Shift in limiting nutrients in late Ediacaran-early Cambrian oceans

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Nutrient cycles play a key role in the oceanic primary production and productivity-driven photic zone anoxia that is related to mass extinction in the Phanerozoic oceans. In contrast, their relations to primary production and biological events are not well studied during the Ediacaran to Cambrian periods when the diversification/extinction of metazoans and ocean oxygenation occured. We report high resolution stratigraphic profiles of $\delta^{15}N$ and $\delta^{13}Corg$ values of two sections of sediments in South China that were deposited in the shelf and deep basin environments from the early Ediacaran to early Cambrian periods. The $\delta^{15}N$ profiles at the two sections are similar to each other in that 1) the relatively invariable $\delta^{15}N$ values of 5−6‰ in the early-middle Ediacaran (635 Ma–ca. 560 Ma) and 2) the shift of the $\delta^{15}N$ values to 3−4‰ since the beginning of the Shuram $\delta^{13}Ccarb$ Excursion. The $\delta^{15}N$ values in the shelf section decrease from the late Ediacaran to the Cambrian Stage 2 and then increased from −1‰ to +4‰ during the first appearance and diversification of trilobites in the Cambrian Series 2. Nitrogen cyle in the Ediacaran to early Cambrian periods are interpreted by integrateing the $\delta^{15}N$ profiles with previously reported stratigraphic profiles of $\delta^{15}N$, $\delta^{13}Corg$, $\delta^{13}Ccarb$, P content in carbonate, and Mo/TOC from the Yangtze Platform, South China. Consequently, the following conclusions on ancient nutrient cycles are newly obtained. 1) The early-middle Ediacaran ocean is characterized by i) the existence of a stable nitrate reservoir, in common with the modern ocean, and ii) N–Mo colimitation of long-term primary production that is different from P limitation of long-term primary production in the modern ocean (Tyrrell, 1999). 2) The shift in "ultimate" limiting nutrients from N and Mo to P likely occurred in the late Ediacaran. This shift may have been prior condition for the extinction of small shelly fossils related to the development of the photic zone anoxia for several million years in the Cambrian Stage 2, which was followed by the most prominent phase of metazoan diversification.

Tyrrell, T. (1999) Nature 400, 525-531.