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Biostratigraphy and biofacies of the Middle Darriwilian (Ordovician) conodonts from the Laoshidan section in the western margin of the North China Craton

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ABSTRACT

Middle Ordovician conodonts from the Sandaokan and Zhuozishan formations of the Laoshidan section at the western margin of the North China Craton, consist of 39 identified and six indeterminate species belonging to 21 genera, and three taxa left in open nomenclature at both genus and species levels. Of particular biostratigraphic importance is the presence of morphologically advanced species of *Histiodella* associated with several age-diagnostic endemic taxa, making it possible to recognize international conodont biozones in the main part of the sequence. Three *Histiodella*-based zones are recognized in the studied section; including the *Histiodella* cf. *holodentata*, *Histiodella kristinae* and *Histiodella bellburnensis* zones, in ascending order. They can be directly correlated with the conodont zonations established in western Newfoundland, Canada and Tarim, western China, and compared well with the conodont biozones of Baltoscandia and Yangtze, central China. However, the same stratigraphic interval on the North China Platform is barren of conodonts. Multivariate statistical studies on these conodonts allow recognition of four conodont biofacies: *Scalpellodus* biofacies, *Panderodus* biofacies, *Drepanoistodus* biofacies and *Phragmodus* biofacies. Turnovers of the conodont biofacies are related to either sea-level changes or mixing of shallow water conodonts due to down slope transportation. Excluding the effect of the allochthonous conodonts, the transgressive-regressive patterns demonstrated by the conodont biofacies compare closely to the published sea-level curves for the western margin of the North China Craton.

1. Introduction

Ordovician strata are extensively distributed along the western margin of the North China Craton. These carbonate and clastic sediments are biostratigraphically important because of the richness of their macrofossils and microfossils, which have been successively studied since the 1950s (e.g., Lu, 1954; Mu, 1959; Zhang, 1959; Zhang, 1962; Chen, 1976; Wang and Luo, 1984; An and Zheng, 1990; Finney et al., 1999; Wang et al., 2013a; Jing et al., in press). Therefore, within the carbonate successions of Ordovician sequences, conodonts are one of the most useful fossil groups for biostratigraphy and age dating.

New conodont collections from the carbonate-dominant Sandaokan and Zhuozishan formations of the Laoshidan section provide significant new information on genera and species occurrences and ranges, and necessitate revisions of and additions to the biostratigraphic data provided previously by Chen et al. (1984, Table 3); Wang and Luo (1984, p. 242–247) and An and Zheng (1990, p. 28–33). Moreover, these collections supply excellent material for detailed description of the conodont paleoecology of the mid-Ordovician in North China. This paper presents descriptions of the mid-Darriwilian conodont sequence and biofacies, with the aims of revising the fauna to provide support for a more precise biostratigraphic correlation, and examining the relationship between the turnovers of conodont biofacies and sea-level changes.

2. Geological setting

The tectonic framework of China includes three major continental-scale cratonic masses: the North China Craton, the South China block, and the Tarim block (Fig. 1A). The North China Craton is bounded in the north by the Central Asian Orogenic Belt, in the west by the western Tethyan subdomain, in the south by the Qinling–Tongbai–Hong'an–Dabie–Sulu orogenic belt, and in the east by the Pacific subduction zone (Fig. 1A; also see Zheng et al., 2013). The North China Craton is one of the major Archean cratons in the world, and it comprises most of North China and parts of the Korean Peninsula (Fig.1B; also see Zhu et al., 2012). The North China Craton experienced a long and complicated geological history, stabilizing during the Paleoproterozoic and

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subsequently overlain by a thick succession of Neoproterozoic to Paleozoic sedimentary deposits (Zhao and Zhai, 2013; Zheng et al., 2013).

The North China Craton was largely confined to the tropical zone near the equator during the Ordovician period (Zhen et al., 2015). However, its paleogeographic position is still a controversial issue, that was interpreted as a peri-Gondwanan terrane located along the northeast Gondwana margin and fringed by subduction–accretion complexes and island arcs (Metcalfe, 1996, 1998; De Jong et al., 2006; Metcalfe, 2006) or as a part of eastern Gondwana until it was separated at the end of the Ordovician (Cho et al., 2014). Ordovician rocks on the North China Craton can be subdivided into two major depositional settings, i.e., the broad North China Platform and the narrow western slope to southwestern marginal platform (Yang et al., 2005; Cao et al., 2011; Feng et al., 2014; Zhen et al., 2015). The North China Platform, covered by a vast epicontinental sea, was the site of shallow water carbonate-dominated deposition with Ordovician successions attaining 500–1000 m in thickness. Along the western to southwestern margin of the North China Craton even thicker accumulations (up to 2600 m) of mixed carbonates and siliciclastics were deposited in slope to marginal platform environments.

Our study site is located in the northern part of the Helan Aulacogen (Fig. 1B), which was connected to the western margin of the North China Craton. The Helan Aulacogen, ~300 km in NNE trend, formed as a failed rift relative to the Qinling and Qilian rifts during the Mesoproterozoic. Regional uplift during the Neoproterozoic resulted in formation of an unconformity, and subsidence during the earliest Paleozoic led to deposition of Cambrian and Ordovician strata in shallow-marine to deep slope settings (Lin et al., 1991). The Helan Aulacogen eventually closed in the Late Ordovician, and the subsequent uplift associated with the Huaiyuan Epeirogeny II (lasting from the latest Ordovician to the latest

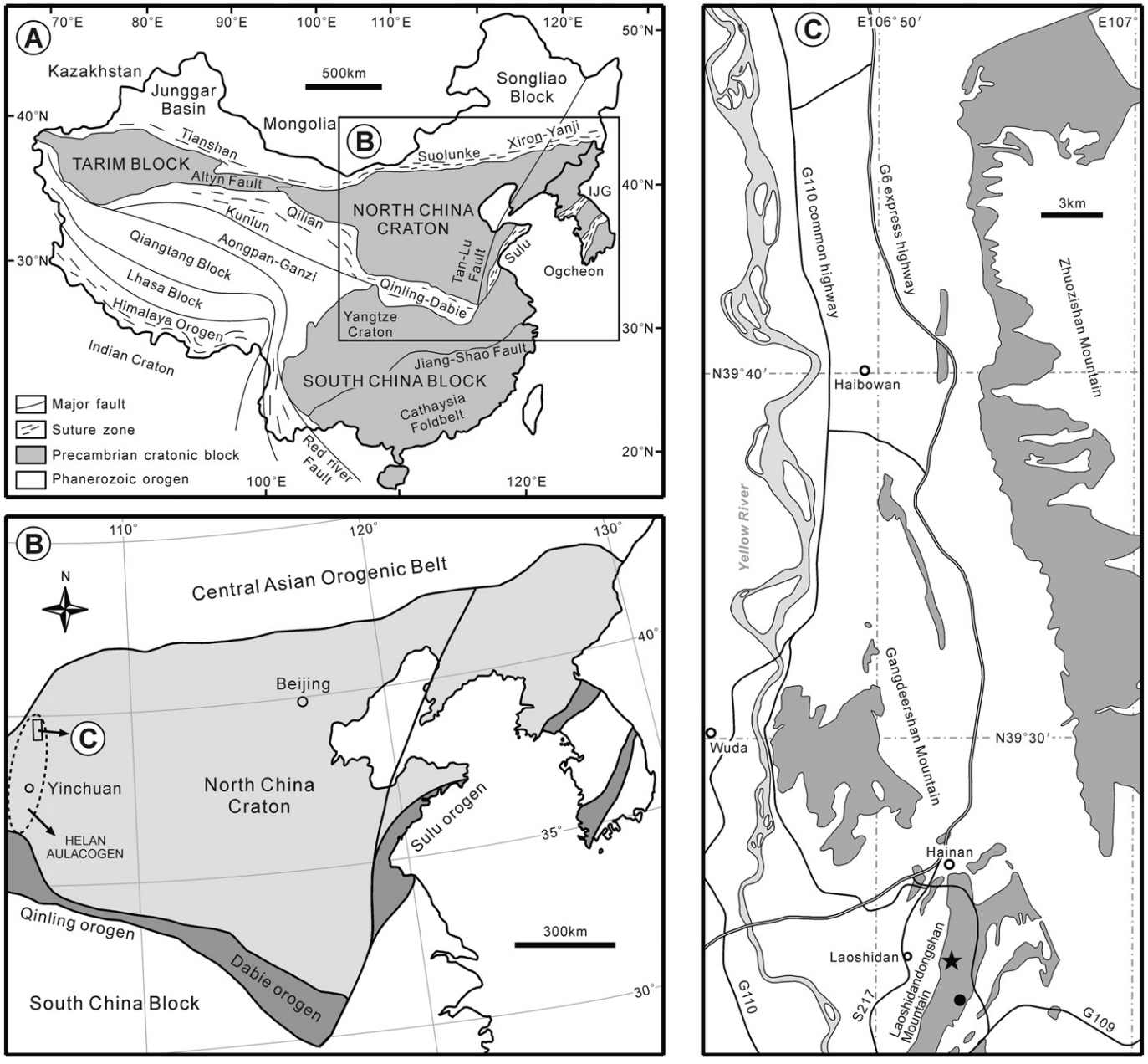

Fig. 1. (A) Simplified tectonic map of China showing major cratonic blocks and orogenic belts (from Zheng et al., 2013). (B) Map of North China Craton showing major tectonic stratigraphic framework of the Ordovician (modified after Zhu et al., 2012), and the location of the field area in the western Inner Mongolia region. The dashed ellipse indicates the approximate scope of the Helan Aulacogen. (C) Close-up map showing location of the successive two sections in the vicinity of the town of Laoshidan. Black star indicates the locality of the Laoshidan section, black dot shows the locality of the Wolonggang section. Gray areas indicate Ordovician outcrop exposures.