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Ecology and phylogenetic affinity of the early Cambrian tubular microfossil *Megathrix longus*

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Megathrix longus is one of the common types of the early Cambrian. It was originally interpreted as being related to extant Oscillatoriaceae. Taking the corrugation of cross-walls as a biologically diagnostic feature, Yao et al. and Dong et al. claimed that *Megathrix longus* was unlikely to be a filamentous cyanobacterium, and related it to the Neoproterozoic tubular microfossil *Sinocyclocyclicus guizhouensis*. Although *Megathrix longus* closely resembles *S. guizhouensis*, there are different opinions about the affinity of *S. guizhouensis*, whether it is a stem-group cnidarian, a filamentous cyanobacterium or other alga. Due to the poor preservation and lack of fossils, morphology and taphonomy on *Megathrix longus* is still unclear. And previous studies have not provided an exact answer concerning its phylogenetic affinities.

Abundant, exquisitely preserved specimens of the enigmatic tubular microfossil *Megathrix longus* are found from the early Cambrian Yanjiahe Formation in the Yangtze Gorges area. Studies of their morphology and taphonomy reveal that the inner cross-wall of *Megathrix longus* is topographically flat, the trichome terminus is blunt and closed, and incomplete cross-walls are regularly intercalated between complete ones. The deformation of trichomes, as well as the corrugation of their cross-walls, are postmortem features caused by compaction, rather than biological features as previously interpreted.

Morphologically, *Megathrix longus* bears a striking similarity to the extant Oscillatoria. Both trichomes are uniserial, consisting of cylindrical or discoid chambers/cells as well as having round termini. The termini of *Megathrix longus* suggest that it was planktonic. Besides, the complete cross-walls of *Megathrix longus* are comparable with the transversal cell walls in the filaments of Oscillatoria, and the incomplete cross-walls of *Megathrix longus* are comparable with the centripetally growing membranes in Oscillatoria. Furthermore, statistical analysis indicates that chamber division of *Megathrix longus* is accomplished by the closure of incomplete cross-walls. This process contributing to trichome growth is also comparable with the cell division of Oscillatoria. In other words, the trichomes of the two organisms have highly analogous modes of growth. Even more interestingly, Trichome fragmentation of *Megathrix longus* was also observed in a series of specimens, which closely resembles that of cyanobacteria, particularly the Oscillatoriaceae.

In general, our study tends to support a close phylogenetic affinity between *Megathrix longus* and Oscillatoriaceae (Cyanophyta). Considering the resemblance of *Megathrix longus* and Sinocyclocyclicus guizhouensis, our study also supports the opinion that S. guizhouensis might be a kind of large filamentous cyanobacterium.