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Neoproterozoic to early Cambrian small shelly fossil assemblages and a revised biostratigraphic correlation of the Yangtze Platform (China)

Michael Steiner [a,*], Guoxiang Li [b], Yi Qian [b], Maoyan Zhu [b], Bernd-Dietrich Erdtmann [a]

[a] *TU Berlin, Sekr. ACK 14, Ackerstrasse 71-76, 13355 Berlin, Germany*
[b] *Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China*

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Abstract

Small shelly fossils (SSFs) occur widely on the Yangtze Platform and have great potential for biostratigraphic subdivision of pre-trilobitic Early Cambrian strata. Based on the SSF record of the shallow water realm, five biozones can be recognized for the Meishucunian Stage. In ascending order the biozones are: *Anabarites trisulcatus–Protohertzina anabarica* Assemblage Zone; *Paragloborilus subglobosus–Purella squamulosa* Assemblage Zone; *Watsonella crosbyi* Assemblage Zone (formerly *Heraultipegma yunnanensis* Zone); poorly fossiliferous interzone; *Sinosachites flabelliformis–Tannuolina zhangwentangi* Assemblage Zone. In addition one SSF biozone is recognized for the overlying Qiongzhusian Stage: *Pelagiella subangulata* Taxon-range Zone. The formerly used *Siphogonuchites triangularis–Paragloborilus subglobosus* Zone and *Heraultipegma yunnanensis* Zone are discussed and redefined. Approximately 80 species of SSFs were screened for their spatial and temporal distribution on the Yangtze Platform. Variations in lithofacies and biofacies can be recognized throughout the Yangtze Platform, extending over an area of 2000×900 km. In a deeper water shelf setting the first zone is represented by the *Protohertzina anabarica–Kaiyangites novilis* Assemblage Zone, while younger zones are not recognized in the southern region. At the northern platform margin the Qiongzhusian is represented by the *Ninella tarimensis–Cambroclavus fangxianensis* Assemblage Zone and the *Rhombocorniculum cancellatum* Taxon-range Zone. The southeastern Shaanxi–western Hubei region followed a slightly different lithological and faunal development than the rest of Yangtze Platform, indicating a stronger similarity with parts of East Gondwana.

Some taxa such as *W. crosbyi*, *P. subangulata*, *R. cancellatum*, *Microdictyon effusum*, *A. trisulcatus*, *Protohertzina unguliformis*, and *P. anabarica* occur nearly worldwide and support an international correlation of Early Cambrian sequences between the Yangtze Platform and smaller West Gondwanan blocks, Siberia, Newfoundland, and Australia. The six investigated zones of the Yangtze Platform comprise an interval spanning the early Nemakit–Daldynian to the late Atdabanian/early Botoman Stage on the Siberian Platform. Palaeobiogeographic analysis revealed a strong taxic similarity between the Yangtze Platform and the Tarim Platform. A smaller number of species are shared with other West Gondwanan platform fragments such as India and Iran. Palaeobiogeographic results do not support the previously reported position of the South China Block between Australia and Siberia during the Early Cambrian.

Keywords: Palaeontology; Yangtze Platform; South China; Lower Cambrian; Small shelly fossils; Biostratigraphy

* Corresponding author. Tel.: +49 30 314 72876.
E-mail address: steishhb@mailbox.tu-berlin.de (M. Steiner).

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1. Introduction

The aim of the present study is to define and discuss the SSF biozonation for the Yangtze Platform (South China) and to discuss the regional and international correlation of earliest Cambrian strata. SSFs represent an important biostratigraphic tool for the subdivision and correlation of pre-trilobitic strata of the Cambrian. Despite strong attempts which are currently being made to settle internationally accepted series and stage subdivisions of the Cambrian system, the lower boundary problem and subdivision of pre-trilobitic Lower Cambrian strata require continued attention. The new subdivision of the Lower Cambrian of South China using two series (Diandongian; Qiandongian) and four stages (Jinningian, Meishucunian, Nangaoan, Duyunian) as proposed by Geyer and Shergold (2000), Peng (2000), and Peng and Babcock (2001) did not find broad approval and application, because it had not yet been fully discussed and approved by the national and international working groups on Cambrian stratigraphy. To prevent premature judgement regarding the decisions of the international working group of stage subdivision we herein do not intend to apply the newly advocated series and stage subdivision for the Lower Cambrian of South China. An application of the newly proposed stages for the Lower Cambrian is also discredited by the fact that the intended zonal subdivision based on SSF genera and a "*Hupediscus–Sinodiscus* Zone" covering the entire Qiongzhusian and the lower part of Canglangpuian (Geyer and Shergold, 2000; Peng, 2000; Peng and Babcock, 2001) is not acceptable (cf. Yang et al., 2003) and the proposed index fossils (first appearance datum (FAD) of *Treptichnus*/*Trichophycus pedum*, *Paraglo-borilus subglobosus*; FAD of trilobites) for defining the stages are problematic.

Mineralized remains of disarticulated endoskeletons and exoskeletons of mainly unknown metazoans and shells of brachiopods and molluscs are widely distributed in the Lower Cambrian of many platforms. The term "small shelly fossils" was first used by Matthews and Missarzhevsky (1975), accommodating mostly problematica, but also poriferans, molluscs, and hyoliths. Subsequently, the term found broad application for small-sized phosphatized problematica of pre-trilobitic strata of the traditional Lower Cambrian. Later, the term was often used as "small skeletal fossils", because most remains are scaffoldings, stiffened walls, or shells. However, neither Matthews and Missarzhevsky (1975) nor any later authors have given a definition for the terms "small shelly fossils" or "small skeletal fossils" (SSFs), which resulted in diverging applications of the terms. Some authors only considered problematic mineralized metazoan fossils of the Lower to Middle Cambrian and unrelated to younger Palaeozoic or modern faunas as SSFs, thus treating SSFs separately from brachiopod and mollusc shell material (Brock et al., 2000).

Sepkoski (1992) included data of "small shelly fossils" in his statistical investigation of patterns of diversification and faunal changes in the early metazoan fossil record and proposed the term "Tommotian Fauna" for orthothecimorph hyoliths, monoplacophorans, sabelliditids, and a variety of short-ranging problematica. The term remained weakly defined, because it was derived from factor analysis of diversity data, which were subjectively influenced (limited knowledge of distribution data; selection of data; uncertainties in taxonomy). In contrast to the common usage of the term "small shelly fossils", the "Tommotian Fauna" was neither strictly confined to mineralized remains (but possibly indirectly influenced by taphonomic windows promoting specific preservational modes in the fossil record and thus also influencing the data basis) nor to a stratigraphic distribution within the Cambrian. Dzik (1994) also applied the term SSFs in a broader context to various phosphatized skeletal remains of the Palaeozoic, such as macheridians, gastropods, and bivalves. Porter (2004) later tried to test the influence of the phosphatization taphonomic window on the diversity pattern of SSFs. Although she recognized a taphonomic bias on the diversity pattern of SSFs, she concluded that the decline of SSFs in the Botoman, previously recognized by Sepkoski (1992), was real. However, this analysis excluded all fossils known from younger strata, such as bradoriids, trilobites, and brachiopods, but partly preserved in a manner similar to most problematic SSFs, thus influencing the study by a preselection of investigated skeletal fossils.

It is obvious that the term "small shelly fossils" does not embrace a single biological group defined by autapomorphies, but rather represents a broad category of mineralized fossil remains of a specific taphonomic window in the latest Neoproterozoic to early Palaeozoic. The SSFs are not always shell or skeletal materials, nor are they in all cases small (mostly ranging between 0.1 and 1 mm, but sometimes reaching 1 cm or more). Here we apply the term "small shelly fossils" (SSFs) in the broadest sense, as small (mostly millimeter scale, but ranging from tens of micrometers to centimeters scale) and primarily or secondarily mineralized (phosphatized, silicified, carbonatic, pyritic/limonitic) remains (skeletal and non-skeletal) of metazoans. Following this view, the term describes a preservational mode of metazoan fossils, not a specific taxonomic group. We propose to