

Cretaceous saurischian tracksites from southwest Sichuan Province and overview of Late Cretaceous dinosaur track assemblages of China



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ABSTRACT

Dinosaur tracks from Upper Cretaceous deposits of Sichuan Province, China have proved of great significance for two reasons: they (1) provide unambiguous evidence of dinosaurs from this epoch in this region, and (2) demonstrate that the track bearing units of the Leidashu Formation are not Paleocene-Eocene in age as previously claimed by some authors. We herein describe five small sites, from the Zhaojue area and the nearby Xide areas. Two sites are dominated by theropod tracks, including one with small tracks of *Eubrontes*-like morphology, and another with deep tracks revealing long metatarsal impressions, probably indicating a soft substrate. Three sites yield only sauropod tracks. Combined data from these five tracksites document a typical saurischian dominated ichnofauna, and based on present evidence these assemblages are less diverse than those from Lower Cretaceous sites in the region. However a larger sample is necessary to test this suggestion.

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1. Introduction

Early Cretaceous vertebrate skeletal fossils from the Sichuan area (including Sichuan Basin and Panxi region) are limited to very scarce theropod and sauropod fragments (Wang et al., 2008), which currently lack scientific description. By comparison, the Early Cretaceous vertebrate track record of the Sichuan area is rich and diverse, comprising at least 15 mostly-documented sites. Since 2007, the main authors of this paper have found and documented a growing number of Early Cretaceous vertebrate tracksites in the Sichuan area including non-avian theropod, bird, sauropod, ornithopod and pterosaur tracks (Xing et al., 2007, 2013a, 2014a, 2015; Xing and Lockley, 2014). Therefore, the reconstruction of the Early Cretaceous dinosaur fauna of the Sichuan area is largely based on the track record. In contrast, the composition of the Late Cretaceous dinosaur fauna of Sichuan is almost obscure. Both the

Late Cretaceous skeletal and track records have been sparse in the Sichuan area and were limited to the Zhengyang Basin at the eastern margin. The Upper Cretaceous Zhengyang Formation has yielded teeth of theropods, titanosaurs and hadrosaurs (Wang et al., 2008), but these have never been formally described.

In 2014, a regional geological survey team from the Sichuan Bureau of Geological Exploration and Development of Mineral Resources discovered two groups of new tracksites in the Zhaojue area and the nearby Xide area, in Sichuan Province (Fig. 1). Both localities include tracksites in Lower and Upper Cretaceous strata. The Late Cretaceous tracks provide the first solid dinosaur record from this time interval in the Sichuan area.

1.1. Institutional abbreviations

CGCMS = Compiling Group of Continental Mesozoic Stratigraphy and Palaeontology in Sichuan Basin of China; JBSI = Jierboshi I tracksite, Zhaojue County, Liangshan, China; JBSII = Jierboshi II tracksite, Zhaojue County, Liangshan, China; SBGED = Sichuan

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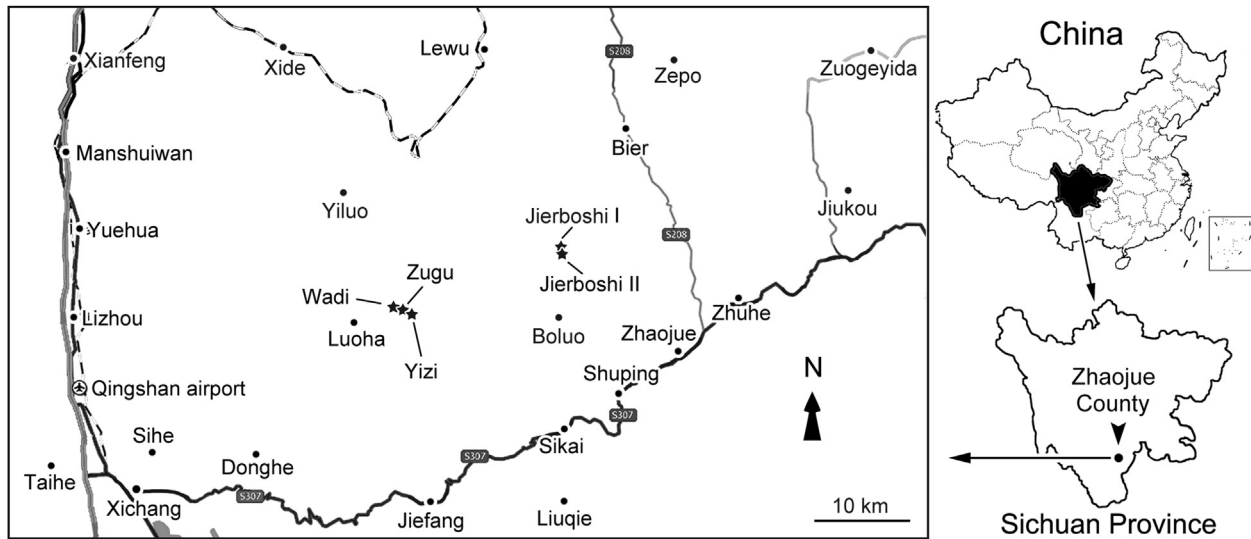


Fig. 1. Geographic map showing the location (star icon) of the dinosaur tracksites in the Zhaojue-Xide area, Sichuan Province, China.

Bureau of Geological Exploration and Development of Mineral Resources; SBGMR = Sichuan Bureau of Geology and Mineral Resources; WD = Wadi tracksite, Xide County, Liangshan, China; YZ = Yizi tracksite, Xide County, Liangshan, China; ZG = Zugu tracksite, Xide County, Liangshan, China.

2. Geological setting

The Southwestern area of Sichuan Province, consisting of the Liangshan autonomous prefecture and Panzhihua city, is commonly known as the Panxi (Panzhihua–Xichang) region. Within the Panxi region, the Cretaceous strata are widely distributed. The largest basin in this area is the Mishi (Xichang)–Jiangzhou Basin (Luo, 1999). Based on biostratigraphic indices (ostracod, and plants/stoneworts), the Cretaceous strata in the Mishi-Jiangzhou Basin have been divided into the Lower Cretaceous Feitianshan and Xiaoba formations, and the Upper Cretaceous-Paleogene Leidashu Formation (Gu and Liu, 1997; SBGED, 2014; but see re-evaluation below). The Xiaoba Formation is in conformable contact with the Feitianshan Formation below and the Leidashu Formation above.

In the Zhaojue-Xide region, the Xiaoba Formation is divided into three members (Fig. 2). The First Member is 1315 m thick. The lower layers mainly consist of medium and fine purplish red sandstone that is occasionally interbedded with mudstone and argillaceous siltstone; upper layers mainly consist of purplish red thin and medium bedded siltstone and silty mudstone. Planar bedding is typical. The Second Member is 573.7 m thick. Its lower layers are formed by dark purple mudstone, argillaceous siltstone and mudstone interbedded with greyish-green marlstone. Convolute bedding and planar bedding, respectively, are developed within the siltstone and argillaceous siltstone units. The middle layers consist of mudstone, argillaceous siltstone, silty mudstone interbedded with argillaceous siltstone and fine sandstone interbedded with thin siltstone layers. The upper layers mainly consist of dark purple mudstone, purplish red thick bedded-massive fine sandstone and pebbly sandstone. The Third Member is 545.8 m thick. Its lower layers are comprised of purplish red thick-bedded fine sandstone and medium-bedded fine sandstone interbedded with mudstone in unequal thickness. The middle layers are mainly formed by mudstone and argillaceous siltstone interbedded with mudstone in

unequal thickness. The upper layers are comprised of purplish red medium-thick bedded coarse sandstone interbedded with mudstone, medium-thick bedded siltstone interbedded with mudstone, and gravel developed along the surface. The gravel is mainly formed by mudstone.

Based on its lithostratigraphic zone, the Xiaoba Formation has been referred to the “mid-” or Upper Cretaceous (SBGMR, 1991). The sedimentary depositional environments were alluvial-fan, fluvial river and lacustrine systems (Chang et al., 1990). The First Member of the Xiaoba Formation matches the Jiaguan Formation from the Sichuan Basin based on the lithostratigraphic correlation (CG CMS, 1982).

In the Zhaojue-Xide region, the Upper Cretaceous-Paleogene Leidashu Formation is divided into two Members. The First Member is 643.5 m thick, with a set of purplish red pebbly sandstone at the bottom; lower layers that are purplish red medium-thick bedded feldspathic quartzose sandstone with parallel beddings developed inside; and upper layers with smaller granularity consists of thin-medium bedded sandstone and siltstone interbedded with mudstone. The Second Member is 285.8 m thick and lithologically characterized by purplish red thin-medium siltstone and mudstone with cross bedding and argillaceous siltstone with parallel bedding.

The sedimentary depositional environment of the Leidashu Formation was a lacustrine system (Yao et al., 2002). Some authors have referred the Leidashu Formation to the Paleocene-Eocene based on its lithostratigraphic zone (SBGMR, 1991; Zhang, 2009). However, this conclusion is clearly erroneous based on the presence of a dinosaur fossil track record (see below).

3. Distribution of dinosaur tracks

- (1). The Jierboshi I tracksite (GPS: 28° 6'55.13"N, 102°42'38.52"E) (WGS84 Datum) of Jierboshi Village, Zhaojue County, Liangshan, China, is an exposed calcareous siltstone surface from the First Member of the Xiaoba Formation. Highly developed ripple marks are readily observed. Tracks include those of theropods and possibly saurpods.
- (2). Jierboshi II tracksite (GPS: 28° 6'51.04"N, 102°42'38.90"E) of Jierboshi Village, Zhaojue County, Liangshan, China, is an exposed purplish red sandstone surface from the First

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