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Palaeoredox and environmental constraints on early eukaryote ecosystems: insights from the Greater McArthur Basin, northern Australia

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Eukaryotic life resulted from the union of an archaeon with a bacterium (which would become the mitochondrion) during the Proterozoic Eon. This major evolutionary transition provided eukaryotes with the ability to respire using O_2, paving the way for the eventual rise of complex animals, plants and fungi. Despite recent advances into eukaryogenesis from molecular phylogenomics, the nature of ancient eukaryote microfossils remains enigmatic, and the role of O_2 in early eukaryote evolution continues to be debated. In order to gain insight into the ecology of early eukaryotes, we conducted an integrated sedimentological–geochemical–palaeontological study of the middle Proterozoic McArthur and Birrindudu basins in the Northern Territory of Australia. These sedimentary successions are well preserved in drill core, recording deposition from ca. 1.75–1.3 Ga in a range of depositional environments, and host abundant microfossils of eukaryote-grade complexity. Following analysis of over 100 rock samples, we report over 1200 specimens of probable eukaryotic taxa, allowing the possibility to search for environmental trends in fossil assemblage composition. Based on sedimentological and stratigraphic context, we assigned these microfossils to specific depositional settings, with eukaryote fossils being far more abundant and diverse in nearshore environments such as tidal flat, lagoon and back-barrier settings. We subsequently analysed the iron speciation and redox-sensitive trace metal abundance of the host siliciclastic rocks in effort to reconstruct the water column redox state of these habitats. Collectively, these results provide novel constraints on the palaeoecology and metabolic preferences of early eukaryotes, which may be used to inform models of eukaryogenesis.