



Early Pennsylvanian conodonts from the Luokun section of Luodian, Guizhou, South China

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Abstract

An abundant and taxonomically diverse conodont association was recovered from the Bashkirian strata at the Luokun section, southern Guizhou, South China. Forty-six species and subspecies, which belong to 10 genera, were identified. Seven conodont zones were recognized. They are, in ascending order, the *Declinognathodus noduliferus*, *Idiognathoides sulcatus sulcatus*, *Idiognathoides sinuatus*, *Idiognathoides sulcatus parvus*, “*Streptognathodus*” *expansus* M1, “*Streptognathodus*” *expansus* M2, and *Diplognathodus* cf. *ellesmerensis* zones. The base of the Bashkirian in the Luokun section is identified by the first occurrence of *Declinognathodus noduliferus*. *Declinognathodus praenoduliferus* and *D.* cf. *bernesgae* occur in the underlying beds. The base of the Moscovian can be recognized by the first occurrence of *Diplognathodus* cf. *ellesmerensis*, which is one of the most significant markers for the Bashkirian–Moscovian boundary in China. The conodont zonation is compared with that of the Naqing section nearby, as well as with that of the contemporaneous deposits of the South Urals, Donets Basin, North America and other areas. © 2016 Elsevier B.V. and Nanjing Institute of Geology and Palaeontology, CAS. All rights reserved.

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1. Introduction

The Bashkirian Stage was established by Semikhatova (1934) in the Bashkiria Mountains, South Urals, Russia, but no specific type section was chosen as a stratotype. Later, Semikhatova (1941) described the type locality of the Bashkirian Stage and designated a section on the left side of River Yuryuzan, which was regarded as the stratotype. Since then, several sections that are stratigraphically more complete and have more detailed palaeontology data have been proposed to be a new stratotype for the Bashkirian Stage. One of the best exposed and studied sections, the Askyn section in Bashkirian type area, was chosen as

the hypostratotype for the stage (Sinitsyna, 1975; Semikhatova et al., 1978).

The Bashkirian Stage is characterized by conodonts, foraminifers, brachiopods, corals, and other fossils in its type area. Conodonts have the greatest potential for correlation of Bashkirian strata around the world. Bashkirian conodonts have been well studied in the Donets Basin, Ukraine (Nemyrovska, 1999), the Askyn section, South Urals (Nemirovskaya and Alekseev, 1994), the Naqing section, South China (Wang et al., 1987a, 1987b; Wang and Higgins, 1989; Wang and Qi, 2002a, 2002b, 2003a; Qi et al., 2011), and USA (Baesemann and Lane, 1985; Barrick et al., 2004, 2013). Many Bashkirian conodont species have been reported from Western Europe, Japan, and North China (e.g., Koike, 1967; Higgins, 1975; Wang and Qi, 2003b).

After the Mid-Carboniferous extinction event (Nemirovskaya and Nigmadganov, 1994), conodonts rapidly diversified into new groups during the early Pennsylvanian.

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At the Mid-Carboniferous event, *Lochriea*, *Gnathodus*, and other genera that characterized the late Mississippian strata disappeared, and *Declinognathodus* and *Idiognathoides*, which dominated the early Pennsylvanian strata, appeared. During the Bashkirian stage all of the Pennsylvanian and Early Permian genera originated (Nemyrovskaya, 1999), such as *Neognathodus*, *Idiognathodus*, and “*Streptognathodus*”.

The GSSP (Global Stratotype Section and Point) of Bashkirian Stage and the lower Pennsylvanian Series was placed in the lower Bird Spring Formation at Arrow Canyon, Nevada, USA (Lane et al., 1999). The First Appearance Datum (FAD) of *Declinognathodus noduliferus sensu lato* indicates the beginning of the Bashkirian. *Idiognathoides* appeared later and prevailed into the early Moscovian. In general, *Neognathodus* arose after the entry of *Idiognathoides*, but in some regions of North America, *Neognathodus* appeared just after *Declinognathodus* (Grayson et al., 1985). *Neognathodus* survived into the late Moscovian and played a significant role in biostratigraphic zonation in North America during the Morrowan–Desmoinesian age (Baesemann and Lane, 1985). *Idiognathodus*, one of the most diverse genera in Pennsylvanian period, appeared near the middle of the Bashkirian. “*Streptognathodus*” (e.g., “*S.*” *expansus*) occurred later. Although the FAD of *Diplognathodus* was reported from the Visean strata (von Bitter and Plint-Geberl, 1982), its increase in diversity probably started during the late Bashkirian, and it subsequently gave rise to *Sweetognathus* in the Early Permian.

Deep-water Bashkirian conodonts have been studied in Spain, Middle Asia, and South China (e.g., Nigmatganov and Nemirovskaya, 1992; Wang and Qi, 2003a; Sanz-López et al., 2013), but the successions in the former two regions are not complete. Previous studies on the Bashkirian conodonts in the Naqing section, South China (Wang et al., 1987a, 1987b, 2004, 2008; Wang and Higgins, 1989; Wang and Qi, 2002a, 2002b, 2003a; Qi et al., 2011) were based on old collections that are now out of date to some degree. The Luokun section was originally selected as a reference section for correlation of the deep-water Naqing section, together with other shallow-water ones that contain both conodonts and fusulinids. A preliminary conodont range chart of the Luokun section was published by Qi et al. (2010). Later, the biostratigraphy of the Bashkirian–Moscovian boundary interval based on the fusulinid and conodont data was discussed (Ma et al., 2013). Recently, more samples were collected from the Bashkirian–Moscovian boundary interval from the Luokun section in order to determine the precise position of the boundary. This study provides us a new understanding of another deep-water Bashkirian conodont succession in South China. This paper focuses on conodont biostratigraphy of the uppermost Serpukhovian through the lowermost Moscovian strata of the Luokun section, and the position of the global Bashkirian–Moscovian boundary.

2. Geological settings and the study section

The Carboniferous deposits, mainly carbonate rocks, are widespread in the Guizhou Province, South China. Based on lithostratigraphy, fossils, and lithofacies, the Carboniferous

of Guizhou Province can be subdivided into three subareas: (1) Dushan-Weining subarea, (2) Pu’an-Mawei subarea, (3) Langdai-Luodian subarea. The Luokun and Naqing sections are both located in the Langdai-Luodian subarea, which is also called the “Black area” due to its dark carbonate and siliceous rock succession (Bureau of Geology and Mineral Resources of Guizhou Province, 1987).

The study area was located in the Dian-Qian Basin of the early Mississippian. The basin was influenced by NE- and NW-trending faults (Wang et al., 1994), and several transgressions from the northeast occurred during the middle to late Mississippian. Three isolated intraplateau basins formed during the early Bashkirian, i.e., the Luodian Basin, the Baise Basin, and the Tiandeng Basin (Fig. 1B), where numerous Carboniferous carbonate successions crop out. One of the best-exposed sections is the Naqing section, which is the candidate for the four unrati-fied GSSPs of Carboniferous. The Luokun section in this paper is about 10 km ENE of the Naqing section.

The Luokun section (25°18′29″N, 106°34′10″E) is a road-cut section located near the village of Dongshang, Luokun County, close to the Luodian-Wangmo highway (S312), and about 27.6 km SW of Luodian County (Fig. 1C). This section consists of platform margin to upper-slope facies, which are well exposed along the southern limb of the Chuangjing Vault Anticline within the NW Wangmo deformation zone. Carbonate rocks, 207 m thick, with a NNE strike and 60–70° dip, span the interval from the upper Visean through the upper Moscovian. The lower part of this section (–1 to 96 m) is composed mainly of gray thin- to medium-bedded siliceous banded packstone, intercalated with gray thick-bedded grainstone. The upper part (96 to 206 m) is composed mainly of grayish medium- to thick-bedded siliceous banded packstone and grainstone, intercalated with rare dark gray siliceous rocks. Conodonts are abundant throughout the section, whereas fusulinids are mostly concentrated in the upper part.

Each meter of the section was marked by an aluminum pin. The studied interval includes the uppermost Serpukhovian through the lowermost Moscovian succession from 96.3 m to 133.2 m above the base of the section. Previously, the Bashkirian–Moscovian boundary in Luokun section was tentatively placed as the FAD of “*Streptognathodus*” *expansus* Igo and Koike, 1964 at 116.8 m whereas the fusulinids species *Profusulinella* (= *Aljutovella*) *aljutovica* (Rauser-Chernousova, 1938), which is the traditional marker for the basal Moscovian in its type area, occurs at 121.9 m in the Luokun section (Ma et al., 2013).

3. Conodont biostratigraphy and correlation

The portion of the Luokun section studied here is composed of typical platform margin to upper-slope deposits that contain abundant conodonts, fusulinids, and a few brachiopods and crinoids. Fifty-eight conodont samples, each weighing about 4 to 8 kg, were collected from the 96.3 m to 132.2 m interval in the Luokun section (Table 1). Numerous (6313) platform (P₁) and a few P₂ and ramiform conodont elements were extracted from these samples. Only P₁ elements were examined and listed in

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