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Theropod tracks from the Lower Jurassic of Gulin area, Sichuan Province, China

Li-Da Xing [a], Martin G. Lockley [b], Jian-Ping Zhang [a], Hendrik Klein [c], Susanna B. Kümmell [d], W. Scott Persons IV [e], Hong-Wei Kuang [f,*]

[a] *School of the Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China*
[b] *Dinosaur Trackers Research Group, CB 172, University of Colorado Denver, PO Box 173364, Denver, CO 80217-3364, USA*
[c] *Saurierwelt Paläontologisches Museum, Neumarkt D-92318, Germany*
[d] *Department of Biological Sciences, University of Alberta, 11455 Saskatchewan Drive, Edmonton, Alberta T6G 2E9, Canada*
[e] *Institute of Evolutionary Biology, University Witten/Herdecke, Stockumerstr. 10-12, 58454 Witten, Germany*
[f] *Institute of Geology, Chinese Academy of Geological Sciences, No.26 Baiwanzhuang Road, Beijing 100037, China*

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Abstract

The Jiaoyuan tracksite in the Gulin area of Sichuan Province, China represents a typical saurischian-dominated assemblage with trackways of theropods and sauropods. They occur in the Lower Jurassic Da'anzhai Member of the Ziliujing Formation, a sandstone-siltstone succession of fluvial origin and deposited in the southern Sichuan Basin. Four trackways as well as isolated tracks of theropods are documented and analyzed in this first part a study of sauropod tracks will follow elsewhere. Two morphotypes and size-classes, respectively, can be observed. The larger one is 25–34 cm in length and shows weak to moderate mesaxony. The smaller is 7–15 cm in length and moderately mesaxonic. Despite a few similarities with the ichnogenus *Kayentapus*, the former is assigned here to *Eubrontes*, well known from Lower Jurassic assemblages, in North America, Europe, and southern Africa. The smaller morphotype resembles typical *Grallator* tracks except in its wider digit divarication and the metatarsophalangeal pad IV being positioned in line with the long-axis of digit III, similar to *Jialingpus* described, for example, from Upper Jurassic deposits of Sichuan. A relatively wide digit divarication in *Grallator*-type tracks is apparently common in Jurassic assemblages of China and may represent a distinct feature related to provinciality of theropod faunas in this region.

Keywords: Sichuan Basin; Lower Jurassic; Ziliujing Formation; Theropod tracks; *Eubrontes*; *Grallator*

1. Introduction

Fossil tracks from the Early Jurassic of China, much like skeletal material, are rare. The Early Jurassic track record includes those from Jinning (Yunnan Province) (Zhen et al., 1986; Lockley et al., 2013), Zigong (Xing et al., 2014a), Weiyuan (Xing et al., 2014b), Lufeng (Yunnan Province) (Xing et al., 2009a), and Wusu (Xinjiang Province) (Xing et al., 2014c). Zhen et al. (1986) named four ichnogenera from the Lower Jurassic Fengjiahe Formation of Jinning, Yunnan Province: *Paracoelurosaurichnus monax*, *Schizograllator xiaohebaensis*, *Youngichnus xiyangansis*, and *Zhenichnus jinningensis*. In addition, Zhen et al. (1986) recognized the new ichnospecies *Grallator limnosus*, and the previously known ichnospecies *Eubrontes platypus* (Lull, 1904). Lockley et al. (2013) reviewed these ichnogenera, and referred them to the *Grallator-Eubrontes-Kayentapus* plexus: i.e., to well-known and ubiquitous ichnogenera. Early Jurassic tracks from the Zizhong sites were assigned to a *Grallator-Eubrontes/Changpeipus-Kayentapus* plexus (Lockley et al., 2013; Xing et al., 2014d). These ichnofaunal assemblages are consistent with what appears to have been the near global

* Corresponding author. Tel.: +86 10 68998618.
E-mail address: kuanghw@126.com (H.W. Kuang).

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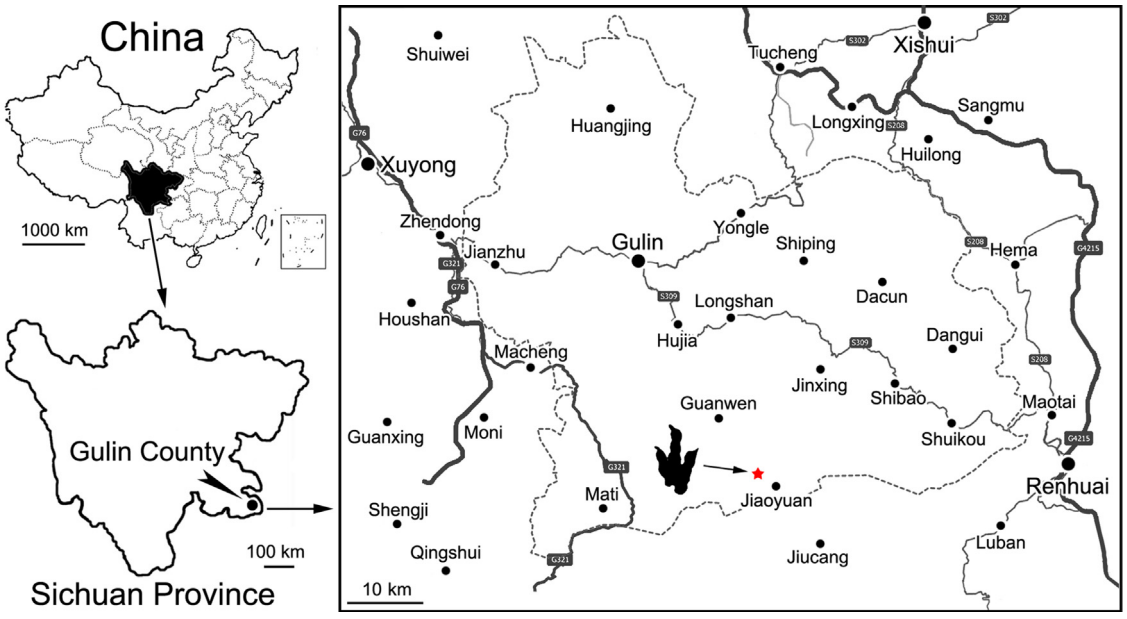

Fig. 1. Geographical setting showing the location (footprint icon) of the Jiaoyuan dinosaur tracksite in Gulin County, Sichuan Province, China.

distribution of *Grallator*- and *Eubrontes*-dominated Early Jurassic ichnofaunas (Olsen and Galton, 1984; Lucas, 2007; Lockley et al., 2011).

In May, 2009, Yi-Guang Chen and Jian-Ming Tang, engineers of the No. 113 Geological Team, Sichuan Bureau of Geology and Mineral Resources, discovered Early Jurassic sauropodomorph trackways at Heping brickfield, Jiaoyuan Township, Gulin County (Fig. 1). Unfortunately, due to the steep cliff (~70° dip), the ensuing expedition was unable to reach the fossils. During 2010–2014, the senior author of this paper worked at the site on six occasions. Other authors (MGL and SBK) also participated in field work. Two experienced climbers from the Sichuan Mountaineering Association were employed to set ropes and assist with gaining access to the site. This paper elaborates on a very preliminary note on the site by Xing (2010). Theropod and sauropodomorph tracks (Liujianpus shunan, Xing et al., in press) were discovered, including at least 10 parallel sauropodomorph trackways with bimodal distribution. Here we describe the theropod tracks, whereas the sauropodomorph trackways will be described in detail elsewhere.

Institutional and other abbreviations

JY = Jiaoyuan tracksite, Gulin County, Sichuan, China; T = theropod; L/R = left/right; I = isolated; UCM = University of Colorado Museum.

2. Geological setting

The Gulin County is situated at the southern border of the Sichuan Basin, in the northern portion of the Yunnan-Guizhou Plateau. The Jiaoyuan tracksite (24°02′32.78″N, 105°48′53.05″E) is part of the Lower Jurassic Da'anzhai Member of the Ziliujing Formation. From base to top, the Ziliujing Formation is divided into the Dongyuemiao, Ma'anshan and Da'anzhai members (Gu et al., 1997). The Ziliujing Formation lies on top of the Lower Jurassic Zhenzhuchong Formation and is overlain by the Middle Jurassic Xintiangou Formation. The Da'anzhai Member and the lower part of the Xintiangou Formation meet at a conformable contact.

The Early Jurassic age of the Da'anzhai Member is based on the presence of characteristic invertebrate and vertebrate body fossils including bivalves and the sauropodomorph dinosaur *Lufengosaurus* (Cai and Liu, 1978; Dong et al., 1983; Dong, 1984).

Lithologically the Da'anzhai Member comprises carbonatic and siliciclastic successions. The main Jiaoyuan tracksite occurs as part of a sequence dominated by friable siltstones with a few resistant sandstones (Figs. 2, 3), in which a minimum of eight track-bearing levels have been identified. Each of these layers also bears developed ripple marks and desiccation cracks.

The depositional environment can be characterized as lacustrine freshwater with fluctuating water levels and occasional drying up along the margin as indicated by the mud cracks. A detailed sequence stratigraphic succession of the Da'anzhai Member of the Ziliujing Formation was documented by Zheng (1998).

3. Methods and materials

Four theropod trackways (JYT1–JYT4) are present. These include 7, 4, 3 and 3 continuous footprints, respectively (Figs. 4–8). Furthermore four separate isolated tracks (JYTI-1–4) occur on the main surface. A replica of the best preserved one is housed in the UCM collections and catalogued as UCM 178.20.

Maximum length (ML), maximum width (MW), divarication angle (II–IV), pace length (PL), stride length (SL), and pace angulation (PA) were measured according to the standard procedures of Leonardi (1987) and Lockley and Hunt (1995).