High atmospheric CO_2 Levels in the Mesoproterozoic estimated from paired carbon isotopic records in carbonates from North China

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Mesoproterozoic was thought as a long interval of relative stability in tectonic activities, carbon cycle, global climate and surface oxidation states, and was so called as a "boring" period. Paleontological evolution indicates that the Mesoproterozoic was not a "boring" time, but a period in which both red and green algae evolved, as well as fungi and calcifying cyanobacteria, and marine stromatolites well developed. The rapid evolution of algae and the peak in stromatolite abundance were attributed to the evolution of CO_2-concentrating mechanisms by cyanobacteria. It is proposed that the Mesoproterozoic was prevailing warm climate and high atmospheric pCO_2 level. However, accurately constraint on Mesoproterozoic atmospheric pCO_2 still remains scare. Here we reported high-resolution organic- and inorganic carbon-isotope records in ~1.6Ga-ago sedimentary samples collected from Hebei Province, northern China. Those paired carbonate and organic carbon isotope records can be used as a proxy to quantify atmospheric CO_2 concentration in the Mesoproterozoic. In those Mesoproterozoic samples, $\delta^{13}C_{org}$ values vary from -28.4 to -34.3 ‰, and $\delta^{13}C_{carbonate}$ values range from -2.1 to 0.4 ‰. According to the isotopic difference between organic carbon and carbonate ($\Delta B = \delta^{13}C_{org} - \delta^{13}C_{carb}$), atmospheric CO_2 concentrations were estimated at the range from 780 ppm to 9300 ppm, with an average of 3350 ppm that is ~10 times the present atmospheric level. Those results suggest that atmospheric CO_2 was at a high level and a greenhouse environment was prevailing in the Mesoproterozoic.