Meganodular Limestone Points South China Paleoplate to the Late Ordovician Equator

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Objective

Time-specific litho- and biofacies often holds important information about unique ancient ecosystems that no longer exist on Earth today. This report summarizes one of such time-specific facies—the 3-D network structure of the Upper Ordovician Pagoda Formation in South China, as investigated by Zhan et al. (Palaeogeography, Palaeoclimatology, Palaeoecology, DOI:10.1016/j.palaeo.2015.07.039).

Methods

Investigations of the Pagoda Formation in South China were based on 13 sections, measured and sampled in detail to gather paleontological, sedimentological, and geochemical data. Rich trilobites, brachiopods, nautiloids and conodonts were studied to provide paleoecological and biostratigraphic information. Carbonate microfacies were analysed for interpreting the depositional environments. Geochemical analyses of the 3-D network structures included stable C and O isotopes, and the major and trace elements, using the MAT 253 at the Nanjing Institute of Geology and Palaeontology (CAS), and the Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) in China University of Geosciences (Wuhan).

Results

(1) The Pagoda Formation consists of medium- to thick-bedded limestone, marked by decimeter-scale, polygonal to sinuous partings (with some resemblance to desiccation cracks), extending on the Yangtze Platform for more than 2000 km from west to east and about 800 km from south to north. It is generally 10–20 m thick, but varies from only a few meters to about 90 m. In general, its thickness increases towards the paleoshoreline.

(2) From nearshore to offshore localities, the network bands (i.e. “cracks” in previous studies) become thinner and more widely spaced, with increasing amount of purple red lithofacies but decreasing argillaceous contents.

(3) There is no clear-cut boundary between the network bands and the regular rock matrix bounded by the network, especially when thin sections are examined. Instead, the boundary is gradational in terms of coloration, suggesting a lithological change as a result of diagenetic alteration.

(4) The common skeletal components (brachiopods, trilobites, ostracodes, crinoids) in the network bands are essentially the same as those in the rest of the rock in terms of taxonomic composition and relative abundance, without any trace of crack fill material. The only difference is that the skeletal material shows a more notable degree of recrystallization in the regular rock matrix than in the network bands.

(5) The large orthocone nautiloids (mainly Sinoceras) usually span several network bands, showing no cross-cutting by the network, nor shell surface offset or other types of damage at intersections with the network. Instead, the network bands always bend around and continue along the outer shell surface. This indicates that the Pagoda sediments did not experience any cracking during diagenesis.

(6) The $\delta^{13}$C values of the network markings are consistently different from those of the nodules, and the $\delta^{13}$C values across the nodular matrix between two network bands usually form a plateau with only minor fluctuations of 0.1‰–0.2‰.

(7) The $\delta^{18}$O values show minor difference between the network markings and nodules. It is suggested that the network bands formed during early diagenesis within an open system of soft carbonate sediments and buried marine pore water because any significant meteoric water involvement in the formation of the network markings would have caused a decrease in $\delta^{18}$O values.

(8) The chemical compositions of the inter-nodule networks are highly variable in the analyzed samples, which might be attributed to the complicated textural

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fabrics of the inter-nodule networks.

Conclusions

The sharp differentiation between the network markings and the nodules in $\delta^{13}$C values and elemental concentration levels is interpreted in this study as the result of the concretion effect. With continuous enlargement of the nodules through early cementation, the impurity-rich bands became squeezed into polygonal, sinuous, or meandering network bands. The vast paleogeographic expanse of the Pagoda network structure in South China, in contrast to its general rarity in the global geological record, implies a highly time-specific lithofacies. It was formed under a spatiotemporally rare combination or convergence of the following paleoenvironmental parameters: a moderate water depth where the carbonate factory is most productive to produce medium- to thick-bedded deposits, a protracted period (~5 million years) of tectonic quiescence to favour uninterrupted growth of large carbonate nodules, without significant siliciclastic sediment influx, and a hurricane-free paleoequatorial location to avoid destruction of the nodular structure in semi-consolidated deposits by severe storms. Thus, the unique Pagoda network structure corroborates recent paleogeographic reconstruction to position the South China paleoepicenter on the paleoequator during the early Late Ordovician.

Acknowledgements

This project was supported by the National Natural Science Foundation of China (grant No. 41521061, 41290260) and the State Key Laboratory of Palaeobiology and Stratigraphy (LPS). This paper is also a contribution to IGCP 591 "Early to Middle Palaeozoic Revolution".