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

BPT28-P02 会場:コンベンションホール 時間:5 月 24 日 10:45-12:15

後生動物出現と進化の原因を探る：多元素多同位体解析に基づく環境解読
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.

キーワード: カンブリア大爆発, 化学層序, 表層環境変動, 栄養塩依存の進化, エディアカラ紀, 後生動物
Keywords: Cambrian explosion, chemostratigraphy, surface environmental changes, nutrient-dependent biological evolution, Ediacaran, Metazoa