Geochemical Partitioning Between Soft Tissues and Chitinous Tubes of Siboglinid Tubeworms as a Potential Indicator of Methane Flux

Mingze Li[1,2], Shun Chen[1*]

[1] Deep Sea Science Division, Institute of Deep Sea Science and Engineering, Chinese Academy of Sciences, Sanya, Hainan, China

[2] University of Chinese Academy of Sciences, Beijing, China

Corresponding author: Shun Chen (chans@idsse.ac.cn)

Abstract

Fossil tubeworm tubes are widely used to reconstruct ancient cold-seep ecosystems, yet distinguishing biological signals from environmental overprints remains challenging. Here, we integrate carbon isotope ($\delta^{13}C$), trace-element, and rare earth element (REE) datasets from soft tissues and serially sectioned chitinous tubes of *Paraescarpia echinospica* collected from two geologically distinct cold-seep sites (Ganquan Plateau in the South China Sea and the Wenhai seep in the Okinawa Trough). Our results indicate that soft tissues from both sites exhibit nearly identical Post-Archean Australian Shale (PAAS)-normalized REE patterns, consistent with the established thiotrophic symbiotic background of this species. In contrast, mean $\delta^{13}C$ values differ markedly between the specimens in both soft tissues (−24.8‰ at Ganquan Plateau and −34.7‰ at Wenhai) and chitinous tubes (−26.9‰ and −37.0‰, respectively), potentially reflecting varying contributions of seawater dissolved inorganic carbon (DIC) and ^{13}C-depleted, methane-derived porewater DIC. These differences in carbon-source contributions may be associated with differences in local methane supply. The Wenhai tube exhibits pronounced interfacial Fe–Mn–Co enrichment, stratified redox-sensitive element accumulation, and REE fractionation changes, whereas the Ganquan Plateau tube shows less pronounced geochemical variation. These contrasts are consistent with stronger redox and porewater influences at Wenhai and may reflect stronger methane seepage. This study provides a modern reference framework for distinguishing biological and environmental signals in tubeworm geochemistry and a testable baseline for evaluating tube elemental zonation as a potential indicator of relative paleo-seep activity.