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放射光 X 線顕微コンピュータ断層撮影による初期後生動物進化解読
Synchrotron X-ray micro-CT analyses of the early Cambrian microfossils: Decoding of the early evolution of Metazoa

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Cambrian Explosion is the most drastic event in history of life on Earth. Chemopaleontological studies are very important to reveal early evolution of Metazoa. Recent X-ray micro-CT analyses of microfossils yielded new methods to observe the internal structures (e.g. Donoghue et al., 2006). Compared with microscopic and SEM observations of cutting planes of the microfossils, the technique has two advantages of “ nondestructive ” analyses on “ any ” cross-sections of internal structures. This work presents observations of three-dimensional structures of about 60 specimens of the Early Cambrian microfossils, interpreted as embryo, larvae, and adult species of cnidarian with a Synchrotron X-ray micro-CT at SPring-8, Japan (BL47XU). The fossils occur in Kuanchuanpu Formation at Shizhonggou area, Shanxi Province, China, together with Anabarites and Protohertzina (Yao et al., 2011).

Yao et al., (2011) proposed various Olivooides fossils as each stage of Gastrulation based on the external morphology (Epiboly). Our direct observation of the interiors reveals a blastopore, supporting the interpretation. In addition, their other cross-sections display ten-fold radial structures. Cheng and Dong (2008) showed five-fold structures on top of Punctatus. Our observations show the five or ten-fold structures are present even in the Gastrula. Micro-CT observations of internal structures of sea anemone-like microfossils display digestive systems of mouth, gastrovascular cavity and partitions. In addition, the Micro-CT analyses show that microfossils, interpreted as polyps of cnidarians, have pentaradial symmetry, apparently inconsistent between the external and internal morphology. The pentaradial structures are very common in the embryo and larvae fossils in the Kuanchuanpu Formation. In addition, their symmetry is very good, and directive axis can be defined in many microfossils. Recent molecular biological studies revealed that even cnidarians possess HOX/paraHOX clusters related to the bilateral symmetry (e.g. Martindale, 2005, Nature Reviews Genetics, 6, 917-927; Baguna et al., 2008, Phils. Trans. R. Soc. B, 363, 1481-1491). Our paleontological studies support that the cnidarians had bilateral structures in the early evolution, and lost the structures later. Alternatively, the fossils provide a stem group with a bilateral structure and diploblastic. High-resolution observations of internal structures of microfossils with the Synchrotron X-ray micro-CT possibly help in developing insight into early biological evolution from diploblastic to triploblastic organisms and from radial to bilateral symmetry.