What controls the preservation of Precambrian organic-walled microfossils in shales?

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Much of our understanding of early eukaryote diversity and paleoecology comes from the record of organic-walled microfossils in shales, yet the conditions controlling their preservation are poorly understood. It has been suggested that high concentrations of total organic carbon (TOC) inhibit the preservation of organisms as organic fossils in shale, but this has never been tested.

We compared the presence, preservational quality, and diversity of organic-walled microfossils to TOC concentrations (in wt%) in 248 shale and siltstone samples from twelve units spanning late Mesoproterozoic to late Neoproterozoic time from Australia, Canada, Svalbard, and the United States. We found that shales containing fossils have significantly lower TOC values (μ= 0.62 wt%, σ=1.23 wt%, n=124) than those containing no fossils (μ= 2.67 wt%, σ=3.42 wt%, n=124). Within the fossiliferous samples, preservational quality, as measured by the degree of pitting and definition of vesicle margin, decreased with increasing TOC levels. Finally, as might be expected if unfavorable preservational conditions preserved fewer labile forms, species richness was inversely correlated with TOC: 90% of assemblages that contained three or more taxa occurred in samples with TOC <0.5 wt%. Fossiliferous samples with TOC > 0.5 wt% were dominated by *Leiosphaeridia* sp., a polyphyletic, long-ranging group. Also present were several widespread taxa including a few that have been proposed as index fossils.

These results suggest that relative species richness may be underestimated in times and places of high organic matter accumulation, and that to reconstruct paleoecological and species richness patterns, paleontologists should target shales with TOC values <0.5 wt%.