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# Evolutionary trends of the earliest eukaryotes: evidence from the 1.8 Ga Changcheng Group and the 1.7-1.4 Ga Ruyang Group, North China Craton

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Deposits from the North China Craton contain some of the earliest single-celled fossils of eukaryotic affinity [1][2]. These fossils document primary evolutionary trends in ancient eukaryotes. Distinct organic-walled microfossil assemblages from two Paleo- to Mesoproterozoic successions were examined via transmitted light, scanning and transmission electron microscopy, and provided observations for a better understanding of the origin and subsequent morphological innovations among the first protists.

Studied samples came from the silty shales of the Paleoproterozoic Changzhougou Formation, Changcheng Group, Yanshan Range, and the organic-rich shale intervals of the terminal Paleoproterozoic to Mesoproterozoic Baicaoping and Beidajian formations, Ruyang Group, Shanxi Province, both exposed in northern China. Acritarch-rich levels in both successions were deposited in a near-shore, peridital environment. The age of the Changcheng Group is about 1823 ±68 Ma based on zircon Pb-Pb dating [3], and the Ruyang Group was deposited between 1744±22 to 1411±27 Ma (U-Pb and Pb-Pb dating, [4]). Acetolysis-resistant microfossils were extracted from the rocks via palynological HF-maceration [5].

The older, Changzhougou assemblage is dominated by sphaeromorphic taxa [6]; containing 10 morphological entities of either smooth-walled leiosphaerids, or sphaeromorphs bearing a distinct wall microsculpture and excystment structures (openings in the vesicle). In contrast, the slightly younger Ruyang Group shows a considerable diversity of morphologically complex organic-walled microfossils (26 taxa), including acanthomorph (spine-bearing), netromorph (fusiform), and envelope-bearing taxa.

By comparing the older, Paleoproterozoic microfossils with the succeeding diverse assemblage of unicellular eukaryotes, we document the first divergences of the protistan clades. Additionally, we revise the taxonomy of several poorly understood Proterozoic palynomorphs, and identify their diagnostic characters based on the microstructural studies of their organic cell walls.

A compilation of characters in the earliest eukaryotes (from the 1.8 Ga old rocks) and the first morphologically complex eukaryotes (1.7-1.4 Ga, [7]), along with the changes therein, reveal the initial steps in early protistan evolution. Comparing these fossils with microstructural characters in extant single-celled protists results in better constraints on the phylogenetic position of the Changzhougou and Ruyang fossils, and provides the minimum age for the origins of certain lineages of the crown-group Eukarya.

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