

# C and S isotope records in Doushantuo Formation: Implication for Redox Fluctuation of the Ediacaran Ocean

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Carbon and sulfur isotope evidence from Oman and iron speciation data from Newfoundland suggested a stepwise oxidation of the Ediacaran ocean from ca. 635 Ma to ca. 542 Ma (Fike et al., 2006; Canfield et al., 2007). New isotope data obtained from the Ediacaran Doushantuo Formation, however, reveal alternative oxidation events from ca. 635 Ma to ca. 551 Ma that suggest stepwise oxidation of the Ediacaran ocean, with significant ocean anoxia following each oxidation event. No  $\Delta\delta^{34}\text{S}$  values exceed 46‰ in the Doushantuo Formation, indicating the absence of sulfur disproportionation before 551 Ma and a complete oxidation of deep oceans did not occur until the latest Ediacaran or early Cambrian. Our data of  $\delta^{13}\text{C}_{\text{carb}}$ ,  $\delta^{13}\text{C}_{\text{org}}$ ,  $\delta^{34}\text{S}_{\text{CAS}}$ , and  $\delta^{34}\text{S}_{\text{py}}$  provide an alternative environmental interpretation for the evolution of early animal life and subsequent Cambrian explosion.

Increases of  $\delta^{13}\text{C}_{\text{carb}}$  and  $\Delta\delta^{34}\text{S}$ , with occurrence and diversification of Doushantuo-Pertatataka acritarchs (DPA), in the lower and middle Doushantuo Formation after the Nantuo (or Marinoan) glaciation indicate the first oxidation event to cause oxic water column in the shelf. Constant  $\delta^{13}\text{C}_{\text{org}}$  values (about -29‰) with variable  $\delta^{13}\text{C}_{\text{carb}}$  (-6.93‰ ~ +6.17‰) are consistent with the existence of DOM (dissolved organic matter) rich deep-ocean. Following negative shifts in  $\delta^{13}\text{C}_{\text{carb}}$  (down to -9.62‰) and  $\delta^{34}\text{S}_{\text{CAS}}$  (down to +9.5‰), a temporary anoxia occurred between the middle and upper Doushantuo Formation that is concordant with DPA's extinction. Another oxidation in the upper Doushantuo Formation, where multicellular, macroscopic algae (the Miaohe biota) were found. The prominent negative  $\delta^{13}\text{C}_{\text{carb}}$  (down to -8.98‰) excursions and associated decline of  $\delta^{34}\text{S}_{\text{CAS}}$  (from +43.5‰ to +10.2‰) imply both oxidations of DOM and sulfide from anoxic water column of deep-ocean. Unusually low  $\delta^{13}\text{C}_{\text{org}}$  values (down to -38‰) and increasing  $\delta^{13}\text{C}_{\text{carb}}$  (from -8.16‰ to -2.00‰) in the uppermost Doushantuo Formation (ca. 551 Ma) suggest involvement of anaerobic methane oxidation, possibly associated with the upwelling of anoxic deep-ocean seawater. Eventually, another anoxia possibly occurred at the near Dengying-Doushantuo boundary.

## References

- Fike D.A., Crotzinger J.P., Pratt L.M. and Summons R.E., (2006), *Nature* **444**, 744-747.  
Canfield D.E., Poulton S.W. and Narbonne G.M., (2007), *Science* **315**, 92-95.