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

BPT23-01 Room:301B Time:May 24 11:00-11:15

Origin of life: Six environmental requirements to bear life

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The origin of life has been an issue historically paramount to natural science, with improved understanding through time of the environmental conditions in which life was born, including step-wise progress to make life in the laboratory. Since the first attempt to synthesize amino acids by Miller (1953), numerous papers have been written and different models of the origin of life have been proposed.

We think there are six environmental requirements for the origin of life: (1) the presence of water, (2) influx of nutrients from primordial continental crustal materials composed of KREEP/anorthosite, (3) N-fixation system, (4) evaporation-condensation conditions and catalysts for the synthesis of amino acids, (5) a layer of water/clay minerals to shield life from UV radiation, and (6) a H2 supply for metabolic activity.

The prime habitat for the origin of life to fulfill these requirements is a lacustrine environment within a primordial continent in the Hadean.

BPT23-02 Room:301B Time:May 24 11:15-11:30

Origin of ultramafic CH4: the CH4-H2-H2O hydrogen isotope systematics of the Hakuba Happo hot spring

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Ultramafic-hosted hydrothermal fluids are characterized by high concentration of H2 derived from serpentinization. Ultramafic rock is rare in the surface of the Earth today, but is likely to have been an abundant component of the early crust due to higher potential mantle temperature. Ultramafic-hosted hydrothermal ecosystem has attracted attention as a potential habitat of the Earth's earliest microbial community because the earliest chemolithoautotrophs may have utilized molecular H2 as an electron donor. Along with hydrogen, high concentrations of methane and hydrocarbons have been reported in ultramafic hydrothermal fluid. They are usually 13C-rich compare to microbialy-produced methane, and could have been synthesized by abiotic reactions. However, origin of the methane in the ultramafic hydrothermal system is not clearly understood yet. In this study, we collected fluid samples from ultramafic rocks in Hakuba Happo hot spring, and conducted chemical and C-H isotopic analyses of the CH4 as well as compounds possibly involved in the methane formation reaction in fluids. Samples from Happo hot spring located on the serpentinite body were directly collected from two drilling wells (Happo #1 and Happo #3). The hot spring water is strongly alkaline (pH>10) and rich in H2 (201~664 umol/L) and CH4 (124~201 umol/L). These chemistries were typical of fluids associated with ultramafic rock. Even lower temperature regime, H2 in Hakuba Happo is derived from serpentinization. We measured the concentrations of dissolved gas and the hydrogen and carbon isotope compositions of H2, CH4, CO2 and H2O. Hydrogen isotope compositions for Happo #1 were dD-H2= -700 permil, dD-CH4= -210 permil, dD-H2O= -84.5 permil, and those for Happo #3 were dD-H2= -710 permil, dD-CH4= -300 permil, dD-H2O= -84.2 permil. Hydrogen and water at Happo#1 had similar dD values to those at Happo#3, but methane from Happo#1 was approximately 80 permil enriched in deuterium relative to Happo #3. On the other hand, carbon isotope compositions of methane from Happo#1 and Happo#3 were d13C= -34.5 permil and -33.9 permil, respectively, and there was almost no difference. The CH4-H2-H2O hydrogen isotope systematics suggests that the most likely production process of Happo #1 methane is the olivine hydration with carbon source, and that biological methane contributes to Happo #3 methane.

Keywords: ultramafic-hosted hydrothermal system, origin of CH4, hyperalkaline, hydrogen isotope composition

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BPT23-03 Room:301B Time:May 24 11:30-11:45

Hadean crust inferred from mineral inclusions in detrital zircons from the Jack Hills, Western Australia

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The first 500 million years of the Earth history remain poorly understood. Terrestrial rock records during Hadean era (>4.0Ga) are scarcely preserved, probably due to surface and/or subduction erosion and intense meteorite bombardment. However, clues about conditions during this time can be deduced from detrital zircon grains as old as 4.4 Ga preserved in metasedimentary rocks at Jack Hills in the Narryer Gneiss Complex, Western Australia (e.g. Compston & Pidgeon, 1986; Wild et al., 2001). Jack Hills metaconglomerates deposited in ca. 3 Ga contain detrital zircons with ages continuously spanning from 3.0 to 4.4 Ga. Previous investigations of these grains have suggested the existence of a hydrosphere, granitic continental crust, sedimentary cycling and a thermal excursion by the Late Heavy Bombardment on early Earth (e.g. Valley et al., 2002; Harrison, 2009; Abbott et al., 2012). Especially, granitic mineral inclusions in Hadean detrital zircons from Jack Hills provide strong evidence for the existence of granitic crust on early Earth. On the other hand, in-situ U-Pb dating of monazite and xenotime inclusions in 4.25?3.35 Ga detrital zircons from Jack Hills shows ages with 2.68 Ga or 0.8 Ga, suggesting that the most mineral inclusions are not primary, but suffered from metamorphic/metasomatic overprint during late stage metamorphism (Rasmussen et al. 2011). These results call for a reassessment of mineral inclusions in Hadean detrital zircons.

To better understand the nature of earliest crust on the Earth, we focus on apatite mineral inclusions in Hadean detrital zircons. Chemistry of apatite inclusions in zircon (especially Y2O3 and SrO content) reflects the chemical compositions of the whole rocks and can characterize the host magma (Belousova et al., 2002; Jennings et al., 2011). We performed U-Pb age analyses for Jack Hills zircons using LA-ICP-MS, and a total of 103 mineral inclusions was obtained in 315 Jack Hills zircon grains. The type of inclusions in Hadean zircons identified with EDS and Laser-Raman spectroscopy are as follow; quartz, muscovite, biotite, apatite, albite and REE oxide (monazite?). Although low-abundance of apatite inclusions in detrital zircons from Jack Hills compared to those in granitic rocks suggests a secondary replacement on mineral inclusions proposed by Rasmussen et al. (2011), primary apatite inclusions are observed in detrital zircons from Jack Hills. Most apatite inclusions in zircons show prismatic morphology with no visible cracks. SrO content in apatite determined by EPMA ranges from below detection limit (0.03) to 0.1 wt%. Our preliminary data suggest that both mafic and granitic crust contribute for Hadean detrital zircons from Jack Hills as a source rock. Thus, further geochemical analysis (e.g. oxygen isotopes and Ti-thermometer in zircon, and Pb-Pb ages of apatite inclusions) are required and should provide significant constraints for the earliest crust on the Earth.

Keywords: Hadean crust, detrital zircon, Jack Hills, Mineral inclusion

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BPT23-04 Room:301B Time:May 24 11:45-12:00

Geology and geochronology of the Saglek Block, northern Labrador, Canada

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The Saglek-Hebron area is located in the northeastern part of the Labrador Peninsula, northeast Canada, and belongs to a coastal, central part of the early Archean terrane, called Saglek Block. The block is the west end of the North Atlantic Craton from the Scotland through the southern part of Greenland to the Labrador. The block contains well-preserved Early to Late Archean suites including the Nulliak supracrustal assemblage (>3.73 Ga), *ca.* 3.73 Ga Uivak TTG gneisses, 3.24 Ga Lister gneiss and *ca.* 2.5 Ga granite. In addition, Collerson (1984) and Collerson and Regelous (1995) found >3.9 Ga zircon cores, and suggested pre-3.8 Ga Nanok Fe-rich monzodioritic gneiss. However, the origin of the >3.9 Ga zircon cores is still obscure: inherited or directly crystallized from the host magma (Schiotte et al., 1989: Krogh and Kamo, 2006). The orthogneisses and supracrustals underwent high-grade metamorphism, locally reaching granulite facies at 2.8-2.7 Ga. In the area, the orthogneisses are predominant, and account for about 80 %. It is considered that the Nulliak supracrustal assemblage and Uivak TTG gneisses are equivalent to the Akilia association and Amitsoq gneiss complex in southern West Greenland, respectively. However, the detailed geology within the supracrustal belts, and the relationship between the supracrustal belts and surrounding orthogneiss complex is still unclear. Additionally, detailed geochronological works, including comprehensive dating with LA-ICPMS and cathodoluminescence for igneous and detrital zircons, still lack. Thus, we made detailed geological maps at 9 areas, including relatively low metamorphic grade areas, amphibolite facies condition in order to reveal the Nanok Gneiss, and find the oldest rocks in this area. Especially, we made detailed sketch maps to describe cross-cutting relationships among orthogneisses and determine the oldest suite in each outcrop. In addition, we conducted LA-ICPMS U-Pb dating of zircons from the orthogneisses.

We classified the orthogneisses into eight groups based on the cross-cutting relationships in each outcrop and the distribution of zircon ages: ˜3.90 Ga, 3.83 Ga, 3.73-3.65 Ga, 3.60 Ga, 3.35 Ga, 2.84 Ga, 2.73 Ga and 2.56 Ga, respectively. The presence of >3.9 Ga zircons provides very important constraint on the formation of felsic continental crust because of the second oldest ages in the world. Collerson (1983) named the pre-3.8 Ga orthogneiss the Nanok Gneiss, but they could not obtain compelling evidence that the >3.8 Ga zircon grains are not inherited/xenocrystic grains. However, the age distribution of oscillatory-zoned zircon grains in the oldest group of the orthogneisses shows presence of older zircons than 3.8 Ga, with the maximum age of 3,956 Ma in $^{207}Pb/^{206}Pb$ age, and apparent lack of 3.7 to 2.7 Ga zircons. In addition, field observation clearly differentiates two orthogneiss suites in an outcrop, and shows the gneiss containing >3.90 Ga zircons is cut by a 3.83 Ga gneiss. The age distribution of the zircons and field occurrence indicates that the old grains, >3.9 Ga, are not inherited or xenocrystic zircons in young (3.7 to 3.8 Ga) orthogneiss but the host orthogneiss were formed at >3.9 Ga. As a result, our geochronological and geological study provides line of evidence of the >3.9 Ga Nanok Gneiss in the Nain Complex.

The Nanok gneiss is the second oldest rock to the Acasta gneiss in the world. The geological relationship that the Nulliak supracrustal rocks are intruded by the orthogneisses implies that the supracrustal rocks also have >3.9 Ga ages, and they are the oldest supracrustal rocks in the world.

Keywords: U-Pb dating, Early Archean, zircon, orthogneiss, supracrustals

BPT23-05 Room:301B Time:May 24 12:00-12:15

Field occurrence and geochemistry of the Eoarchean banded iron formations(BIFs) in the Nulliak Assemblages in Nain Provi

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The earth is the only planet where various life exits ubiquitously, thus it is very important to decode the surface environment in the early Earth in order to understand the origin and early evolution of life. Banded Iron Formation (BIF) is one of the chemical sediments in open sea, and consists of interlayering of white silica layers and black or red iron-rich layers. The BIF occurs from the Early Archean to the Paleoproterozoic, and is a key sediment of deciphering chemical evolution of seawter throughout the Preca

mbrian. Particularly, only the BIF provides a record of nutrient contents of sewater in the Eoarchean. However, there are found only few pre-3.6Ga supracrustal belts including BIFs, e.g. the 3.71- 3.81Ga Isua supracrustal belt, >3.75Ga Nuvvuagittuq supracrutal belt and the Nulliak supracrustal rocks in the Labrador. Recently, reassessment of comprehensive U-Pb dating of zircons in the Early Archean Uivak gneisses, Labrador suggested the Nulliak supracrustal rocks were formed >3.9 Ga (Shimojo et al., 2012, Mineral. Mag.). This paper presents geological and geochemical data of the BIFs in the >3.9Ga Nulliak supracrustal rocks in the Nain Complex, Northern Labrador, Canada.

The Nulliak supracrustal rocks comprises ultramafic rocks, mafic rocks, BIF, chert, carbonate rocks, conglomerate, and paragneisses. They underwent the amphibolite to granulite facies metamorphism in the Archean. Especially, the metamorphic grade reached the granulite facies in the western side of the Handy Fault, including the Pangertok Inlet, whereas the metamorphic grade of the eastern side never exceed amphibolite facies, including the Big Island and Nulliak Island. There are two types of BIFs in the area: thin BIF layers associated with mafic rocks, and BIF layers interlayered with carbonate rocks, respectively. The former is a typical Algoma-type BIF, but the latter is associated with shallow-water carbonates, and uncommon in the Archean supracrustal belts. Mineral assemblages of the BIFs are similar each other, and are magnetite + quartz + actinolite + cummingtonite, which are typical of an amphibolite facies assemblage for BIFs (Klein, 2005, Am. Mineral.).

Preliminary chemical analyses show that these BIFs contain >1wt% Al_2O_3 and relatively high abundances of HFSE (e.g. up to 20ppm Zr). Their high abundances suggest that detritus input was common in the sedimentary environments of the Nulliak supracrustals. On the other hand, their rare earth element (REE) patters display seawater and hydrothermal fluid-like patters, namely positive La and Eu anomalies, and superchondritic Y/Ho ratios. In addition, they contain high Cr, Ni, Zn, Sr and Ba (>50ppm) contents. Particularly, the high abundances of Ni and Zn suggest that the >3.9 Ga seawater were enriched in the transition metals due to high hydrothermal activities or alteration of ultramafic magmas, analogous to the other Archean BIFs, <3.8 Ga (e.g. Konhauser et al., 2009, Nature, Mloszewska et al., 2012, EPSL).

Keywords: the Early Earth, Eoarchean, Banded Iron Formaions(BIFs), Rare Earth Elements

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BPT23-06 Room:301B Time:May 24 12:15-12:30

Lateral variation of Mesoarchean Cleaverivlle Iron Formation: DXCL2 drilling preliminary report 2

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We did scientific drilling, which is called DXCL 1 and DXCL 2, at 2007 and 2011 summer and more detailed mapping and collated stratigraphy at coast line of eastern most of the Cleaverville Beach. Two coastal sites had been selected for these drilling projects; CL site (CL1, CL2 and CL3) at the Cleaverville Formation, and DX site at the upper Dixon Island Formation.

The 3.1 Ga Cleaverville Formation preserves black shale to banded iron formation (BIF) sequences; only affected by low-grade metamorphism (prehnite-pumpellyite facies) without intensive deformation (Kiyokawa et al., 2012). The Cleaverville Formation situated above of chemical-volcano sedimentary sequences, which are identified by accreted immature island arc setting. The >400m-thick Cleaverville Formation, which conformably overlays pillow basalt, contains Black chert submember and BIF submember to the top. The detailed mapping along the eastern coast of the Cleaverville Beach and observation of lateral variation in these sequences indicate that thickness of stratigraphic beds are changed within about 50 m in width. Therefore, these sedimentary sequence dose not show super deep sedimentary sequence.

In detailed lithology from the drill-core of the Cleaverville Formation, the CL1 and CL2 core samples mainly consist of the organic-rich massive black shale bed (20cm in thickness) with few cross-laminated fine volcaniclastic sandstone. The CL3 core, which is upper part of the Cleaverville Formation, preserved lithological change from black shale to Banded Iron Formation. Especially, greenish siderite rich shale preserved as about 30m thick between organic-rich black shale beds to fine laminated magnetite beds. As a result of stratigraphy, the Cleaverville iron formation formed by hydrothermal input to produced extra iron and deposite siderite BIF at the relative carbonaceous anoxic condition ocean.

Keywords: Archean, BIF, bedded chert, black shale, hydrothermal activity, Pilbara

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BPT23-07 Room:301B Time:May 24 12:30-12:45

S-MIF Chemostratigraphy of the Late Archean In the Dharwar Supergroup, South India

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Earths tectonic and climatic systems may have fundamentaly changed through the late Archean period, which is characterized by major deposition of banded iron formation (BIF) and appearance of stromatolite reef along continental margins. The earliest known glaciation (~2.9Ga) is recorded in the Mozaan Group of South Africa (Young et al., 1998). Also, in the earliest Proterozoic, Snowball Earth event is recorded in the Huronian Supergroup of Ontario, Canada (~2.4Ga; Young et al., 2001). In accord with the climate change, mass-independent fractionation of sulfur isotopes (S-MIF) demonstrated that Earth atmosphere and ocean was oxygenated at around 2.3 Ga from virtually oxygen-free environment (Farquhar et al., 2000). Before the oxidation event, the S-MIF signature changed dramatically: minimam D33S at around 2.9 Ga, subsequent large D33S variation culminated at 2.5 Ga and its sudden drop at the end of Archean. Moreover, D33S-D36S reration shows characteristic ratio of roughly -0.9 in the Archean period. Change of this D36S/D33S relation may reflect the perturbation of atmospheric chemistry. But there is an active debate about the cause of the large D33S variations and D33S-D36S relation through the Archean period.

We studied late Archean volcano-sedimentary sequence of the Dharwar Supergroup, distributed in the Chitradurga Schist Belt, Western Dharwar craton. Our new field mapping and zircon U-Pb dating allows us to reconstruct detailed lithostratigraphy (Hokada et al., 2012). The lower unit (post-3.0 Ga) consists of basal conglomerate, stromatolitic carbonate, silici-clastics with diamictite, chert/BIF and pillowed basalt in assending order, all of which are older than 2676 Ma magmatic zircon ages from dacite dyke intruded into the topmost pillowed basalt. The upper unit unconformably overlies the pillow lava, and consists of conglomerate/sandstone with ~ 2600 Ma detrital zircons, komatiite lava, BIF and silici-clastic sequence with mafic volcanics.

Sulfur isotope analysis of extracted sulfide of these sedimentary rocks show a clear MIF and D33S-D36S correlation. The lower group of the Dharwar Supergroup shows D36S/D33S slope of -1.52, middle group shows -1.20, and upper gropu shows -0.96. This trend is similar to those reported from Pilbara-Kaapvaal equivalents, thus could be a global signature. Moreover, a marked change of D36S/D33S is observed across a diamictite layer (Talya conglomerate) between the lower and the middle group. If this diamictite was glacial in origin, these changes in sulfur isotopes may indicate the link between some transition in atmospheric chemistry and Earths surface environmental change.

Keywords: mass independent fractionation, sulfur isotope, Dharwar supergroup, late Archean, glaciation

BPT23-08 Room:301B Time:May 24 14:15-14:30

Life cycle reconstruction and taxonomy of Archean (3.0Ga) microfossil assemblage

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Carbonaceous chert of the 3.0 Ga. Farrel Quartzite in the Pilbara Craton, Western Australia contains abundant lenticular microfossils with flange-like appendage that range mostly from 30 to 40 microns and are up to 100 microns along the major dimension. They are distinct from the other Archean microfossils in their morphology. It may be also mentioned that FLM are organic-walled and extractable by HCl-HF maceration.

The author examined more than 2000 specimens of this flanged lenticular microfossil (FLM) and other morphological types, and identified the following distinct individuals and complex modes of occurrences; 1) specimens with small spheroidal objects inside; 2) colonies composed of mixture of small spheroids and FLM; 3) specimens that appear to expel a single spheroid; 4) dumbbell- or chain-like structures. Since the biogenicity of FLM has already been well established by previous multiple studies of wide range, the specimens and occurrences described above are likely interpreted in the context of life cycle variants and taxonomy. Microfossils conveniently called FLM are believed to be composed of at least two taxa or more. One species represents microbes that was reproduced by multiple fissions, whereas the other by ordinary binary fission. The latter occasionally formed chain-like structures. Either or both of these species might have produced spore. Although these interpretations may be taken as "vaporous", the presence of FLM in the 3.0 Ga. and older succession (the 3.4 Ga. Strelley Pool Formation) is now firmly established, and they may provide quite important information about the early evolution of life.

Keywords: Archean, microfossils, life cycle, taxonomy, Pilbara

BPT23-09 Room:301B Time:May 24 14:30-14:45

In-situ iron isotope analyses of pyrites from 3.5 to 3.2 Ga sedimentary rocks of the Barberton Greenstone Belt, Kaapvaal

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The Barberton Greenstone Belt (BGB), South Africa consists of volcano-sedimentary successions which, were deposited between 3.5 and 3.2 Ga, and is subdivided into three groups: the Onverwacht, Fig Tree, and Moodies groups (Viljoen and Viljoen, 1969). The Barberton Greenstone Belt underwent relatively low-grade tectonothermal events after the deposition, suitable to estimate the surface environmental events and biological evolution in the Middle Archean. Several putative morphological fossils (filamentous and spheroidal type) and trace fossils were reported from the Hooggenoeg and Kromberg formations in the Onverwacht Group (e.g. Engel et al., 1968; Walsh and Lowe, 1985; Schopf, 1992, 1993, 1999; Furnes et al., 2004; Glikson et al., 2008; Javaux et al., 2010).

Isotopic studies of sulfur and carbon of biogenic pyrites and organic carbons suggested activities of methanogen, sulfate-reducing bacteria and photosynthetic bacteria at 3.4 Ga (Ueno et al., 2006; Kakegawa and Ohmoto, 1999; Shen et al., 2001, 2009; Ueno et al., 2008; Philippot et al., 2007). On the other hand, it is well known that dissimilatory iron reduction (DIR) is one of the earliest metabolisms on Earth (Vargas et al., 1998; Lovley, 2004), but the evidence for the microbial DIR is still uncertain in the Archean (i.e. Craddock and Dauphas, 2011; Yamaguchi et al., 2005). We performed in-situ iron isotope analyses of individual pyrites in the sedimentary rocks from the BGB, using femtosecond laser ablation multi-collector ICP-MS technique (fs-LA-MC-ICP-MS) to find isotopic evidence for the microbial activity. We obtained a large variation of iron isotope values from -1.9 to +3.6 permil in $d^{56}Fe$ values for 139 pyrite grains in 24 samples: 7 cherts from the Hooggenoeg Complex, 10 cherts from the Noisy Complex, 2 cherts from the Kromberg Complex, 1 sandstone from the Fig Tree Group, and 4 sandstones from the Moodies Group, respectively. The $d^{56}Fe$ values in pyrites from the Hooggenoeg Complex show positive values, whereas those from the Noisy Complex show a wide variation from positive to negative $d^{56}Fe$ values. One of the main differences between these Complexies is their depositional environments. The Hooggenoeg Complex was considered to be deposited in deep-ocean, whereas that of the Noisy Complex was shallow. The negative $d^{56}Fe$ value of pyrites with a nadir down to -1.9 permil in the Moodies Group indicates the occurrence of microbial DIR in the middle archean shallow sea.

Keywords: Barberton Greenstone Belt (BGB), iron isotope, microbial dissimilatory iron reduction, pyrite, middle archean

BPT23-10 Room:301B Time:May 24 14:45-15:00

Conditions required for Proterozoic oceanic chemistry: Constrains from an ocean bio-geochemical cycle model

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During the Mesoproterozoic Eon (~1.6-1.0 Ga), oceanic interior below euphotic layer had been kept in pervasive anoxic condition. Such reducing condition has been considered a corollary of a weakly oxidized atmosphere at that time (Holland, 2009, GCA).

Accumulating geochemical data, such as iron speciation, reveal that the pervasive anoxic and ferruginous conditions in the ocean interior have been prevailed during the mid-Proterozoic, and sulfidic waters are restricted around continental margins. However, the atmospheric oxygen level (pO_2) in the Proterozoic has not been well constrained, and it remains unclear exactly what biogeochemical conditions are necessary to explain the redox structure in the Proterozoic ocean interior.

Here we constrain the conditions for Proterozoic ocean redox structure by use of a marine biogeochemical cycle model in which C-N-P-O-S-Fe coupled marine biogeochemical cycles are adequately taken into account. The sensitivity experiments with respect to pO_2 demonstrate that pervasive anoxia and euxinia would appear when $pO_2 < 0.14$ atm and < 0.12 atm, respectively. An expansion of anoxic environments in the ocean interior significantly stimulates the sulfate reduction. As a consequence, the pyrite precipitation into marine sediments is promoted, giving rise to a low sulfate condition ($SO_4 < 5$ mM) when $pO_2 < 0.11$ atm. We also found that, under $pO_2 <$ ~0.02 atm, a scarcity of sulfate results in the anoxic but non-sulfidic (namely low O_2 and low H_2S) condition (i.e., ferruginous conditions). Systematic sensitivity experiments regarding pO_2 and chemical weathering rate on land unequivocally show that the conditions for pervasive euxinia are very limited, implying that widespread ferruginous condition would be a plausible consequence of low pO_2 and high burial efficiency of pyrite during the Proterozoic eon. Sensitivity experiments with respect to other factors affecting long-term oceanic redox state (e.g, sea-level stand, settling rate of particulate organic matters in water column) indicate that the essential biogeochemical consequences are not changed by such factors.

These quantitative results would provide insight into further understanding of the Earth's redox history and its stabilization mechanism(s) from a perspective of the biogeochemical dynamics.

Keywords: Proterozoic, biogeochemistry, anoxia, euxinia, ferruginous

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BPT23-11 Room:301B Time:May 24 15:00-15:15

Early metazoan evolution and extinction controlled by oxygen levels

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Organic-molecular dissolved-oxygen index above and below storm wave base, from Cryogenian to Cambrian marine sedimentary rocks in Australia and China records three rises in dissolved oxygen levels. The first rise in dissolved oxygen levels coincides with molecular diversification of animals in the early Ediacaran, the second rise with appearance of large Ediacaran animal fossils, its drop with extinction of Ediacaran metazoa, and the third rise is coeval the explosion of Cambrian metazoa. Our evidence for widespread dissolved-oxygen changes synchronizing with macroevolution and extinction suggests that the global dissolved oxygen level in the sea had controlled the evolution of metazoans during the Neoproterozoic-Phanerozoic transition. The first rise in dissolved oxygen levels in the early Ediacaran is newly found and consistent with molecular diversification of animals in the early Ediacaran.

Keywords: oxygen, evolution, extinction

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Numerical modeling to evaluate carbon cycle changes in the Ediacaran for identifying the cause of the Shuram excursion

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Ediacaran is one of the most important periods, because some environmental changes are proposed (e.g. Oxidation, nutrient and carbon cycle) before the Cambrian explosion and macroscopic multicellular metazoan first appeared and their sizes became drastically large. Therefore, quantitative carbon cycle changes in Ediacaran period need to decode in order to compare of environmental changes and evolution.

We assumed box model that there were two carbon reservoirs in Ocean and fluxes are taken as the first order reaction of each reservoir (Rothman et al., 2003; Ishikawa et al., 2012). Thus, we could estimate both d1 and d2 by changes of parameters to trace analyzed d13Ccarb and d13Corg curves from drilling core samples in Three Gorges through the Ediacaran to the early Cambrian (Tahata et al., 2012; Kikumoto et al., 2013; Ishikawa et al., 2012). The d13Ccarb in Three Gorges shows negative excursions in Gaskiers glaciation (ca. 580 Ma), Shuram excursion (ca. 570-550 Ma) and Precambrian/Cambrian boundary (ca. 542 Ma). On the other hand, the d13Corg in Three Gorges show constant ca. -30 per mill in early Ediacaran and correlation to d13Ccarb after Shuram excursion.

The parameter sets suggested carbon cycle changes in Ediacaran period. This Reconstructed Three Gorges carbon cycle quantitatively estimated carbon cycle changes in these periods. The results indicate the rate of remineralization need to increase before the Shuram excursion and the rate of organic carbon burial increase to ca. 100 times in the late stage of Shuram excursion. The increase of remineralization might indicate step-by-step changes of dominant metabolism from anaerobic respiration to aerobic respiration. In addition, the change of organic carbon burial is possibly consistent with the first appearance of mobile metazoan and zooplankton.

Keywords: Ediacaran, Shuram excursion, carbon cycle change

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Geochemical characterization of impact ejecta layers from the Upper Triassic deep-sea deposits in Southwest Japan

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Anomalously high platinum group element (PGE) concentrations have been reported for Upper Triassic (middle Norian) deep-sea sediments in the Sakahogi section, central Japan, which have been interpreted to be derived from an extraterrestrial impact event that formed the 100 km Manicouagan crater in Canada. The Late Triassic PGE anomalies have been identified in deep-sea claystone layers at three new bedded chert sections in Southwest Japan: (i) Unuma section in the Inuyama area, Mino Terrane, (ii) Hisuikyo section in the Kamiaso area, Mino Terrane, and (iii) Enoura section in the Tsukumi area, Chichibu Terrane. At each of these sites, the Late Triassic claystone layers are characterized by high PGEs abundances, coincident with minor enrichments of Ni and Cr, and abundant Ni-rich magnetite grains and microspherules. These claystone samples have high PGE concentrations of up to 7.0-38.1 ppb Ir, 13.2-65.1 ppb Ru, and 18.0-27.5 ppb Pt, which are comparable to that observed at the Sakahogi section. Given that PGEs are highly depleted in continental crust of the Earth relative to solar abundances, these anomalously high PGE abundances may have resulted from a large extraterrestrial impactor, similar to the Chicxulub impact event at the Cretaceous?Paleogene boundary. Redistribution of PGEs under reducing conditions can also result in PGE enrichments in marine sediments, but the Sakahogi claystone samples have unique geochemical signatures such as anomalously high Os contents (11.4 ppb) with unradiogenic Os. These lines of geochemical evidence are consistent with a significant extraterrestrial input to the claystone, which can account for the anomalously high PGEs concentrations.