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Spatiotemporal marine redox evolution during the Ediacaran-Cambrian transition: Implications for carbon cycling and early-animal evolution

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The Ediacaran-Cambrian (E-C) transition is pivotal time which is characterized by a strong negative 'Basal Cambrian Carbon Isotope Excursion' (termed BACE) as well as the decline of Ediacaran Biota and the emergence of Cambrian small shelly faunas, which is postulated to have a causal link with marine redox conditions. However, the marine redox conditions during the BACE remain largely debated, impeding our understanding of their role in these transitions. In this study, we reconstructed oceanic redox evolution across the BACE at two sections in South China—Daqiao Mine (DQM; inner shelf) and Caojiawan (CJW; mid-shelf) using a set of paleoceanic redox tools [Ce/Ce*, iron speciation and paired $\delta^{34}S$ data of pyrite and carbonate-associated sulfate ($\delta^{34}S_{py}$-$\delta^{34}S_{CAS}$)]. Our data show a differential redox evolution between DQM and CJW sections: shallow waters at DQM shifted from oxic conditions prior to the BACE to ferruginous during the BACE and back to oxic again after the BACE, whereas mid-shelf waters at CJW shifted from oxic conditions before BACE to euxinic at onset of the BACE, to ferruginous during the rest of the BACE and back to euxinic again after the BACE. Integrating previously published data, our new dataset supports a redox-stratified structure for the BACE ocean, in which a mid-depth euxinic zone encroaching on the continental shelf, situated between shallow oxic and deep ferruginous waters. Accompanying redox-sensitive element and paired $\delta^{34}S_{py}$-$\delta^{34}S_{CAS}$ data indicate that the oceanic redox evolution in South China during the BACE may have been influenced by basin-wide renewal driven by upwelling. We propose that upwelled anoxic deep waters may have brought significant amount of dissolved organic matter (DOM) into shallow waters which not only depleted oxygen and sulfate levels in shelf area, increasing anoxia and leading to the extinction of the Ediacaran Biota, but also caused the BACE event via DOM oxidation which released ^{12}C-riched dissolved inorganic carbon for carbonate formation.