Redox controls on the preservation of organic fossils through the Neoproterozoic and the Cambrian

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The record of small organic-walled metazoan fragments, known as 'small carbonaceous fossils' (SCFs), offer a substantial alternative to the records of shelly fossils and rare 'exceptionally preserved' biotas in reconstructing the Cambrian radiation. Because of the organic nature of SCFs, their record potentially persists where the preservation of mineralized forms is otherwise compromised, and because of their size, they are prone to be less readily altered than larger structures, (e.g. Burgess Shale macrofossils). However, the taphonomic pathways which control their preservation are poorly understood. Here, we studied C, Fe and P systematics throughout eight cored SCF-bearing sections from the early- to middle-Cambrian Baltic Basin. We evaluate the role of major geochemical processes usually associated with 'exceptional preservation' of organic remains, including phosphatization, pyritization and the involvement of other highly reactive iron minerals. We found that water column redox chemistry exerts major controls on SCF preservation, promoted by anoxic and Fe(II)-rich (ferruginous) or low-oxygen conditions. We draw comparisons with geochemical patterns exhibited for the preservation of other organic compressions, including tubular fossils and early to mid-Neoproterozoic acritarchs. We find a remarkable similarity in the taphonomic behavior of SCFs and ornamented acritarchs, suggesting that ferruginous water columns may be prerequisite conditions for the preservation of delicate organic fossil structures.