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Biogeographic dynamics of graptolite species during the end-Ordovician mass extinction in South China

Qing Chen and Linna Zhang

State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

ABSTRACT

Spatial and temporal analysis of geographical biodiversity dynamics and reconstruction of species distribution areas are essential for revealing the patterns of evolution of graptolites and their survival strategies during bio-events. Over 800 occurrences of graptolites representing 84 species from five graptolite biozones (GB) through the interval of the end-Ordovician mass extinction (from the late Katian *Dicellograptus complexus* GB up to the early Rhuddanian *Akidograptus ascensus* GB) coming from 60 localities in South China were integrated for this study. All earlier identifications of taxa were updated following a unified taxonomic scheme and their distribution presented in a biozone-level stratigraphic correlation framework.

The distribution areas of 26 species occurring in the study interval were reconstructed using GIS software whereby the convex hull areas and maximum distribution distances were calculated. Based on variations in geographical distribution and the relationship with the end-Ordovician mass extinction, graptolite species can be divided into three evolutionary types: the background extinction type, the mass extinction type, and the origination type. The first and second types belong to Diplograptina, and the third one belongs to Neograptina. The analysis of the reduction rate in the geographic distribution of diplograptid species shows that the extinction event not only hit the mass extinction type taxa, but also impacted those of the background extinction type. It also shows that the original distribution area of selected species is not directly related to their extinction risk. Changes in distribution areas of the graptolite species indicate the replacement of neograptids for diplograptids during the end-Ordovician mass extinction.

To study patterns and changes in the spatial distribution of graptolite fauna, quantitative analyses of species-level α-, β-diversity, and occurrences were performed. Our results demonstrate that the end-Ordovician extinction mainly affected graptolites in the offshore and low-energy areas. Meanwhile, the extinction not only led to a sudden decline in the total diversity, but also resulted in a significant change in the composition and geographic differentiation of the graptolite fauna. Cluster analysis demonstrates that, before the extinction, the graptolite fauna showed two different geographic clusters, which resulted from the hydrodynamic conditions rather than from the distance to the coastline. After the extinction, the fauna became highly similar all over the study area, from nearshore to offshore and from high-energy to low-energy environments, which were mainly comprised by widespread, eurytopic species all over South China.

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Corresponding author:
Qing Chen
qchen@nigpas.ac.cn

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