Palaeoecological model of the Mesoproterozoic Taoudeni Basin and implications for early eukaryotes evolution

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Abstract

The mid-Proterozoic rock record preserves a relatively moderate diversity of early eukaryotes, despite the early evolution of fundamental features of the eukaryotic cell. Common hypotheses involve the redox state of stratified oceans with oxic shallow waters, euxinic mid-depth waters, and anoxic and ferruginous deep waters during this time period. Mid-Proterozoic eukaryotes would have found suitable ecological niches in estuarine, fluvio-deltaic and coastal shallow marine environments near nutrient sources, while N_2-fixing photoautotrophs bacteria would have been better competitors than eukaryotic algae in nutrient-poor niches. Here, we present the first palaeoecological model of the late Mesoproterozoic Taoudeni Basin, Mauritania, Northwestern Africa. Previous palaeontological studies in the basin reported stromatolites, a low diversity of microfossils – including one species of presumed eukaryotes: verrucae-bearing acritarch – and biomarkers of anoxygenic phototrophic purple and green sulfur bacteria, cyanobacteria and microaerophilic methanotrophs. However, no biomarkers diagnostic for crown group eukaryotes were reported so far. In addition to exceptionally well preserved microbial mats showing chain-like aggregates of pyrite grains, we observed a total of sixty-two morphotaxa including nine presumed prokaryotes, thirty-five possible prokaryotes or eukaryotes, fifteen presumed species of eukaryotes – ornamented and process-bearing acritarchs, multicellular morphotaxon, putative VSMs, large budding vesicles, and vesicles with a sophisticated excystment structure: the pylome – and three remains of structured kerogen. Here, we combined the geological context, iron speciation – with the aim of reconstructing palaeoredox environmental conditions –, and microfossils quantitative analysis. Sediments were deposited under shallow waters in distal (pericratonic) and proximal (epicratonic) marine environments during a depositional sequence linked to a marine transgression and regression. Both microfossil assemblages and iron speciation were analyzed on the same samples, with the aim of better understanding the palaeoecology of early eukaryotes. Palaeoredox conditions rapidly fluctuated from oxic to anoxic states across the basin, but in terms of anoxic episodes, ferruginous conditions dominated in epicratonic environments, while euxinia was more prevalent in pericratonic environments. A relatively higher fossil eukaryotic diversity, both in terms of richness and abundance, was observed in the more proximal environments during the marine transgression. Our results could possibly suggest that both the availability of molecular oxygen and nutrients are needed for a high eukaryotic diversity and could confirm a previous hypothesis suggesting that mid-Proterozoic eukaryotes would have found suitable ecological niches in shallow marine environments near nutrient sources.