·基础地质·

# Early Jurassic sauropod tracks from the Yimen Formation of Panxi region, Southwest China: Ichnotaxonomy and potential trackmaker

# 中国西南攀西地区下侏罗统益门组蜥脚类足迹:分类学与潜在的造迹者

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**Abstract:** Dinosaur track and bone records often occur at different locations. However, a few formations show a close correspondence between bones and tracks that correspond to likely trackmakers. In this paper, the authors report sauropod tracks (*Brontopodus*) in very close geographic and stratigraphic proximity to the type locality of the eusauropod *Tonganosaurus* hei in the middle-upper parts of the Lower Jurassic Yimen Formation in Tongbao Village, Huili County, Panxi region of Sichuan Province. This Huili track-trackmaker correlation is possibly existent, but still needs more evidence to confirm. As the first Jurassic sauropod tracks found in the Panxi region, the Tongbao Brontopodus tracks have provided evidence indicating coexistence of primitive sauropod and basal sauropodomorphs in Southwest China during Early Jurassic.

**Key words:** dinosaur tracks; sauropod; Yimen Formation; Lower Jurassic; Tong´an

**摘要:** 恐龙足迹和骨骼的记录往往出现在不同的地区。然而,一些地层显示了关系紧密的骨骼和足迹,它们都指向同一个来源。报道了来自四川省攀西地区会理县通安镇通保村下侏罗统益门组中上部的蜥脚类足迹(雷龙足迹 *Brontopodus*),其地理和地层归属均与真蜥脚类的何氏通安龙极为接近。通保足迹与造迹者的关联是可能的,但目前还需要更多的证据。通保的雷龙足迹是攀西地区首次发现侏罗纪的蜥脚类足迹,这也表明,在早侏罗世,原始蜥脚类和基干蜥脚型类共存于中国西南地区。

**关键词:** 恐龙足迹;蜥脚类;益门组;下侏罗统;通安

**中图分类号:** P534.52;Q915.2+2 **文献标志码:** A **文章编号:** 1671-2552(2016)06-0851-05

The Early Jurassic deposits of China contain an abundance of basal sauropodomorph skeletal fossils, such as *Lufengosaurus*[1-2]and *Yunnanosaurus*[3]. Sauropod remains are far less common, but include, for example, the basal sauropod *Gongxianosaurus shibeiensis*[4] and the eusauropod *Tonganosaurus hei*[5]. The exact taxonomic position of *Gongxianosaurus* is currently disputed[6-7], while *Tonganosaurus* is confidently assignable to the Mamenchisauridae[5]. The Gulin tracks from the Lower Jurassic Ziliujing Formation record the coexistence of basal sauropodomorphs (*Liujianpus*) and sauropods (*Brontopodus*)[7].

The type specimen of *Tonganosaurus* was found in Tongbao Village, Tongan Town, Huili County, Sichuan Province. When investigating the *Tonganosaurus* locality in December 2014, we discovered an assortment of sauropod tracks, roughly 7m away from and 70cm above the *Tonganosaurus* site (GPS: N 26° 20´34.81", E 102° 18´40.25") ( Figs.1,2). The first author investigated this site again in November 2015.

Institutional abbreviations

TB=Tongbao site, Huili County, Sichuan, China; SI=isolated sauropod tracks.

## 1 Geological setting

Mesozoic sediments in the Xichang- Liangshan area are often collectively referred to as the Yimen Red Beds. Among which, the red bed profile of Huili is divided into Lower Yimen Formation and Upper Yimen Formation[8]. In 1962, the First Survey Team of Sichuan Bureau of Geology divided the Yimen Red Bed into the Upper Triassic Baiguowan Formation, the Middle Jurassic Yimen, Xincun, Niugundang and Guangou Formations, and the Upper Jurassic Feitianshan Formation[9-10]. Based on bivalve fossils, Yuan[9]suggested that Yimen Formation (= Lower Yimen Formation) was formed during the Early Jurassic (comparable to the Zhenzhuchong Formation of Sichuan Basin and Lower Lufeng Formation / Fengjiahe Formation of Yunnan), the lower and middle parts formed in the Middle Jurassic (comparable to Xincun Formation), and the upper part formed in the Upper Jurassic (comparable to Niugundang and Guangou formations). Liu et al.[11]proposed the same conclusion, based on stonewort fossils.

The Yimen Formation is 300- 680m thick, composed of purple- red mudstone interbedded with greyish- white or yellow- gray fine grain quartz sandstone and siltstone in different thicknesses, and contains abundant invertebrate fossils, including ostracoda, stoneworts, bivalves and conchostraca[10]. The Yimen Red

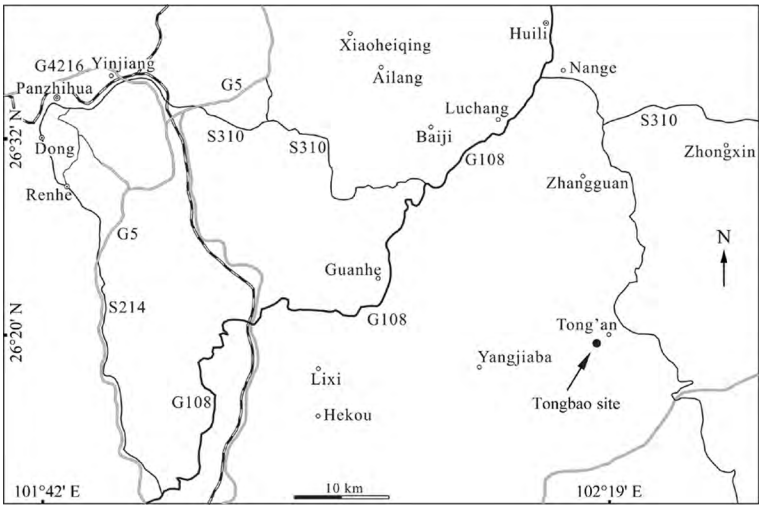


Fig. 1　Locality map showing location of the Tongbao site

Beds reflect shallow-deep lake and flood environments[9].

Based on the lithologic features and the 1∶200000 geologic map, Li et al.[5]suggested that Tonganosaurus was from the middle-upper parts of the Lower Jurassic Yimen Formation. The newly discovered dinosaur tracks are from a purple-red silty mudstone layer, 70cm above the *Tonganosaurus* site.

## 2　Description of tracks

The track level surface is severely weathered and plants growing in some of the tracks have nearly destroyed them. All observed tracks so far are isolated, and except for a manus-pes set, there is no indication of any trackways. The best preserved sets are TB-SI-1p and 1m (Figs. 3,4). They are scheduled to be cut out and stored in Huili County Cultural Relic Administration. The manus print imprint TB-SI-1m is sub-crescent in shape, while claw traces and the metacarpo-phalangeal region are indistinct. There is a possible claw drag mark at the end of the track, where digit Ⅲ was likely positioned. The pes impression TB-SI-1p is oval, with the metatarso-phalangeal region narrower than the anterior portion. The trace of digit I is the most developed, while those of digits Ⅱ and Ⅲ are the most anterior, but with no border between them. Digit Ⅳ is identifiable. The heteropody (manus:pes area ratio) is relatively high (1∶2.8).

TB-SI-2p is a poorly preserved isolated pes impression, slightly smaller than TB-SI-1p. The pes impression possesses three poorly defined indentations at its anterior margin, corresponding to the predicted positions of digits Ⅰ, Ⅱ and Ⅲ+Ⅳ. TB-SI-3m is a poorly preserved manus impression and is slightly larger than TB-SI-1m, with clear digit Ⅰ and Ⅴ.

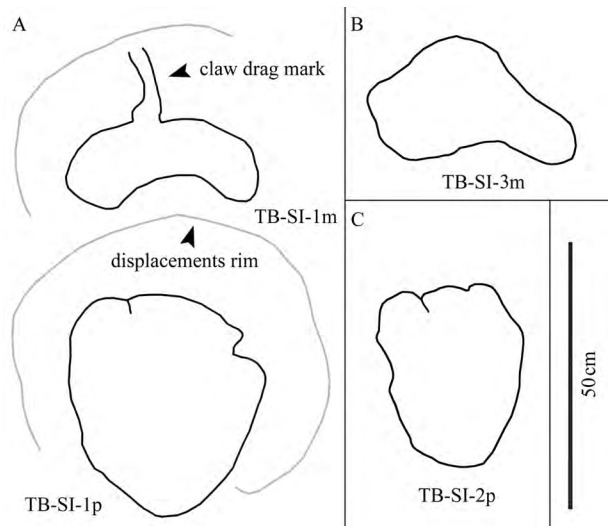


Fig. 3　Outline drawings of Tongbao tracks

## 3　Interpretation

In the Cretaceous, the sauropod track type *Brontopodus*[12]is common world-wide. In the past, Early Cretaceous sauropod tracks in East Asia were frequently attributed to either wide gauge *Brontopodus*[13]or nar-

**Table 1　Measurements of sauropod tracks from the Tongbao tracksite, Sichuan Province, China**

cm

| No. | ML | MW | ML/MW |
|---|---|---|---|
| TB-SI-1p | 41.5 | 37.8 | 1.1 |
| TB-SI-1m | 14.5 | 36.0 | 0.4 |
| TB-SI-2p | 33.8 | 27.0 | 1.3 |
| TB-SI-3m | 22.0 | 38.7 | 0.6 |

Note:ML—Maximum length; MW—Maximum width; ML/MW—Maximum length/Maximum width

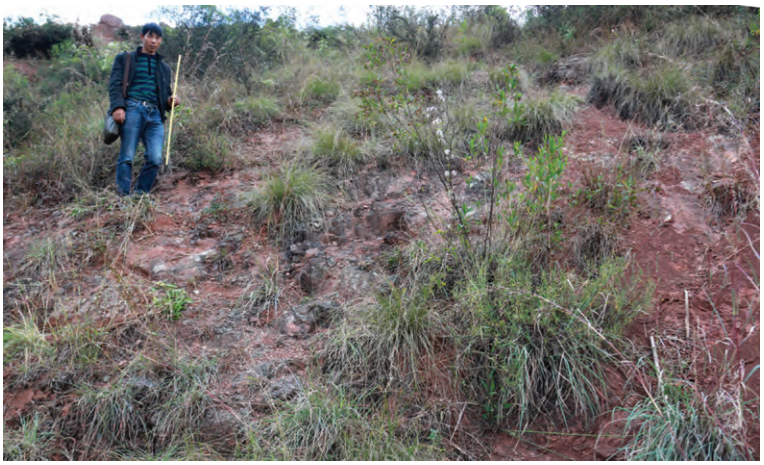

Fig. 2 General view of the Tongbao site, the yellow bar is 1m

row gauge *Parabrontopodus*[14−16].

Because no trackway has been found at the Tongbao sauropod trackway, further comparisons are difficult. For the Tongbao sauropod pes traces, however, the length/width ratios are 1.1−1.3 and, for the manus, they are 0.4− 0.6. These measurements are closer to those typical of sauropod tracks such as *Brontopodus*[12]. In addition, the Tongbao sauropod manus− pes set shows a heteropody of 1∶2.8 which is similar to Brontopodus birdi (1∶3) but significantly less than that of the narrow− gauge ichnotaxa *Breviparopus* (1∶3.6) or *Parabrontopodus* (1∶4 or 1∶5) [17]. Therefore, the isolated tracks from Tongbao Village probably belong to *Brontopodus*.

Assuming a hip height/foot length ratio in the range of 4.0∶1−5.9∶1 for a sauropod[18−19], the hip height of the Tongbao sauropod trackmaker TB− SI− 1p is approximately 1.2− 2.4m. The body length/hip height ratio is 3.7∶1 (based on *Shunosaurus*) [20]. The body length of the Tongbao sauropod trackmaker is estimated to be 4.5−9.1m. The body length of type *Tonganosaurus* is estimated to be 12m[5], reasonably close to that of the Tongbao sauropod trackmaker.

The Tongbao *Brontopodus* trackmaker has an obvious potential affinity with *Tonganosaurus* (Mamenchisaurid) given their proximities. Brontopodus type tracks also exist in levels which yield Middle Jurassic *Chuanjiesaurus* (Mamenchisaurid) [20]. If *Brontopodus* tracks from the Chuanjie Formation correspond to *Chuanjiesaurus*, then *Brontopodus* may have affinity with

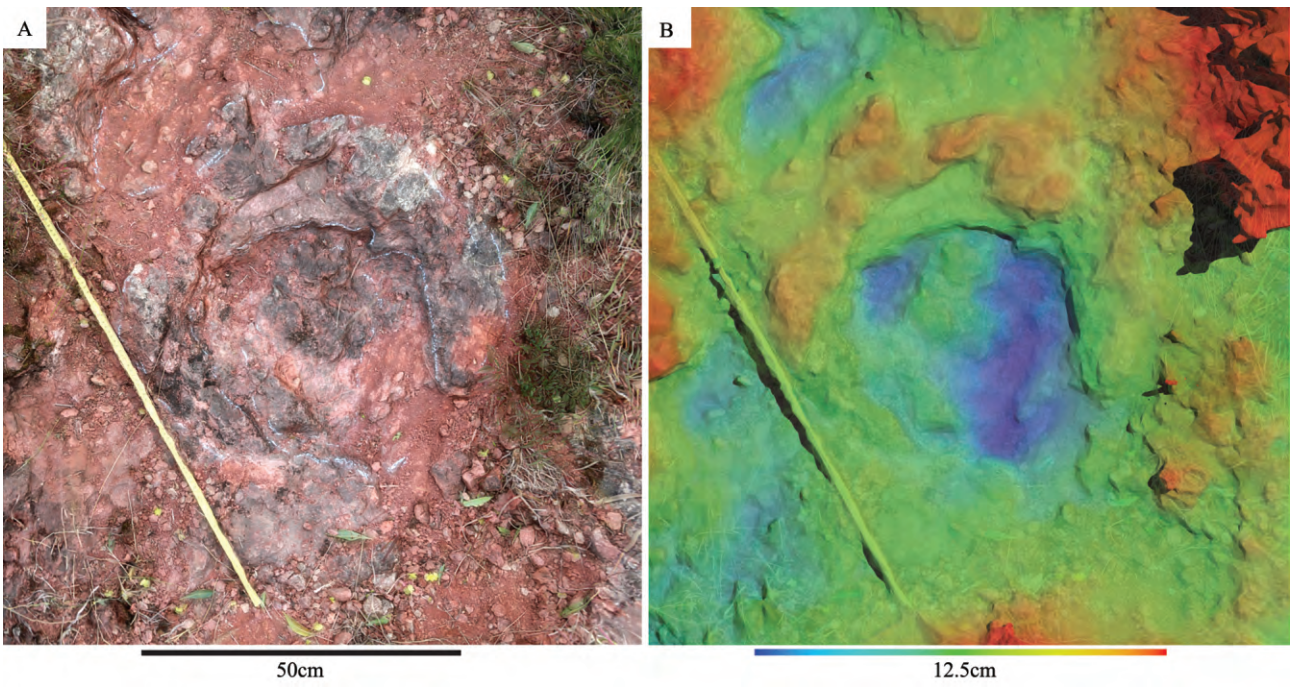


Fig. 4 Photo (A) and photogrammetric image (B) of manus−pes set

Mamenchisaurid tracks. However, the Jurassic *Brontopodus* tracks also have been found from the Changdu Basin, and areinferred to have been left by titanosauriforms[21].

## 4 Conclusion

(1)The Tongbao *Brontopodus* tracks are the first Jurassic sauropod tracks found in the Panxi region

(2)The Tongbao *Brontopodus* tracks provide evidence that primitive sauropod and basal sauropodomorphs coexisted in Southwest China during Early Jurassic.

(3)The corresponding trackmaker types of Jurassic *Brontopodus* tracks probably include titanosauriforms, basal eusauropods, and mamenchisaurids.

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