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Three steps evolution of multicellular animals

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The period from the Ediacaran to Cambrian is one of the most exciting periods when the first multicellular animals appeared and quickly evolved. The biological evolution is very unique because it takes very long time, >2000 my, until multicellular animals appeared after the emergence of eukaryotes, 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 origin. This work estimates environmental changes from the Ediacaran to Cambrian, from geochemistry of drill core samples in Three Gorges area, South China, and proposes that distinct environments between the Ediacaran and Cambrian contributed to the emergence and diversification, respectively.

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 N 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, N and Ca-rich condition. Especially, the transition from P to N-rich seawater possibly supported increase of Redfield ratio and contributed to diversification of more mobile multicellular animals.

Keywords: multicellular animals, surface environmental change, Snowball Earth, Cambrian explosion, Cambrian-Precambrian boundary, Multi-elemental, isotope analyses