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Composite *Phymatoderma* from Neogene deep-marine deposits in Japan: Implications for Phanerozoic benthic interactions between burrows and the trace-makers of *Chondrites* and *Phycosiphon*

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Among composite trace fossils, one of the most common structures throughout the Phanerozoic are structures (e.g., dwelling trace, feeding trace) reworked by *Chondrites* and/or *Phycosiphon*. However, differences in the nature of the reworking behaviors of these two ichnogenera remain unknown. Thus, in this study, composite *Phymatoderma* specimens from the Neogene deep-marine Shiramazu Formation in Japan, particularly those reworked by *Chondrites* and *Phycosiphon*, were analyzed to reveal the specific conditions that might control the activities of these trace-makers. Phymatoderma reworked by *Phycosiphon* is significantly larger than non-reworked *Phymatoderma*, whereas *Phymatoderma* reworked by *Chondrites* shows no significant difference in burrow diameter compared with non-reworked *Phymatoderma* . The recognized size selectivity (i.e., preference for larger burrows) by the *Phycosiphon* trace-maker can be explained by considering the different feeding strategies of these two ichnogenera; namely deposit-feeding *Phycosiphon*-makers, which must have processed a significant mass of sediment to obtain sufficient organic matter, whereas chemosymbiotic *Chondrites*-producers did not require a lot of sediment to obtain nutrients. In order to test these interpretations, a dataset of Phanerozoic trace fossils reworked by *Chondrites*/*Phycosiphon* were compiled. Consequently, the *Phycosiphon*-producers' preference toward relatively larger burrows was recognized, quantitatively supporting the results of this study. The compilation also indicates that the burrow size might have become one of the important limiting factors for the *Phycosiphon*-producers that tried to rework the sediments within previous subsurface burrows, at least for 80 million years.

Key words: *Phymatoderma, Phycosiphon, Chondrites*, burrows, size, benthic interactions, Phanerozoic, Neogene, Japan.

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