



Biostratinomy of bivalves from Jurassic and Early Cretaceous lakes of NE China

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Abstract

Bivalves are comparatively rare elements of the benthic faunas of Jurassic and Early Cretaceous lakes of northeastern China. In the past, *Arguniella* and *Sphaerium* have been regarded as belonging to the communities that populated the offshore areas of lake Sihetun, represented by the Lower Cretaceous Yixian Formation of western Liaoning. A detailed biostratinomic analysis of these bivalves suggests, however, that they were introduced from marginal lake habitats where they were reworked by storms and occasionally were transported in suspension offshore. Some of these bivalves were dead and settled on the lake floor as single valves or articulated but opened valves (butterfly position). Others were transported alive but died on their arrival at the bottom due to inimical conditions caused by reduced oxygen levels. A similar interpretation is given for articulated valves of *Ferganoconcha* in thinly bedded siltstones of the Jurassic Daohugou Fossil Beds of Inner Mongolia, which were also carried alive by hyperpycnal flows to their burial site where they died due to lack of oxygen.

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1. Introduction

Biostratinomy (Weigelt, 1927) is a part of taphonomy that deals with processes that act on organisms after their death until final burial (Seilacher, 1973; Kidwell and Bosence, 1991). These processes leave characteristic marks on any preservable parts (taphonomic signatures), which allow us to reconstruct some of these processes in fossils and hence to gain insight in the environment in which the organisms lived. In marine environments, bivalves are preferred object of such biostratinomic studies due to their great abundance at least since Mesozoic times (e.g., Fürsich and Oschmann, 1993; Best and Kidwell, 2000; Donato et al., 2008; Schneider-Storz et al., 2008; Fürsich et al., 2012; for a review see Kidwell and Bosence, 1991), whereas in

non-marine environments such studies are scarce (e.g., Pan et al., 2012a; Skawina, 2013; Erthal et al., 2015) and have been pursued only since the last few years.

Biostratinomic studies are also essential to evaluate the reliability of palaeoecological data and help to recognise distortion of community relicts caused by processes such as sorting and mixing. It is this latter application which is the subject of this study. Bivalves are accessory elements of the benthic macrofauna of the Early Cretaceous lakes of northeastern China and have been regarded as autochthonous elements of the benthic lake communities (Fürsich et al., 2007). In most cases only a few individuals are present in the finely laminated offshore deposits of lake Sihetun, the only lake that has been investigated in detail so far, but they contribute significantly to the diversity of the assemblages, which generally consist of less than a handful of species. Moreover, their presence suggests extended periods of oxygenation of the bottom waters, which somewhat contradicts the environmental models proposed for the lakes. These models (Fürsich et al., 2007; Hethke et al., 2013) assume

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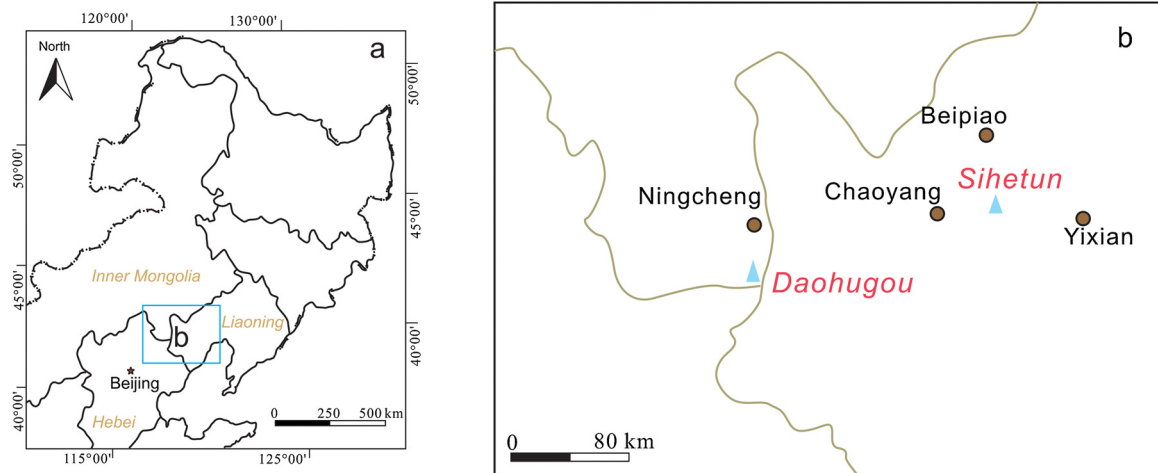


Fig. 1. Map of northeastern China (a) and localities of the Jurassic Daohugou Fossil Beds and the lower Cretaceous Yixian Formation (b) from which the bivalve material has been obtained.

meromictic (with bottom anoxia) and holomictic (with bottom dysoxia) conditions for lake Sihetun. The aim of this study is to address the question of autochthony/allochthony of the lake bivalves by investigating their taphonomic signatures. Together with the sedimentological evidence they suggest that the bivalves were transported to their present position. This view has been already expressed in a study of the diagenetic history of the lake bivalves (Fürsich and Pan, 2015) without having been elaborated in detail.

2. Material and methods

The bivalves come from two famous fossil lagerstätten in northeastern China, the Jurassic Daohugou Fossil Beds of Inner Mongolia and the Lower Cretaceous Yixian Formation of western Liaoning (Fig. 1).

Jurassic Daohugou Fossil Beds: Forty small slabs were available for study, each with a surface area between 10 and 50 cm² (NIGP160867-160905, 160937) and containing one (common) to four (rare) bivalves belonging to *Ferganoconcha sibirica* Chernyshev (Fig. 2B). The slabs come from several localities near the village of Daohugou in the easternmost part of Inner Mongolia (Fig. 1, N41°19', E119°14'). As the slabs were not recovered from sections, the up-down orientation of the slabs is unknown.

Lower Cretaceous Yixian Formation: The database consists of about 120 bivalves (NIGP160906-160964) from two excavations in the Sihetun area (Erdaogou: N41°31.942', E120°47.747'; Zhangjiagou: N41°36'13.3'', E120°49'28.7'') (Fig. 1) and from scree. In most cases, the original up-down orientation is unknown. The bivalves belong to two species, *Sphaerium anderssoni* Grabau (Fig. 2A) and *Arguniella ventricosa* Martinson (Fig. 2C).

The material was cleaned, prepared where necessary, and was observed under the binocular microscope. It has been deposited in the collections of the Nanjing Institute of Geology and Palaeontology (collection numbers NIGP160867-160905 in the case of the Jurassic specimens and NIGP160906-160964 in the

case of the Lower Cretaceous specimens). The same material was used to reconstruct the diagenetic history of the bivalves, i.e., their fate after final burial (Fürsich and Pan, 2015).

3. Geological background

3.1. Daohugou Fossil Beds

The Daohugou Fossil Beds are Jurassic lacustrine deposits occurring in the Ningcheng county of Inner Mongolia (Fig. 1). The succession consists of thick tuff beds, graded ash layers, breccias, and finely laminated mudstones and siltstones.

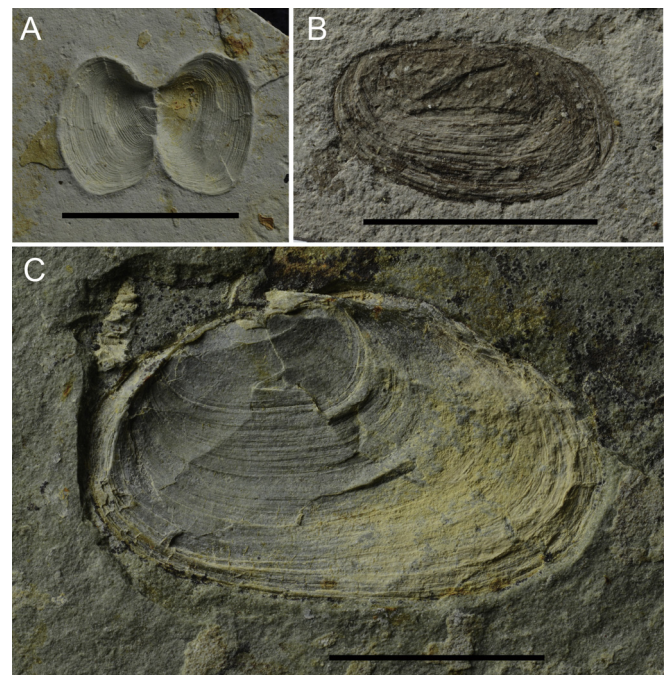


Fig. 2. (A, C) Bivalves from the Lower Cretaceous Yixian Formation at Zhangjiagou; (A) *Sphaerium anderssoni* Grabau; (C) *Arguniella ventricosa* Martinson. (B) *Ferganoconcha sibirica* Chernyshev from the Jurassic Daohugou Beds. Scale bar = 1 cm.

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