Geochemical mapping of living animal eggs and embryos, and the Ediacaran Weng'an embryo fossils for taxonomic identification of the oldest animal embryo fossils

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The Weng'an biota is an Ediacaran biotic group, and has some unique features such as phosphatization of soft tissues of the original organisms and predominance of microfossils. This study focuses on the spherical phosphatized microfossils, which have multi-layered chorions with spiny or reticulated decorations on those surfaces, and whose internal spheres are divided into one to several hundred vesicles. Previous studies have interpreted them as animal embryos because of the palintomic cell division, but the taxonomic identification, namely animal phylum, is still on debate because the morphology is quite different from any modern animal eggs/embryos. In order to identify a taxonomic group of original organisms, more quantitative assessment than the physical analysis should be required. This study tries to establish chemical methodology to study the Ediacaran fossils, and performed four geochemical analyses: micro-CT analyses for reconstruction of three-dimensional structures of the spheroidal fossils without the destruction, laser Raman analyses to obtain distribution of organic matter within the fossils, compositional mapping of twelve trace element contents (B, Na, Al, Mn, Fe, Co, Ni, Cu, Zn, Sr, Ba, and Pb) on red algae and eggs, embryos and gastrulas of living cnidarian Anthozoa and mollusk Gastropoda, and compositional mapping on the four *Megasphaera* (1-cell) stage fossils and two *megaclonophycus* (many cell) stage fossils in the Weng'an. The chemical analyses were performed with LA-ICP-MS, housed at the Gakushuin University.

The compositional mapping shows that the trace element distribution in the living organisms is greatly different not only between algae and animal eggs but also between animal eggs of different phyla. The cnidarian eggs show a uniform distribution in boron and iron contents and enrichment in Na and Cu contents along the rims. The distribution of Ni, Zn, Sr, Ba and Pb contents within the eggs changes with the development stages. The Ni contents are uniformly distributed at the cleavage and gastrulation stages, whereas are concentrated in the outer parts at the blastocyst stage. Zn, Sr, Ba and Pb contents are concentrated in the outer parts at the cleavage and the blastocyst stages, and are uniformly distributed in the gastrulation stage. Al, Mn and Co could not be detected. On the other hand, internal parts of the mollusk eggs are enriched in Na, Co, Cu and Zn contents whereas the rim parts are enriched in Mn, Fe, Sr, Ba and Pb contents. The centers of the red algae are abundant in B, Na, Ni, Cu, Zn, Sr, Ba and Pb contents. Mn and Fe could not be detected in the red algae.

The trace element contents are not necessarily correlated with their requirement; for example Fe, a bioessential element for photosynthesis, contents are quite low in the algae. On the other hand, the trace element mapping reveals that Sr, Pb and Ba contents are high in the rims at the early development and decrease with development. We considered the reason why they are removing from the eggs with development because they are non-bioessential elements. The difference in distribution of bioessential elements in the eggs between the cnidarian and mollusk can be used to identify the phylum of an egg.

We also conducted mappings of fifteen elements including Cr, I and U on the Weng'an fossils. We considered transitional distribution of B, Al, Mn, Fe, Sr and Ba contents between the fossils and surrounding dolomite, and uniform distribution of Co and Ni within the fossils as taphonomic homogenization. Because Cu is highly distributed in enclosed vesicles of all fossils and the Cu contents

sharply change between the fossils and the surrounding, Cu possibly represents a common feature of the original organism of the animal embryos. We compared distributions of Cu, Zn and Pb between the living organisms and Weng' an animal embryos. The distributions are different between them so that we cannot identify the fossils as cnidarian or molluscs.

Keywords: Ediacaran, Doushantuo, Animal embryo fossils

