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Ultrastructure of organic cell walls in Proterozoic microalgae

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The antiquity of life has been well appreciated since the discoveries of microfossils and confirmation of their authenticity, as well as the recognition of geochemical signs of biogenicity in the Archean successions. Resolving the biological affinities of early biota is essential for the unravelling the changes that led to modern biodiversity, but also for the detection of possible biogenic records outside of the terrestrial biosphere. Advanced techniques in microscopy, tomography and spectroscopy applied to examine individual microfossils at the highest attainable spatial resolution have provided unprecedented insights into micro- and nano-scale structure and composition of organic matter.

Transmission and scanning electron microscopy studies of the wall ultrastructure of sphaeromorphic and ornamented acritarchs have revealed complex, single to multilayered walls, having a unique texture in sub-layers and an occasionally preserved trilaminar sheath structure (TLS) of the cell wall. A variety of optical characteristics, the electron density and texture of fabrics of discrete layers, and the properties of biopolymers may indicate the polyphyletic affiliations of such microfossils and/or the preservation of various stages (vegetative, resting) in their life cycle. I evaluate the morphological features of organic-walled unicellular microfossils in conjunction with their cell wall ultrastructure to infer their life cycle and to recognize various developmental stages represented among microfossils attributed to a single form-taxon.

Several cases of fine wall ultrastructure in microfossils have been documented and have had a conclusive influence on understanding their affinities. Some Proterozoic and Cambrian leiosphaerids are of algal affinities. Certain specimens represent chlorophyceaens, having the multilayered composite wall with TLS structure known from vegetative and resting cells in modern genera of the Chlorococcales and Volvocales. The wall ultrastructure of the studied Cambrian and Proterozoic acanthomorphs resembles the resting cysts of green microalgae, but there is no evidence to suggest a close relationship of these taxa to dinoflagellates.