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

BPT28-P01 Room:Convention Hall Time:May 24 10:45-12:15

Paleogenomics: an overview

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A brief summary of the 'paleogenomics project' will be given. Emphasis will be placed on the principles of the ancient genome reconstruction and possible applications of the reconstructed genomes to earth and life sciences.

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Origin and early evolution of Metazoa: Decoding surface environmental changes by multi-isotope analyses

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The period from the Ediacaran to Cambrian is one of the most exciting periods when Metazoa first appeared and quickly evolved. The origin and early evolution of Metazoa are very mysterious because the event suddenly happened after very long time, >2000 m.y. since the emergence of eukaryotes, and proceeded very quickly, and because appearance of new phylum is limited to this period (Cambrian explosion). Previous works combined two biological evolutions of emergence and diversification, and investigated its cause. As a result, it is suggested that increase of oxygen contents caused the origin and diversification of the Metazoa. This work presents environmental changes from the Ediacaran to Cambrian based on geochemistry of drill core samples in Three Gorges area, South China, and proposes that distinct environmental changes between the Ediacaran and Cambrian contributed to the emergence and diversification, respectively, and that the biological evolution occurred just after the environmental changes, especially increase in nutrients. The stepwise increase of oxygen content resulted from the eutrophication events.

We conducted twenty-four drillings in South China. The drilling sites include shallow marine and deep, slope facies, fossiliferous and fossil-poor areas, respectively. The drilling covers from the Neoproterozoic to the boundary between the Early and Middle Cambrian. We made chemostratigraphies of C, O, Sr, Fe and Ca isotopes and Fe, Mn, REE and P contents of carbonates, Mo isotopes of black shales and C and N of organic matters to estimate primary productivity, continental weathering influx, temperature, nutrient contents (P, N), and redox condition of seawater. Sr isotopes display positive excursions and indicate high continental influxes at ca. 580, 570-550 and 540 Ma. P content of carbonate rock was very high until ca. 550 Ma, and then decreased, suggesting the seawater was enriched in P until then. High N and Ca isotope values indicate that seawater was depleted in NO_3^- and Ca contents until ca. 550 Ma, and then increased. Mo isotopes of black shale, and Fe and Mn contents and REE patterns of carbonate rocks indicate that seawater became more oxic since ca. 550 Ma.

The geochemical evidence suggests that the emergence of Metazoan in the Early Ediacaran was caused under the relatively less oxic and P-rich condition, whereas their diversification occurred under oxic, NO_3^- and Ca-rich condition. Especially, the transition from P to NO_3^--rich seawater possibly increased Redfield ratio, and contributed to diversification of more actively mobile multicellular animals. The geochemical data indicate that the biological evolution occurred just after the environmental changes, especially the timing of increase in nutrients, allowing a new insight of biological evolution of multicellular animals. The quick response of biological evolution to the environments suggests that the fundamental base for biological functions were already established long before the environmental changes.

Keywords: Cambrian explosion, chemostratigraphy, surface environmental changes, nutrient-dependent biological evolution, Ediacaran, Metazoa

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What nitrogenous geomolecules tell about Earth's history?

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In terms of Earth's history, it has been claimed that the phosphorus cycle, rather than the nitrogen cycle, is the primary control on the carbon cycle. This classical view is based on the fact that nitrogen is abundant in the atmosphere as N2, and is not, therefore, a limiting element. More recently, a contrasting view has been presented, in which the nitrogen cycle, especially the component representing the balance between N2-fixation and denitrification, is the primary driving force of the carbon cycle. Understanding the relative importance of the nitrogen and phosphorus cycles in controlling carbon cycle activity is fundamental to an understanding of the evolution of carbon cycle over geological time, and the relationship of the carbon cycle to climatological and evolutionary factors.

Examination of natural variations in stable nitrogen isotopic composition over time is a key for understanding the relative importance of the nitrogen cycle to biogeochemical cycles. Despite many efforts, investigations on the nitrogen cycle in the geological past have lagged far behind those on the carbon cycle. One important reason for this is that inorganic minerals produced in the water column contain little nitrogen. This situation contrasts with that of carbon, whose isotopic signature is faithfully recorded in calcium carbonate precipitated in the water column under thermodynamic equilibrium, and which is preserved in sediments for long period of time. Even in sedimentary organic matter, individual nitrogenous compounds have not often been examined as a means of gaining insight into the Earth's historical record. Consider, for example, the application of compound-specific isotopic techniques to study biogeochemical processes in geological samples. The compound-specific isotopic analysis has not been widely applied to the reconstruction of the nitrogen cycle in the geological past, although an extensive literature exists concerning "bulk" nitrogen isotopic investigations.

The organism produces various types of nitrogenous compounds through metabolic processes, and our knowledge of nitrogen metabolism in cells is plentiful. Thus, here I present not only an overview of previous studies on processes related to organic nitrogen in the natural environment, but also try to bridge between nitrogen biochemistry and geochemistry mainly through isotopic signature to provide useful introduction for the future studies. I also present the degradation of nitrogenous compounds, both in the water column and sediments. Such information is useful for interpreting the various types of sedimentary nitrogen represented in the isotopic record.

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Paleogenomics: group discussion

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Participants will discuss science as well as grant application concerning the interrelationships among ancient genome sequences, the phenotypes inferred based on the reconstructed biological functions (metabolic pathways, metallo-proteins, developmental programs, etc.), and the environments in which those hypothetical ancestors inhabited, from a wide variety of viewpoints, including geohistory and biohistory studies, geometallomics, microbial ecology, organic geochemistry, developmental genetics, and genome sciences.