestone; 8 m), and unit 3 (Upper Permian light gray dolomitic limestone; 22 m), in ascending order. We described the detailed stratigraphy of 2) that corresponds to the transitional interval between the black (underlying) and white (overlying) carbonates. Fusuline stratigraphy gives following ages to the units, i.e., unit 1 belongs to the *Neoschwagerina* Zone (Wordian, 8 m), *Yabeina* Zone (Capitanian, 96 m) and the lower part of the barren interval (Capitanian, 17 m), unit 2 to the upper part of the barren interval, and unit 3 to the *Codonofusiella-Reichelina* Zone (Wuchiapingina, 21 m), respectively. ^{87}Sr/^{86}Sr values stayed extremely low around 0.7068 throughout the Capitanian, started to increase rapidly at the disappearance level of large fusuline, and reached to over 0.7074 by the Wuchiapingian. On the other hand, ^{87}Sr/^{86}Sr ratios remained high, i.e., larger than 0.7070 in the Wordian. This study in high stratigraphic resolution confirmed for the first time that the 'Permian minimium' appeared in and persisted throughout the Capitanian. The d^{13}C$_{carb}$ values stayed very high up to $>$ +6 permil from the uppermost Wordian to the latest Capitanian, followed by the drop down to +2 permil at the G-LB. We speculate that the primary productivity of surface ocean was very high in the Middle Permian (Kamura event) until the G-LB.

These isotope data are correlated well with those of Iwato Formation in Kyushu. Thus these isotopic profiles reflect the general signature in the low latitude superocean. The close timing of the rapid increase in ^{87}Sr/^{86}Sr and the extinction of large fusulines suggests that the non-biological process has triggered the mass extinction and the following decrease in primary productivity. The extremely rapid increase in ^{87}Sr/^{86}Sr ratio in the Capitanian may indicate a certain sudden tectonic event, such as the initilal rifting of Pangea.

Keywords: G-L boundary mass extinction, Akasaka limestone, ^{87}Sr/^{86}Sr, d13C$_{carb}$

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MIS01-09 Room:302 Time:May 21 16:00-16:15

The SSF diversification and environmental changes: The lowermost Cambrian stratigraphy in Chengjiang, South China

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As a prelude to the Cambrian Explosion, the diversity of small shelly fossils (SSFs) increased dramatically ca. 534-530 Ma in the earliest Cambrian. In the same interval, a large-scale phosphorite deposition and $d^{13}C$ excursions occurred, suggesting global environmental changes. Nonetheless, detailed conditions for the SSF diversification are unknown. In order to clarify the causal relationship between these events, this study examined the detailed lithostratigraphy, SSF biostratigraphy, and isotope ($d^{13}C$ and $^{87}Sr/^{86}Sr$) stratigraphy of the uppermost Ediacaran-lowermost Cambrian in Chengjiang, Yunnan, S. China.

The uppermost Ediacaran-lowermost Cambrian in Chengjiang is composed of Daibu Mb (50 m, dolomite), Zhongyicun Mb (40 m, phosphorite), and Dahai Mb (1 m, dolomite) in Zhujiaqing Fm. On the basis of the observation of outcrops, polished rock slabs, and thin sections, we classified the Zhongyicun phosphorite into 5 units; Unit A (18 m, bedded ph.), Unit B (5 m, ph/dol alt.), Unit C (5 m, ph/dol alt.), Unit D (8 m, bedded ph.), and Unit E (5 m, phosphate-rich bedded ph.). Basically, all phosphorites are composed of phosphate clastic grains in dolomite matrix. Phosphate content is higher in high-energy deposited phosphorites with coarse clastics. These observations suggest that phosphorites were primarily formed in shallower depositional settings, then eroded and delivered as clastics into relatively deeper carbonate depositional settings to form bedded phosphorite or alternation of phosphorite and dolomite. Moreover, as the SSFs occur in the same manner as phosphate clastic grains, they likely lived in extremely shallow settings along the basin margins.

By identifying 15 genera of SSFs from 10 horizons in the Zhongyicun Mb, we recognized two distinct assemblages; one with *Anabarites* sp. and *Protohertzina* sp. from the bottom of Unit A, and the other with *Paracarinachites* sp. and *Ocruranus-Eohalobia* group from the base of Unit C and Unit E. The faunal shift between the two corresponds to the major diversification of SSFs. We renewed the first appearance of the second assemblage at the horizon at least 5 m below the previous record in Chengjiang, suggesting that SSFs diversified much earlier (2 m.y., at a rough estimate) than previously recognized.

The data of $d^{13}C$ for 55 samples identified two negative $d^{13}C$ shifts (N1 and N2) and one positive shift (P1); i.e. N1 from -1 to -5 permil in the upper Daibu Mb, N2 from -3 to -6 permil in the middle-upper Zhongyicun Mb, and P1 from -6 to -2 permil in the uppermost Zhongyicun Mb. The $d^{13}C$ profile at Hongjiachong confirmed that the major SSF diversification likely occurred not during the positive $d^{13}C$ shift as previously regarded, but during the negative $d^{13}C$ shift (N2) at least in Yunnan. Here we named this negative shift 'the Fuxian Excursion'. This may be the key to clarify the mechanism of the biological and environmental changes.

The data of $^{87}Sr/^{86}Sr$ for 10 samples showed values around 0.709 with a positive excursion up to 0.711 across the Daibu-Zhongyicun boundary. These values are similar to those reported from Three Gorges, Hubei; however, clearly higher than the values from other regions. It may represent local signatures unique in S. China.

On the basis of the above new findings, we speculate the following processes for the earliest Cambrian phosphorite deposition with the SSF diversification. Some inner-shelf basins in the Yangtze platform became isolated from open-ocean probably during regression. In extremely shallow parts of such local basins, phosphorites were primarily precipitated from phosphate-enriched sea-water due to the high detrital flux from continental crust. The SSF diversification occurred also in such extremely shallow settings with unique seawater compositions. The isotopic excursions of $d^{13}C$ and $^{87}Sr/^{86}Sr$ apparently agree with such isolated basin model.

Keywords: small shelly fossils, phosphorite, Cambrian, Chengjiang, South China

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The stepwise surface environmental changes during the Ediacaran and Cambrian.

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The Ediacaran to Cambrian period was one of the most important intervals for the evolution of life. However, the scarcity of well-preserved outcrops of Ediacaran and Cambrian rocks still leaves ambiguity in decoding ambient surface environmental changes and biological evolution.

Recent paleontologists, mainly Chinese scientists, revealed that life on the Earth have evolved through multiple stages than previously proposed. Some of the metazoan fossils were discovered from Ediacaran sedimentary rocks. This suggests that Cambrian Explosion, in the broad sense of the term, already started from the Ediacaran, not from the Cambrian. Therefore, it is of increasing importance to decode surface environmental changes during the Ediacaran.

The Ediacaran to Cambrian strata in South China are almost continuously exposed, comprise mainly carbonate rocks with subordinate black shales and sandstones, and they contain many fossils, suitable for study of environmental and biological changes in the Ediacaran and Cambrian. We (Maruyama laboratory at Tokyo Institute of Technology) conducted drilling through the Nantuo, Doushantuo, Dengying, Yanjiahe and Shuijintuo Fms at three sites in the Three Gorges area to obtain continuous samples. We systematically analyzed some kinds of isotope ratios (carbon isotope ratios of carbonate and organic carbon, oxygen isotope ratios, nitrogen isotope ratios of organic matter, radiogenic strontium isotope ratios, calcium isotope ratios and molybdenum isotope ratios) and elemental concentrations (cerium, phosphorus, manganese and iron concentration in carbonate), using these core samples. The combination of these detailed chemostratigraphies enables us to decode the surface environmental changes and their causes in the Ediacaran and Cambrian. Most important discovery is that surface environment also had evolved through multiple stages during the Ediacaran and the Cambrian.

Some recent researchers suggest relationship between cosmic event, surface environment and life evolution. An estimation indicates high cosmic ray fluxes during the Snowball events. On the other hand, it is thought that cosmic ray fluxes had been low during the Cambrian. Molecular clock analyses also suggest relatively quiet interval for the genetic evolution during the Cambrian. These lines of evidence imply that biological evolution occurred when favorable environments for life was created.

I will talk about preliminary results in the speech.

Keywords: surface environment, Ediacaran

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Nitrogen cycles through Ediacaran to Cambrian transition

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In the Ediacaran and Cambrian, multicellular animals first appeared on Earth and were rapidly evolved. Biogeochemical nitrogen cycles are essential for ecosystems, and thus may have changed after the appearance of animals in this period. However, the link between nitrogen cycling and animal evolution is still largely unknown. Nitrogen isotopes can be useful to trace the past biogeochemical N cycle, though there is so far no report for N isotope geochemistry of the Ediacaran period.

For the first time, I determined nitrogen isotope ratios of organic matter of this time interval, by using drill core samples from South China. The results show that d15NTN values are high (around +6per mil) until middle Ediacaran, and gradually drop down to -1per mil at the earliest Cambrian, then rise back to +5per mil in the end of the Early Cambrian.

The recorded low N isotope anomaly is the most extensive in this two billion years. Onset of the observed negative N isotope excursion coincided with a global carbon isotope excursion event (Shuram excursion), when Ediacaran organic-carbon-rich ocean may have been oxygenated at that time. Before the Shuram event, the high d15N probably reflects denitrification activity and thus implies modestly nitrate-rich Proterozoic ocean condition. At the time of Shuram event, both d13Ccarb and d15NTN values were dropped probably due to massive re-mineralization of organic matter, which may have resulted in anoxic condition. This scenario is supported by anomalously low TOC/TN ratio, implying high ammonium concentration of water column. At the end of Shuram event, d15NTN value continued to decrease in spites of d13Ccarb rose back to +5per mil. This suggests ocean oxygenation may have resulted in more nitrate-rich condition. The long-term negative d15N excursion and gradual decrease of C/N ratio suggests increasing nitrate concentration trend in this period and increasing animal activity depositing more nitrogen into sediment. Thus, the new result first indicates the direct link between oxygenation, nitrogen cycling and appearance of animal within the ecosystem.

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Microbiota in the Early Cambrian implicated by the molecular fossils extracted from the sedimentary rocks in Three Gorge

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The Cambrian period (542 - 488 Ma) is one of the most important intervals for the evolution of life. After the Ediacaran/Cambrian (E/C) boundary, the Cambrian-type shelly biota radiated. In the Atdabanian, almost all of modern phyla had appeared, namely Cambrian Explosion. Although it is expected that the biological evolution influenced biogeochemical cycle in the ocean, the detail is still ambiguous. Biogeochemical cycle is driven by majorly microorganisms such as biological pump and microbial loop. Thus, microbiota at that time should be revealed more to understand how the biogeochemical cycle was changed and the emergence of large animals was influenced.

Molecular fossils which are organic compounds found from sediments are useful tools to understand microbiota in geological time because the sedimentary organic compounds are majorly derived from microorganisms such as phototrophic eukaryote, bacteria or archaea, and they can not be remained well as body fossils. In this study, molecular fossils are extracted from the Early Cambrian sedimentary rocks in Three Gorges area, South China. The rocks are sampled as drilling cores. That makes the continuous and precisely dated sampling possible. Therefore, the data could be correlated with other geochemical proxies analyzed from the core. Analyzed molecular fossils are bitumen and saturated aliphatic hydrocarbons from 63 samples. n-Alkanes and isoprenoids are detected from almost all of samples. Steranes and hopanes are detected from some samples. They are used as the maturity parameter and for the identification of origins.

Longer chain n-alkanes are notably found from many samples, and indicate that they were derived from sulfate-reducing bacteria and their sizes of biomass compared with that of phototrophs were well correlated with the remineralization rate (Ishikawa et al., 2011). That is the first evidence that the remineralization was driven by the sulfate-reducing bacteria at that time (Yamada et al., in prep.). Furthermore, gammaceranes and carotenoid and longer chain n-alkanes which have different carbon isotope ratio from shorter chain n-alkanes are found from some samples. That indicates the existence of stratified sea in the Early Cambrian.

They constrain the condition of the environment which allows the emergence of large nektons need much oxygen. It is more needed to reveal the activity and influence of microbiota in the Early Cambrian.

Keywords: Cambrian, Molecular fossils, South China

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A possible scenario for the evolution of the biomineralization of calcium containing materials

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Biomineralization of calcium containing materials such as calcium carbonate or calcium phosphate is important in the evolution of animals. I here present a possible scenario for its evolution: 1) Biomineralization of calcium carbonate (calcification) started as the byproduct of uptaking of bicarbonate ions as a carbon source for photosynthesis in cyanobacteria. The hard external shells protect soft biological bodies inside against harmful UV-B radiation (280-315 nm) as well as other external threatening (predators, mechanical forces like waves, and desiccation): Since biological calcium carbonate is composed of numerous numbers of particles as small as several hundred nanometers, it selectively scatters UV radiation with shorter wavelengths than optical radiation with longer wavelengths. 2) The common ancestor of metazoans got genes necessary for calcification by horizontal gene transfer through symbiosis with photosynthetic bacteria in Ediacaran period. 3) The external skeletons were developed extensively in metazoans for sunshield and mechanical protection in Cambrian period. In particular, Trilobite invented first imaging eyes with calcite lenses and triggered explosive evolution of metazoans through the light switch. Some of them also have external skeletons made by hydroxylapatite (calcium phosphate) in phosphate rich (probably oversaturated) environment with minor changes of the genes for calcification. 4) Ancestors of vertebrate started to store the apatite skeletons inside their body to adapt phosphate poor (unsaturated) environments as early as Ediacaran period, since phosphate starvation is commonly seen on the Earth.

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MIS01-14 Room:302 Time:May 22 09:15-09:30

Gene Duplication and Diversity of species

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The evolution of complicated systems such as sensory organs and nervous systems is one of the important questions to understand the process of evolution and diversification of living things.

The progress of genome science gives us the understandings of possible evolutionary mechanisms gave the functions to species. The increase of gene repertoire performed as important role for the process. In this talk, I will show how the gene duplication played the role during evolutionary processes by using case of eye evolution as an example.

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MIS01-15 Room:302 Time:May 22 09:30-09:45

Biological effects of long-term low-dose-rate irradiation and biodefense mechanism

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Cells or animals respond to stress through a variety of mechanisms depending on their anti-oxidative capacity, DNA repair capability, apoptosis and immunity. Each mechanism works to defend against disease and cancer formation (carcinogenesis). The IES conducts studies on the biological effects of long-term gamma rays exposure at medium-dose-rate (MDR) and low-dose-rate (LDR) (less than the dose rate of 0.1 mGy/min; 132 mGy/day) in mice using unique facilities designed to irradiate continuously for over 400 days under specific pathogen free (SPF) conditions.

Adaptive response (AR), a mechanism that has been shown to decrease radiation damage, can be induced with MDR and LDR irradiation under limited conditions (priming dose of 10˜50 mGy followed by a second [challenge] dose after 4-12 hours).

AR may be sustained from a few hours to several months in mice. Increased levels of reactive oxygen species (ROS) or nitric oxide (NO) have been observed in adaptive cells and both factors may play an important role in the induction of AR.

The lowest dose rate, approximately 0.28 mGy/min (corresponds to MDR of 200 to 400 mGy/day at IES), at which AR is observed coincides with the minimum dose rate region of the inverse dose rate effects, wherein the frequency of extrinsic radiation-induced DNA dsb is equal to the frequency of endogenous DNA dsb repair. It should be noted however that this dose range is far too high when compared to the doses at which humans or animals are exposed to in real life.

AR and DNA dsb repair observed in MDR radiation exposures could be evidence representing evolutionary remnants. Further study on biological effects such as AR and DNA repair systems at much lower LDR region deserves merit.

Keywords: Radiation, Biodefense, adaptive response, low dose rate, DNA repair

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MIS01-16 Room:302 Time:May 22 09:45-10:00

Wavelength dependent isotope effect as a tracer for paleoatmosphere and solar evolution?

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Discovery of sulfur isotope anomaly in Archean sedimentary rocks demonstrated that Earth's early atmosphere was virtually oxygen-free (Farquhar et al., 2000). The anomalous fractioation is produced by photolysis of SO2. The fractionation factors are sensitive to the wavelength of irradiated UV (Danielache et al., 2008), thus is a potential tracer to understand chemistry of atmosphere and possibly change in solar spectrum. We newly determined higher resolution UV absorption cross sections of not only 32SO2, 33SO2 and 34SO2 but also 36SO2 within the two absorption bands: (1) 190 ? 220 nm and (2) 250 ? 320 nm. These data together with atmospheric reaction model allow us to predict isotopic compositions of photochemical product. The calculated photochemical fractionation pattern assuming broadband solar UV flux reproduce our previous work (Danielache et al., 2008), though the effect of UV shielding by each atmospheric species including SO2 itself differ from previously estimated trend. Nonetheless, almost all of the simulations result in D36S/D33S ratio of -0.9 ~ -1.1, generally reproducing those observed in Archean sedimentary rocks. Thus, we conclude that photodissociation of SO2 was a primary MIF-yielding reaction in the Archean atmosphere. Our simulation predict, however, the remaining SO2 after UV photolysis acquires positive D33S as opposed to widely-accepted previous model where H2SO4 (-D33S) and S8 (+D33S) aerosols carried opposite MIF signals into ocean and sediment (Pavlov and Kasting, 2002; Ono et al., 2003). We speculate the possibility that almost Archean sulfide deposits were produced by sulfate reduction. The new model requires relatively innert reducing form of sulfur reservior. If the atmosphere was strongly reducing and contained high level of CO or CH4, photolytically produced SO was finally transferred into OCS (Ueno et al., 2009) or organo-sulfur compounds (Dewitt et al., 2010), respectively, which remained in the atmosphere and were not readily converted into sulfide. Occasional oxidation of the reducing sulfur pool enhanced sulfate concentration and deposited rare sulfate minerals with negative D33S. The new dynamical sulfur cycle model may explain observed heterogeniety of S-MIF records in the basin to microscopic scale. This senario is tested by our ongoing photochemical chamber experiment. If correct, this implies more reducing Archean atmosphere than previously thought.

Keywords: Archean, atmosphere, sun

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MIS01-17 Room:302 Time:May 22 10:00-10:15

Stellar Nucleosynthesis and Isotope Anomalies in Geologic Samples

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Surface environment of the Earth has been dramatically changed throughout its 4.6 Byr history. The change has continued intermittently with episodic events that caused extraordinary shifts regarding chemical and biological conditions on the Earth. The fingerprints of such events can be found in a variety of geologic samples (e.g., oxygenation of ocean and atmosphere, global glaciations, and mass extinctions). Recently, a large number of geochemical data have emerged that suggests extraterrestrial cause for the major events which modified the surface environment significantly. A prominent example is the mass extinction at the K/T boundary due most likely to an asteroid impact, evidenced by anomalously high Ir abundances in deep-sea limestones of 65 Ma, from Italy, Denmark and New Zealand (Alvarez et al. 1980). It has been also argued that nearby supernova explosions could have caused drastic environmental changes on the Earth (Ellis and Schramm, 1995). The signature of supernova input would be identified by detecting the excess of short-lived radiogenic isotopes such as ^{10}Be, ^{26}Al and ^{60}Fe in deep-sea sediments (Ellis et al., 1996; Basu et al., 2007; Fitoussi et al., 2008). Because the half-lives of these nuclides are less than a few million years, the technique cannot be applied to geologic samples older than ˜10 Ma. To overcome this, here we propose to search for stable isotope anomalies of heavy elements in geologic samples. Isotopes heavier than iron are produced mainly by stellar nucleosynthesis of the s-process, r-process and p-process (Burbidge et al., 1957). The s-process and r-process are slow and rapid neutron capture reactions, respectively. The s-process is thought to occur during H- and He-shell burning in the AGB (asymptotic giant branch) phase of a low mass star with a C/O core, while core collapse supernovae are favored for the possible source of the r-process isotopes. In contrast, the p-process is either a proton capture reaction with the emission of gamma radiation or photosynthetic disintegration reactions that strip off neutrons, both of which might occur in the core-collapse supernova. The s-, r- and p-processes are characterized by the production of isotope compositions drastically different from each other. A good example is a platinum group element, Os: ^{184}Os is a pure p-process isotope, two isotopes (^{189}Os and ^{192}Os) have large (˜90%) contributions from the r-process, and ^{186}Os and ^{187}Os are mainly produced by the s-process. The remaining two isotopes, ^{188}Os and ^{190}Os, are mainly r-process but have moderate (10-20%) contributions from the s-process. Such an isotopic characteristic was extremely effective for detecting nucleosynthetic isotope anomalies residing in meteorites, including the information about the origin of the isotopically anomalous carriers (e.g., Yokoyama et al., 2010). We will apply the methodology to terrestrial materials in order to search for any sign of extraterrestrial inputs recorded in geologic samples, especially those in the Neoproterozoic and early to mid-Phanerozoic period. The isotopic signature would prove the possible sources of the extraterrestrial input (e.g., meteorite impact, nearby supernova, or collision of large molecular clouds). Possible targets are deep-sea clays and cap carbonates around the Sturtian and Marinoan glaciations, or sediments from the Triassic-Jurassic boundary.

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Keywords: surface environmental change, extraterrstrial input, nearby supernova, meteorite, isotope anomaly, nucleosynthesis

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MIS01-18 Room:302 Time:May 22 10:15-10:30

Os stable isotopes and Platinum Group Elements in Ediacaran and Mesozoic Deep-Sea Sediments

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Surface environmental change of the Earth has played a critical role on the evolution of life, particularly after the landing of life on continents since early Paleozoic. Recently by the help of understanding deep Earth and solar activity, the Earth's environment has been strongly affected by the Universe in relation to the Earth system. It is thought that there are four causes derived from universe of exchanging surface environment; (i) latter into extraterrestrial meteorite impact such as K/T, (ii) nearby supernova, (iii) periodical collision bombardment of icy and/or rocky meteorites from the Kuiper belt or far marginal region in the solar system, and (iv) collision of large molecular clouds, and (v) starburst due to collision of dwarf galaxy against our Milky-Way Galaxy. To understand the evolution of life and surface environmental change through time, it is essential to decode the history of cosmic flux to the Earth through time. The best container of cosmic flux is the deep-sea sediments which can be collected through time even back to 3.9 Ga on the Earth. From astronomical viewpoint, the interaction of Earth and Universe can be summarized as nearby supernovae, starbursts in our Galaxy, and collision of dark nebula, which produce abundant galactic cosmic ray and fall interstellar dusts.

In this study, we tried to analyze platinum group elements (PGE) of deep-sea clays collected from (1) the Triassic-Jurassic time in Japan, and (2) right before and after the Marinoan Snowball Earth in United Kingdom. We also examined (3) the cap carbonates at 635Ma from South China. The PGE pattern of IYF76 (Inuyama, Japan) formed in Tarucian (176Ma) is different from the other samples collected from the same area, with an elevated Os concentration enough for analyzing the Os stable isotope composition. However, the isotopic composition was not resolvable from the terrestrial value, suggesting the elevation of Os concentration with an anomalous PGE pattern was not caused by the input of extra-solar materials. For the samples from UK, we found a negative trend in the Pd/Ir versus Ir diagram. Two samples present the elevation of Ir concentration with relatively low Pd/Ir ratios, which is a suggestive of the existence of extraterrestrial dusts. To understand the origin of the putative extraterrestrial input, we need to precisely analyze stable Os isotope ratios for these samples. On the contrary, the Marinoan cap carbonates from south China possesses no sign of Ir accumulation. The maximum Ir abundance in the cap carbonates was 83 ppt, which is only 0.0007 times as much as that in Marinoan cap carbonates from the Eastern Congo craton (Bodiselitsch et al., 2005).

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Keywords: surface environmental change, deep-sea sediments, Os stable isotopes, extraterrestrial input, Marinoan glaciation, T/J boundary

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MIS01-19 Room:302 Time:May 22 10:45-11:00

Meteorite impacts on the early Earth and origin of life

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How and when abundant organic molecules appeared on the early Earth are fundamental inquiries into the origin of life. Intense impacts of extraterrestrial objects melted the embryonic Earth, forming an inorganic body with a CO2, CO and N2-rich atmosphere. Such slightly oxidized ancient atmosphere is not favored for pre-biotic organic synthesis on the Earth, and therefore, creates large number of supporters for Panspermia hypothesis.

However, Panspermia hypothesis does not explain variety and abundance of amino acids required for life. It is hypothesized that the uniqueness of the Earth, such as presence of abundant liquid water and slightly oxidized conditions, and dynamics of the early solar system were responsible for origin of life (Nakazawa, 2006). The late heavy bombardment is a representative dynamics of the early solar system and strongly modified the early environments of Earth.

Here we report a facile impact synthesis of some organic molecules from the mixture of solid carbon, iron, nickel, water, and nitrogen all of which would have been available during impact events on Earth's early oceans. Geological and geochemical studies indicate that ordinary chondrite, the most abundant meteorite, contains a substantial amount of iron-nickel and small quantities of solid carbon.

Biomolecules and their precursors identified in the present shock recovery experiments are carboxylic acids (fatty acids), amines, and an amino acid (Furukawa et al., 2009). The key reaction to produce those organic molecules was a water-splitting reaction by water-mineral interaction, followed by various redox reactions. Such process was not most likely realized in the early solar system except the Earth. The late heavy bombardment may have been related to re-arrangement of the early solar system. Such dynamic solar movement was also important for origin of life.

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Keywords: meteorite, impact, origin of life, shock, early Earth, amino acids

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MIS01-20 Room:302 Time:May 22 11:00-11:15

Astronomical cycle recorded in the bedded chert: Implications for the paleoclimatology and astronomy

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Astronomical forcing is one of the main drivers of climate change. The astronomical cycles recorded as sedimentary rhythms provide a clue to understanding the dynamics of Earth surface system and Solar system. Here we used the bedded chert sequence of Inuyama, central Japan, of which rhythms were proven to be of astronomical origin (Ikeda et al., 2010), to decode the astronomical cycle of approximately 65 myr. long spanning from the Early Triassic to Early Jurassic. The sedimentary rhythms of bedded chert were reflected by the variation in the biogenic silica and terrigenous burial rates on pelagic deep sea floor. The variation in the chert bed thickness was reflected by the biogenic silica burial rate during one precession cycle, which should be proportional to the variations in the dissolved silica input to the ocean, mainly through silicate weathering in Pangea. According to the geochemical modeling studies, a possible major controlling factor of the global silicate weathering intensity could have been the orbitally controlled summer monsoon intensity in low latitude Pangea (e.g. Kutzubach, 1981; Donnadieu et al., 2008). Therefore, the variations in the orbitally-controlled summer monsoon intensity in low latitude Pangea should have had close association with variations in the biogenic silica burial rate in the form of bedded chert during the early Mesozoic.

The long-period astronomical cycles of bedded chert could record the chaotic behavior of Solar system. Wavelet analysis of the chert bed thickness time series revealed the presence of approximately 2-Myr cycle whose periodicity varied between ˜ 1.5- and ˜ 2.4-Myr. According to the astronomical modeling studies, the 2-Myr eccentricity cycles may not necessarily have kept constant periodicities observed today (ca. 2.4-Myr periodicity), but their periodicities may have changed through time due to the chaotic behavior of solar planets, mainly Earth-Mars secular resonance (Laskar et al., 1990, 2004). Our results on the frequency transitions of the approximately 2-Myr cycle are the first geologic evidence for the chaotic transitions of Earth-Mars secular resonance. These transition patterns of approximately 2-Myr cyclicity will provide new constraints on orbital models. Exact timing and mode of transition will be discussed.

Keywords: chert, solar system, chaos, Milankovtich, monsoon, silica

Japan Geoscience Union Meeting 2012
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MIS01-21 Room:302 Time:May 22 11:15-11:30

SPLENDOR OF ELECTROMAGNETIC UNIVERSE

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Electromagnetic waves play a very significant role at all levels in the universe. At the sub-atomic level dominated by the nuclear forces, the EM forces do play an important role to determine the abundance of elements like Carbon and Oxygen, Nitrogen, etc. in the universe. Outside the atom, in the absence of nuclear forces, the EM forces dominate everywhere as the gravitational force is significantly lower in magnitude. Thus EM forces have dominated the three most important stages in the evolution of universe, namely, the Radiation Era, the Matter Era and the Life Era. The cosmic EM radiations within galaxies and stars also determine the Habitable Zones where living organisms could survive, sustain and evolve. Evolution of intelligent life on planet Earth, particularly the anthropoids, has been possible due to the EM forces that trigger electrochemical reactions within the brain. Evolution of human intelligence and the resulting Big Bang of cultural evolution are largely due to the EM interactions among neural circuits within the brain. Magnetohydrodynamic interactions in the Earths core impart our planet the vital magnetic field and are also intricately associated with the thermal perturbations that ultimately cause superplumes that drive various tectonic plates making Earth a Living Planet with a multitude of species to evolve. This life is well protected by the Earths magnetosphere against the harmful EM radiations from the Sun, the Milkyway galaxy and other regions of the universe. Geological records reveal that any breach in the Earths protective cover has resulted in mass extinctions on our planet. The exchange of the Earths internal energy from the core to the surface and from the Sun gives rise to various biological, climatic and environmental interactions that provide the requisite energy for the survival and sustenance of life on the planet. As the universe evolved from chaos to order and from simplicity to complexity, the energy budget from galaxies, stars, planets to various life forms evolved by orders of magnitude. There has been an explosive growth in the energy consumption by the modern human society. It is impossible to overemphasize the role of EM energy in providing a new paradigm for green energy alternatives.

Keywords: Electromagnetic Universe, Green electromagnetic energy, EM and the human brain, Electromagnetics of the planet Earth, Electromagnetics and the Habitable Zones, EM energy interactions between the Earth and Sun

Japan Geoscience Union Meeting 2012
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MIS01-22 Room:302 Time:May 22 11:30-11:45

Probing the history of the Sun based on the reconstruction of solar cycle lengths

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We discuss the possible methodology to constrain the history of the Sun based on the reconstruction of solar activity cycle length in the past.

Keywords: History of the Sun, Faint young sun paradox, Solar cycle

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MIS01-23 Room:302 Time:May 22 11:45-12:00

Estimation of global mean temperature using stable isotope ratios of tree ring cellulose in Yakusugi cedar

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The precise reconstruction of the past global mean temperature is extremely important to predict future climate. The best proxy to trace past global mean temperature is a sea level change. However, it is very difficult to reconstruct past sea level change with high time resolution. This study analyzed Yakusugi tree-ring d13C for the past about 1800years annually. Yakusugi tree-ring d13C is known to show similar pattern with sea level change. Tree-ring d13C is often generally show a positive correlation with temperature. Previous study has shown an apparent negative correlation with temperature (Kitagawa and Matsumoto, 1995). This study suspected the reason of a negative correlation between Tree-ring d13C and temperature is relative to the original meteorological feature of Yakushima. The meteorological observation and the measurement of growth of cedar in the field were conducted. This study performed to verify which climatic factors affect significantly Tree-ring d13C changes. As a result, Ishiduka region where the sample used in this study inhabited was extremely large amount of precipitation. Relative humidity was found to be almost 100% and to be very small changes. Because of short sunshine hours by precipitation and fog, we concluded the summer daylight hours had the most significant impact on the Tree-ring d13C fractionation. The apparent negative correlation between global mean temperature and carbon isotope ratios suggest that summer radiation was small in warm interval and in cold period, summer radiation was large. This can be explained by the strength of the Asian monsoon. In warm period, enhanced Asian monsoon carry a lot of cloud. The cold period can be understood as relative increase in daylight hours by this mechanism become weaker.

Keywords: tree ring stable isotope, climate change, Yakusugi, one year resolution

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MIS01-24 Room:302 Time:May 22 12:00-12:15

A numerical simulation study of climate change induced by changes in cloud properties

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The terrestrial climate has been changing since the Earth's birth. There are some iportant factors to trigger the climate change. The faint young sun, land-sea configuration and atmospheric composition are examples of the important factors. Another important factor may be cloud properties. Cloud droplet size, cloud water/ice content, and the height and amount of clouds can affect the climate. It has been pointed out that changes in the intensity of galactic cosmic ray may change the cloud properties. The intensity of cosmic ray may be affected by the solar activity.

We have conducted a set of numerical simulations of a three-dimensional global atmosphere-ocean model and a vertically one-dimensional radiative-convective equilibrium model in order to address the effect of cloud properties on the climate. According to our results, the climate cools (warms) as cloud droplet size is reduced (increased) in the atmospheric radiation computations.

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MIS01-25 Room:302 Time:May 22 13:45-14:00

Effects of the solar activity on the terrestrial upper atmospheres

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The upper atmospheres of the terrestrial planets (Venus, Earth, and Mars) are strongly affected by the solar energy inputs. For example, changes in the X-ray and extreme ultraviolet (EUV) radiation cause the temperature, wind, and composition variations during a solar cycle. In addition, geomagnetic activity effects are also significant in the Earth's upper atmosphere. The amounts of these energy inputs have been changed since the terrestrial planets were formed. The X-ray and EUV radiation was extremely stronger 3.5 Gyr ago than the present. In order to understand the atmospheric environments and atmospheric evolutions of the terrestrial planets, we should investigate effects of the solar activity on the atmospheres. In particular, the upper atmosphere would be closely related to the atmospheric evolutions because the region is the boundary between the atmosphere and space. We have developed atmospheric models for studies of the aeronomy in the terrestrial planets. Some simulation results for Venus, Earth, and Mars will be shown: e.g., responses of the Venusian and Martian upper atmospheres to changes in the X-ray and EUV radiation, and variations of the Earth's upper atmosphere during geomagnetically quiet and disturbed periods.

Keywords: upper atmosphere, solar activity, terrestrial planets