

Paper Number: 746

## Phosphatized *Quadrapyrgites* from the Early Cambrian of South China

Yunhuan Liu<sup>1</sup>, Tiequan Shao<sup>1</sup>, Qi Wang<sup>2</sup>, Hanhua Tang<sup>2</sup>, Yuan Li<sup>2</sup>, Yingying Ma<sup>2</sup>, Hongtao Zhang<sup>2</sup>

<sup>1</sup>College of Earth Science & Resources, Chang'an University, Xi'an 710054, China; Key Laboratory of Mineral Resources and Geological Engineering Ministry of Education, 710054, China; yunhuanl@chd.edu.cn

<sup>1</sup>College of Earth Science and Resources, Chang'an University, Xi'an 710054, China; stotto@163.com

<sup>2</sup>College of Earth Science and Resources, Chang'an University, Xi'an 710054, China

---

*Quadrapyrgites* has been considered to represent a group of metazoan fossil and assigned as a sister group of the coeval *Punctatus*, both are similar in overall morphology. And the research history of *Quadrapyrgites* is closely related to those of *Punctatus*. However, the apex of *Quadrapyrgites* exhibits tetradial symmetry and has a smooth outer wall with only sparse longitudinal folds, collectively distinct from *Punctatus*.

Due to the scarcity of incompletely preserved fossil specimens, the full morphology of *Quadrapyrgites* remains poorly understood. Hundreds of *Quadrapyrgites* fossils in our collection ensures a more detailed observation of *Quadrapyrgites*. It is a tower-shaped fossil that is covered with an outer membrane. The fossil consists, from proximal to distal ends, of an oral area, a cone, a collar, and an apex. The proximal (oral) end is open and the distal (aboral) end is closed. The growth zone of *Quadrapyrgites* is situated at the oral end, where 12 terminal lobes are generated, enlarged, uplifted, unfolded, and finally evaginated to form a new crest. And meanwhile, new lobes are generated within the oral end. This process cycled and new crest was continuously generated, then the tubes grew long. The terminal lobes were first in control of the opening and closure of the tubes, and later transferred to be part of the tube wall. A one-by-one addition of crest number from two to 13 is recognized herein. The sheath can be lightly or heavily wrinkled, reflecting that they are pliable when alive. The apex exhibits tetradial symmetry with four longitudinal ridges, and the cross section is thus squared. Three morphological types of the apex, the most characteristic feature of *Quadrapyrgites*, are identified from hundreds of *Quadrapyrgites* specimens. They are Type A (conical apex), Type B (flat apex) and Type C (Type A+ Type B). The type A is remarkably rare among them.

*Quadrapyrgites* and *Olivoooides* share great similarities with periderm sheaths of coronate scyphozoans, indicating a possible close relationship between them. Hexangulaconulariidae might link *Olivoooides* with Conulariida. If correct, *Olivoooides*, *Quadrapyrgites*, *Hexangulaconulariidae*, and *Conulariida* are all related with coronate scyphozoans, and might be stem members. The diversity of coronate scyphozoans in the lower Cambrian Kuanchuanpu Formation is thus greatly enlarged. It also hints that there should be medusoid forms (scyphomedusae) co-occurring with *Olivoooides* and *Quadrapyrgites*.

Furthermore, an embryonic development and ontogenetic sequence with embryo and crest is constructed. The ontogenetic sequence of *Quadrapyrgites* is sub-divided into 6 stages: cleavage embryos, organogenesis, pre-halthing, larvae, juvenile and adult. With the ectropion of the oral textures, the number of the body ring gradually increases and thus the tube became longer. The adult

form is marked by more than a dozen of ring ridges. Obviously, there are still missing stages in the current reconstruction of the embryological developmental sequence of *Quadrropyrgites*. Further developmental investigation would provide more evidence for the full reconstruction of the life cycles of this taxon.

#### *Acknowledgements*

Supported by the National Natural Science Foundation of China (**No.41572009**) and College Students' innovative training program of Chang'an University (**No. 201510710060, 201510710056, 20151071017**).

