

·快 报·

First record of dinosaur trackway from Tibet, China

中国西藏恐龙足迹的首次记录

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Abstract: Three sauropod trackways comprise eight tracks that resemble Brontopodus tracks have been found at the Morong track site in Changdu Prefecture, Tibet, China. These wide- (or sub-wide)-gauge tracks suggest that there was a large sauropod, possibly a member of Titanosauriformes, in Changdu Prefecture during the Early–Middle Jurassic. The sauropod fauna from Changdu Prefecture, Tibet not only has elements in common with the sauropod fauna from the Sichuan Basin, but may include more diverse faunal components.

Key words: Early–Middle Jurassic; sauropod trackways; Titanosauriformes; Brontopodus; Changdu Prefecture, Tibet

摘要: 记述了中国西藏昌都地区莫荣化石点的三道蜥脚类恐龙行迹, 共 8 个足迹, 这些足迹被归入雷龙足迹 (Brontopodus)。这些具有宽或亚宽的行迹表明, 早—中侏罗世的昌都地区可能生活有大型的巨龙形类。该发现还表明, 西藏昌都地区的蜥脚类恐龙动物群不仅具有与四川盆地蜥脚类动物群相同的要素, 还可能具有更多多样化的动物区系成分。

关键词: 早—中侏罗世; 蜥脚类足迹; 巨龙形类; 雷龙足迹; 西藏昌都地区

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1 Introduction

Tibet, the roof of the world, is the highest region on Earth, with an average elevation of 4900 m (16000 ft). The Tibetan Scientific Expedition Team of Chinese Academy of Sciences discovered a large quantity of Early and Middle Jurassic dinosaur fossils in Chang

du (Qamdo) Prefecture in the 1970s (Zhao X-J unpublished data), but these specimens have never been published. Among the Early Jurassic fossils reported were *Lufengsaurus* sp., *Scelidosaurus* sp., and two *nomina nuda*: *Damalasaurus magnus* and *Megalosaurus tibetensis*. Aside from another report of *Megalosaurus*, all the reported Middle Jurassic di-

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nosaurus are *nomina nuda*: *Microdontosaurus dayensis*, *Lanchangjiangosaurus cachuensis*, *Ngexisaurus dapukaensis* and *Changdusaurus*(or *Changtusaurus*) *laminaplacodus*. Subsequently, Late Jurassic dinosaur fossils were also reported^[1-2].

Changdu Prefecture is in the eastern part of the Tibet Autonomous Region. In the beginning of 1999, construction workers discovered a several large footprints while constructing the No. 214 state highway to connect the Bangda Airport and Changdu County. Local Tibetans declared that the road construction crew scared away the Shan Shen (the “Deity of the Mountains”). The alarmed Shan Shen escaped from the mountains, leaving the footprints. Some Tibetans believed the footprints were left by warrior King Gesar (the subject of a Tibetan epic poem). These footprints, which were made by sauropod dinosaurs, have now become a tourist attraction.

In 2000, 2003, and 2010, the senior author was invited by the Changdu Prefecture Cultural Relics Bureau to study the dinosaur tracks from exposures in this area.

2 Institutional abbreviations

Changdu Prefecture Cultural Relics Bureau = CPCRb; MRF=Morong Field

3 Geological setting

The tracks were discovered in Morong Village, Aixi Township, Changdu County, Changdu Prefecture, Tibet Autonomous Region(GPS 31°1'15"N, 97°17'32"E)(Fig. 1). The Morong track site is about 20 km from the Changdu County at an elevation of 3214 m above sea level.

Hao^[3] divided the strata of Changdu Prefecture into the Chaya Group and the Xiangdui Group. The Chaya Group comprises, in stratigraphic order, the Daye Formation(Lower Jurassic) and the Dabuka Formation (Middle Jurassic). The Xiangdui Group comprises the Kenzuoga Formation (Upper Jurassic), Lao-ran Formation (“mid” Cretaceous), and Zonggu Formation (Upper Cretaceous)^[2, 4]. However, these for-

mation names have not received wide acceptance or use.

The Chaya Group is composed mainly of terrestrial deposits, but also includes interfingering marine strata in the west^[3]. Purple-red mudstones with mottled colors are common. The Chaya Group represents an island arc-inner arc basin zone^[5]. Mud cracks and ripple marks are found alongside the sauropod trackways from the purple-red mudstones of the Dabuka Formation at the Morong track site.

4 Systematic ichnology

Material: Eight natural molds of manus-pes pairs, cataloged as MRFa1-4, b1-2 and c1-2, from the Morong track site (Fig.2). Within the manus-pes print pairs, the manus prints are denoted with an “m” and pes prints with a “p” after the specimen number (e.g., MRFa1m and MRFa1p). Artificial molds of MRFa2 and a3 are stored at the Changdu Prefecture Cultural Relics Bureau; they currently lack specimen numbers. The original tracks remain in the field.

Type locality and horizon: Chaya Group, Lower-Middle Jurassic. Morong track site, Changdu County, Tibet, China.

Description: When they were first discovered in 1999, the Morong sauropod tracks were well pre-



Fig. 1 Geographic map of the dinosaur footprint locality (indicated by the footprint icon)

served, but over the subsequent years of exposure, they have weathered substantially. The Morong sauropod tracks are located on the surface of a cliff face almost perpendicular to the ground surface. At least three trackways were exposed: MRFa1–3 (trackway 1) (Fig. 3, Table 1), MRFb1–2 (trackway 2), and MRFc1–2 (trackway 3). A fourth footprint (MRFa4) in trackway 1 consists only of an isolated manus print.

As in other sauropod tracks, the pes impressions angle outward with respect to the trackway axis. The manus impressions lie slightly craniomedial to the pes impressions. The morphologies of these tracks can be discussed via either or both their internal and external diameters: the internal diameter consists of the track *sensu stricto*, while the external diameter demarcates concentric mud rings around the track. The internal length:width ratios and external length:width ratios of tracks MRFa2–3 are very similar.

Length:width ratios of the tracks are: MRFa1–4 pes =(1.3–1.4):1, manus =(1–1.1):1; MRFb1–2 pes =(1.3–1.5):1, manus=(0.9):1; MRFc1–2pes=(1.2–1.3):1. There are no distinct manus prints. The manus impressions are rotated 11–18° outward from the trackway axis, approximately equal to the outward rotations of the pes impressions (14°). Pace angulations are 120° in the manus of MRFa1–3. The widths between tracks range from 35–51 cm.

Manus print MRFa3m is sub-circular. Impressions of digits, claws, and the metacarpophalangeal re-

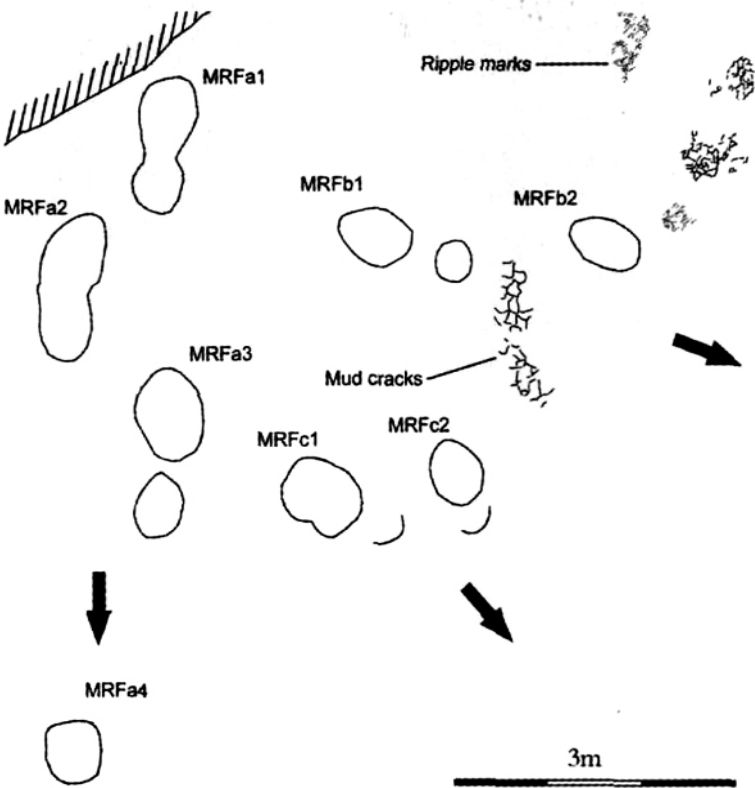


Fig. 2 Distribution of the footprints at the Morong track site

gion are indistinct. Well-preserved pes print MRFa3p is oval; an abbreviated mark on the anterior border may represent the ungual of digit I. The medial border of the pes print has a slightly concave region between metatarsal I and digit I possibly an extramorphological effect of pes–substrate interaction. The metatarsophalangeal pad region is smoothly curved.

Assuming a foot length:hip height ratio in the range of (4.0–5.9):1 for a sauropod^[6–7], the hip height of the MRFa1–3 track maker would be approximately 3.2–4.8 m. The hip height:body length ratio of *Shunosaurus* (a typical Middle Jurassic Chinese sauropod) is 3.7:1 (based on Farlow, 1992: Fig. 3^[8]), so the

Table 1 Measurements of the best preserved sauropod footprints from the Morong track site

Measurement	Internal diameter			External diameter		
	Maximum Length/cm	Maximum Width/cm	L/W	Maximum Length/cm	Maximum Width/cm	L/W
MRFa2m	36	36	1	57	58	1
MRFa2p	82	57	1.4	104	72	1.4
MRFa3m	44	40	1.1	64	58	1.1
MRFa3p	80	60	1.3	112	76	1.5

body of the MRFa1–3 track maker may have been 12–18 m long.

Discussion: Most Chinese sauropod tracks are from Cretaceous deposits, such as the Yongjing track site, Gansu Province^[9–10] and the Chabu track site, Inner Mongolia^[11]. Jurassic sauropod tracks from China are extremely rare. At present, only two sites have been described: the Early Jurassic Dazu track site in the Zhenzhuchong Formation, Sichuan Basin^[11–12]. The crescent shaped manus prints in the Dazu tracks are more similar to *Parabrontopodus* tracks than *Breviparopus* tracks. The senior author has also explored the Early Jurassic Gulin track site in the Ziliujing Formation, near Luzhou City (Sichuan Basin), which has at least seven sauropod trackways. These tracks are more similar to *Breviparopus* or *Parabrontopodus* tracks^[13].

Santos et al.^[14] divided sauropodomorph ichno-morphotypes into five categories: *Tetrasauropus*-like; *Otozoum*-like; *Breviparopus*-like/*Parabrontopodus*-like; *Brontopodus*-like; and *Polyonyx*-like. Among

these, the manus prints of *Tetrasauropus*-like tracks have four inwardly arched claw marks, and *Polyonyx*-like tracks are low degree of heteropody. These characteristics readily differentiate the Morong sauropod tracks from either of these two morphotypes. The Morong sauropod tracks are also dissimilar to *Otozoum* in morphology, lacking elongate pes prints with four inwardly-directed digit marks and a well-developed digit IV impression along the lateral margin of the footprint^[14–15]. The Morong tracks are not attributable to a non-sauropod sauropodomorph.

Most sauropod trackways from China have been referred to *Brontopodus*^[11], though a few individual tracks have been referred to as *Parabrontopodus*-like^[16]. The Morong sauropod tracks are most similar to *Brontopodus* based on the following features: wide (or sub-wide) gauge tracks (Fig. 4), high heteropody, and pes prints longer than broad^[14, 17–18]. However, the manus prints of the Morong sauropod tracks are crescent shaped, a feature of *Parabrontopodus*-type tracks but not *Brontopodus*-type tracks^[14, 18–19].

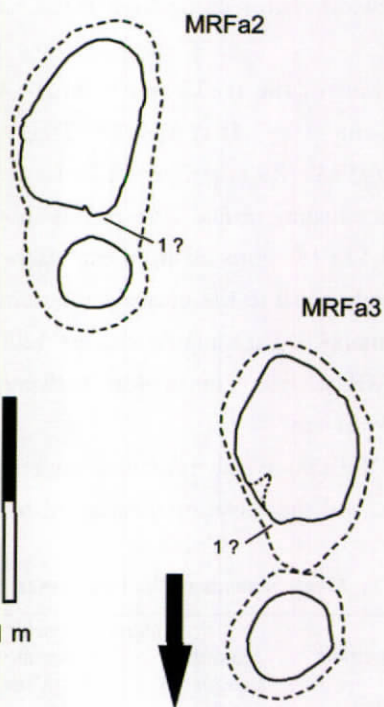


Fig. 3 Morong site sauropod tracks

left: Photographs; right: Outline drawings of MRFa2 and 3

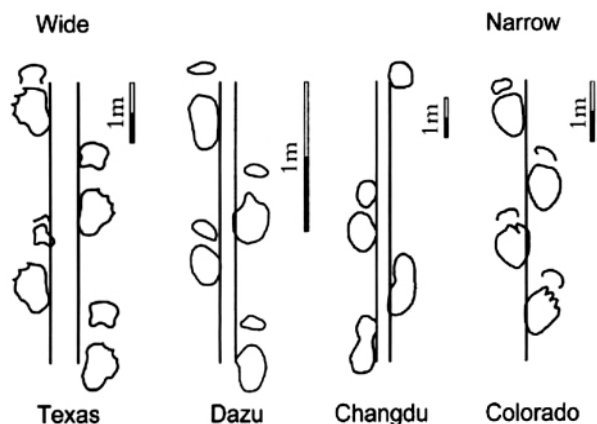


Fig. 4 Wide gauge sauropod trackways from the Cretaceous of Texas, Early Jurassic of Dazu, and Middle Jurassic of Changdu, compared to a narrow gauge sauropod trackway from the Late Jurassic of Colorado (emended from the references[12][18][20])

5 Morong track makers and *Shunosaurus* fauna

Most Jurassic (particularly Tithonian) sauropod track records are of the *Parabrontopodus* type, which have narrow gauge trackways, whereas most Cretaceous sauropod tracks are of the *Brontopodus* type, which typically have wide gauge trackways^[20]. It is unclear which taxa may have created *Breviparopus* and *Parabrontopodus* tracks. The wide-gauge stance of *Brontopodus* trackways suggest that they may have been created by titanosaurian sauropods^[11, 21]. Jurassic sauropod tracks may represent several clades of sauropod dinosaurs, including basal, non-neosauropod sauropods, diplodocoids, basal macronarians and titanosauriforms, and basal titanosaurs^[22–29].

The *Shunosaurus* fauna is widely distributed through the Middle Jurassic Xintiangou and Xiashaximiao formations of the Sichuan Basin and the Lower–Middle Jurassic Chaya Group of Changdu Prefecture^[30–31]; *Bellusaurus*, of uncertain systematic position, is known from the Middle Jurassic Wucuiwan Formation in the Junggar Basin. The *Shunosaurus* fauna includes a diverse array of non-neosauropods, including *Protognathosaurus*, *Shunosaurus*, *Datousaurus*, *Dashan-*

pusaurus, *Omeisaurus*, *Abrosaurus*, and *Mamenchisauridae*^[31]. The Dabuka Formation, in which the Morong tracks were found, has also produced possible basal sauropodomorphs, basal non-neosauropod eu sauropods, and basal titanosauriforms^[1–2]. Which, if any, of these taxa best match the morphologies of the Morong tracks cannot be determined until the body fossils are fully described, but if the fauna truly contains a basal titanosauriform, it would be expected to produce *Brontopodus*-like tracks.

The Morong tracks confirm that there was a large sauropod, possibly a member of Titanosauriformes, in Changdu Prefecture during the Early–Middle Jurassic. The sauropod fauna from Changdu Prefecture, Tibet not only has elements in common with the sauropod fauna from Sichuan Basin, but may include more diverse faunal components.

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