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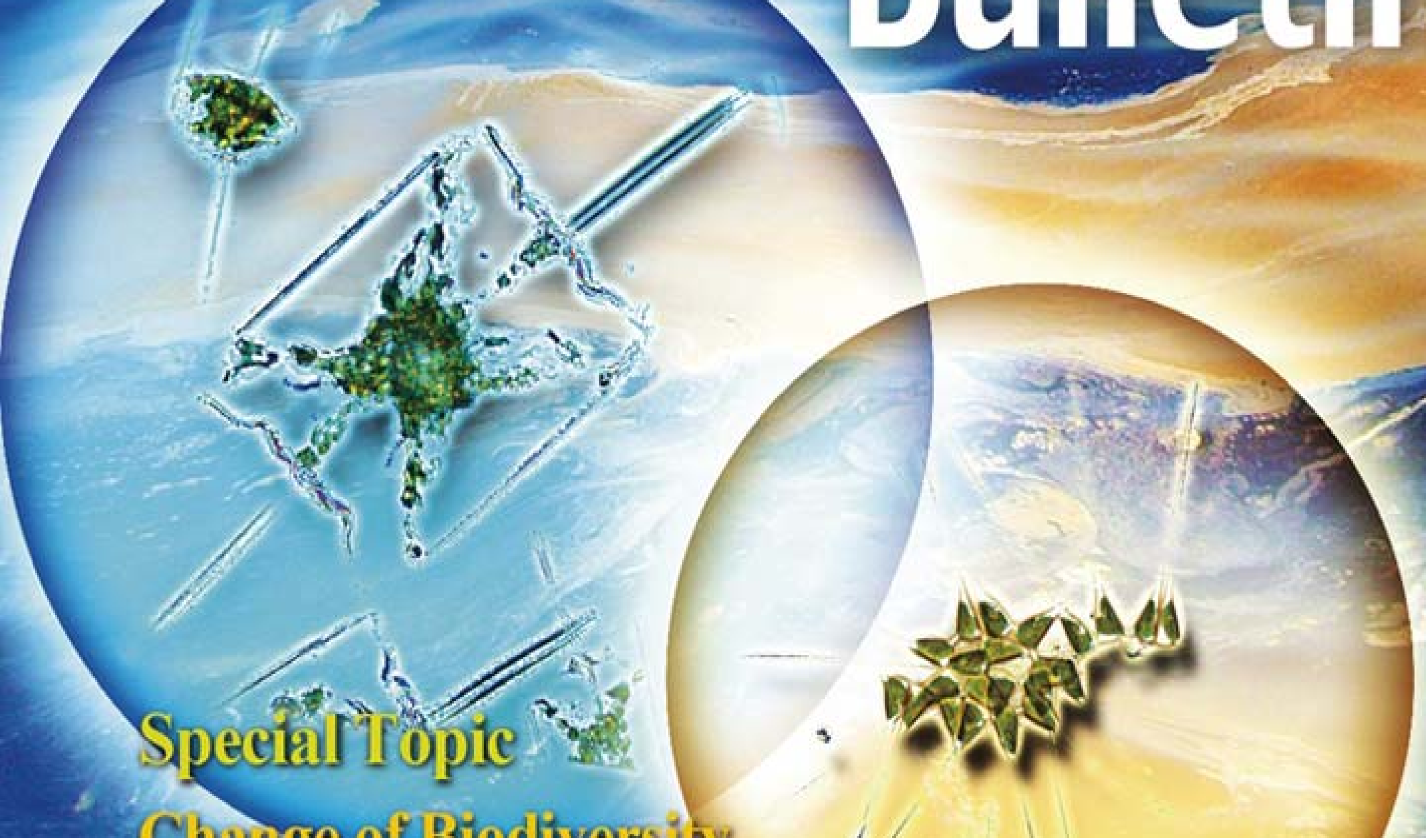

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A new Early Cretaceous dinosaur track assemblage and the first definite non-avian theropod swim trackway from China

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The trackway of a swimming theropod (ichnogenus *Characichnos*) is reported from the Lower Cretaceous Feitianshan Formation of Sichuan, China. These swim tracks help confirm that non-avian theropods were capable of forging moderately deep bodies of water. The trackway occurs on the same surface as a typical walking trackway of a sauropod (ichnogenus *Brontopodus*). Both occurrences are the first reported from the Cretaceous of Sichuan, and the swim tracks are the first well-preserved example of a *Characichnos* trackway from China. Additionally, a theropod walking trackway and several ornithopod walking trackways (similar to the ichnogenus *Caririchnium*) occur in the same horizon. The ornithopod trackways show a parallel orientation, suggesting gregarious behavior of the trackmakers, which may have been iguanodontiforms and/or hadrosauriforms. The co-occurrence of theropod swim tracks and theropod walking tracks suggests a fluctuation of water depth within a distinct time span.

theropod swim tracks, sauropod tracks, ornithopod tracks, Feitianshan Formation, Early Cretaceous

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Fossil tracks attributed to swimming tetrapods are substrate traces left by organisms as they propelled themselves through water. Although somewhat rare, fossil "swim" or swim tracks are attributed to a variety of vertebrates, including dinosaurs, crocodylomorphs [1], fish [2], pterosaurs [3], and turtles [4]. Swim tracks provide unique insight into the behavior of ancient vertebrates in aquatic environments, but are often controversial and difficult to interpret, because they usually display irregular morphologies [5]. Among dinosaurs, non-avian theropod swim tracks are the least controversial, and examples have been discovered in England [6], Poland [7], USA [5], and Spain [8].

In September 1991, mining operations at Sanbiluoga ("Sanbi" is the last name for the local residents, "luoga" meaning walled or fort) copper mine, Sanchahe Township, Zhaojue County, Sichuan Province (Figure 1), exposed a large (approximately 1500 m^2) assemblage of dinosaur tracks (tracksite I: 27°51′22.70″N, 102°40′56.65″E). In December 2004, Jiefang Ebi investigated this tracksite, which was found to include approximately 12 individual trackways. Unfortunately, continued mining operations during 2006–2009 destroyed most of the tracksite. Initial analysis indicated that the track makers include sauropod and theropod dinosaurs, and pterosaurs [9]. In June and October of 2012, the primary authors of this paper investigated the remaining track surfaces and also found possible thyreophoran

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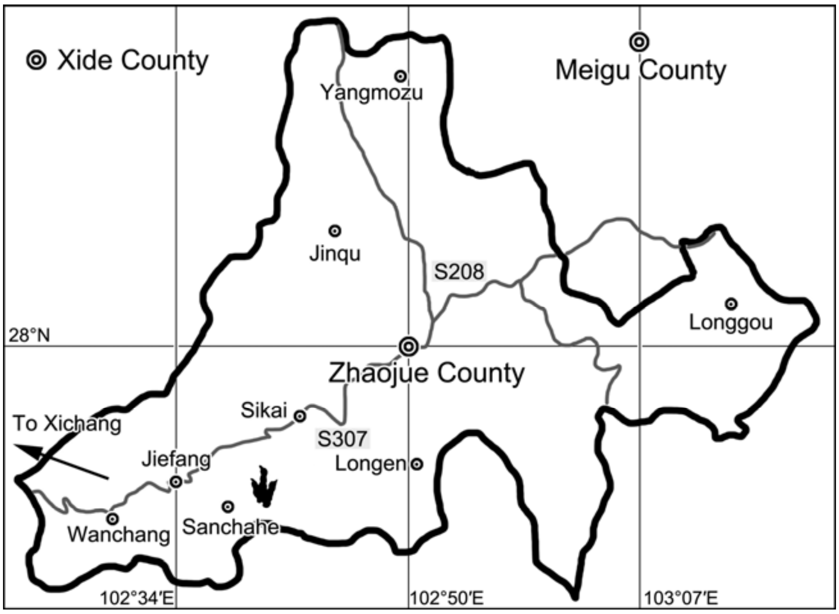

Figure 1 Geographic map indicating the location (footprint icon) of the Zhaojue dinosaur footprint locality in Liangshan Yi Autonomous Prefecture, Sichuan Province, China.

and small ornithopod tracks, which will be described elsewhere. The investigation team also discovered a second, pristine tracksite (tracksite II: coordinates) located 450 meters southwest from tracksite I. Tracksite II includes a trackway of a swimming theropod, an isolated theropod swim track and several trackways of walking theropods, sauropods, and ornithopods.

1 Geological setting

Tracksite I is an exposure of the Feitianshan Formation, a 302–1090-m-thick unit of fluvial facies comprised of red clastic sediments. The Feitianshan Formation was first assigned to the Late Jurassic, but has since been identified as Early Cretaceous [10]. Dinosaur tracks yielded from the upper member of the Feitianshan Formation, which consists of non-uniformly thick alternations of mixed purplish-red and grayish-purple feldspar-quartz sandstone, purplish-red and brick-red calcareous siltstone and mudstone. The base is formed by a thick (174–828 m) layer of feldspar-quartz sandstone, which is rich in copper [10][1)].

The tracksite II exposure is an approximately 1000 m^2 sandstone bedding surface, with a steep (about 50°) northwest dip. In addition to the vertebrate footprints, invertebrate traces are also preserved on the surface. Most common are vertical burrows (*Scoyenia* isp.) that indicate a non-marine shallow water environment. Mudcracks suggest a change in water depth and a short-term exposure to the air. Developed ripple marks are also widespread.

2 Systematic ichnology

2.1 Swim tracks attributable to the ichnogenus *Characichnos*

Materials. Nine complete natural molds of pes prints cataloged as ZJ-II-1.1–1.8, and ZJ-II-2.1 (Figures 2, 3 and Table 1) (ZJ-II: Zhaojue Field, tracksites II). Two fiberglass molds of ZJ-II-1.1–1.2 (HDT.223–224, HDT: Huaxia Dinosaur Tracks Research and Development Center).

Locality and horizon. Upper Member of the Feitianshan Formation, Early Cretaceous. Sanbiluoxia tracksite II, Zhaojue, Xichang City, Sichuan Province, China.

Description and comparison. Trackway ZJ-II-1 (Figures 2 and 3) is composed of at least eight tracks. There is another isolated track ZJ-II-2.1 near ZJ-II-1.1, which might be another track in the series, but which probably represents another trackway. The ZJ-II-1 tracks differ in morphology from other ZJ-II tracks. ZJ-II-1 and ZJ-II-2 consist of slender, tapering digit impressions, and lack any impressions made by the metatarsophalangeal regions. The absence of metatarsophalangeal region impressions is common in swim tracks [5,8]. Specimen ZJ-II-1.1 and ZJ-II-1.2 are the representative specimens at the ZJ-II tracksite. Both consists of three long slender, parallel (slightly S-shaped) digits, interpreted

1) Panzhihua Team, Sichuan Bureau of Geology and Mineral Resources. Sichuan Provincial Zhaojuial County sanbiluoga copper mine geological report. 1993, 102 (internal publication).

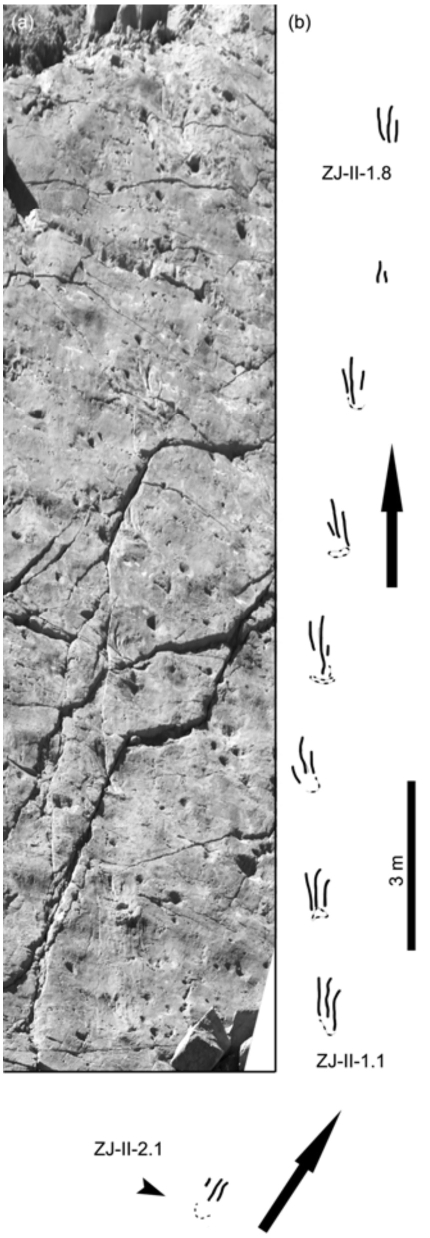

Figure 2 Map with theropod swim trackway ZJ-II-1 at ZJ-II tracksite (illustrated by photography, map indicates the general track distribution, but not the real distances, among individual footprints). (a) Photographs; (b) schematic drawings.

as scratch marks made on the sediment by the distal ends (claws or toe tips) of the trackmaker's hindfeet. The digit III marks are longer and deeper, while the digits II and IV marks are shorter and shallower; digit II marks are always longer and deeper than digit IV marks. Elongated sand mounds are preserved at the posterior end of the ZJ-II-1.1 and ZJ-II-1.2, showing that substrate sediments were raked by the digits and pilled caudally. This configuration is a common feature of swim tracks [11], including those of theropods [8]. The morphological characteristics of the other ZJ-II-1 and ZJ-II-2 tracks are basically consistent, but occasionally only one or two digit impressions are preserved.

In all cases, the anterior portions of the impressions are deepest, and the traces become shallow posteriorly. These features indicate that the distal tip of the foot contacted the sediment initially and with the greatest impact force, and the foot was then lifted and as it moved posteriorly, propelling the animal forward [5,8].

The ichnotaxa *Characichnos* (meaning "scratch mark") from the Middle Jurassic Saltwick Formation of England [6] are dinosaur swim tracks of likely theropod affinities. *Characichnos* also attributed to theropod producers have also been identified in the Early Jurassic Zagaje Formation in Poland [7] and Moenave Formation at the St. George Dinosaur Discovery Site at Johnson Farm in southwestern Utah, USA. The St. George assemblage, comprising thousands of traces, is currently the largest and best-preserved collection of dinosaur swim tracks recorded [5]. Well-preserved swim tracks are also known from several smaller localities in southwestern Utah in the Moenave and Kayenta formations [12–14]. Additional, though unnamed, theropod swim tracks are reported from the Lower Cretaceous of Spain [8]. Hunt and Lucas adopted *Characichnos* as a label for the *Characichnos* ichnofacies which broadly subsumes any ichnofacies dominated by swim tracks, including *Characichnos* and other ichnotaxa [15]. This includes what they call the *Hatcherichnus* ichnocoenosis (*Hatcherichnus* ichnofacies of Lockley et al. [16]), which is characterized by swim tracks such as *Hatcherichnus* with different, often tetradactyl morphologies, attributed to crocodylomorphs or other tetrapods). Such swim tracks occur in large assemblages in the Dakota Group [16,17]. Distinguishing between tracks made by different tetrapod groups is not always easy.

Xing et al. [18] reported five possible theropod swim tracks from the Upper Jurassic-Lower Cretaceous Tuchengzi Formation of Chicheng County, Hebei Province, China. In overall morphology, these tracks are similar to *Characichnos*, but the tracks were isolated and poorly preserved. The characteristics of the ZJ-II theropod swim tracks are consistent with *Characichnos* in having three elongate and parallel epichnial grooves, the terminations of which are straight or sharply reflexed [6]. The ZJ-II theropod swim tracks are, therefore, assigned to *Characichnos*. However, it should be noted that the ZJ-II theropod swim tracks do not form subparallel trackways (as in the holotype of *Characichnos*). It is important to remember that current flow direction (or a lack thereof) in relationship to animal travel direction can greatly modify overall swim track morphology [5].

2.2 Theropod tracks

Materials. Four complete natural molds of pes prints constituting a trackway and are cataloged as ZJ-II-3.1–3.4 Two replicated molds of the tracks are stored at the Huaxia Dinosaur Tracks Research and Development Center (HDT), where they are cataloged as HDT.225–226 (correspond to

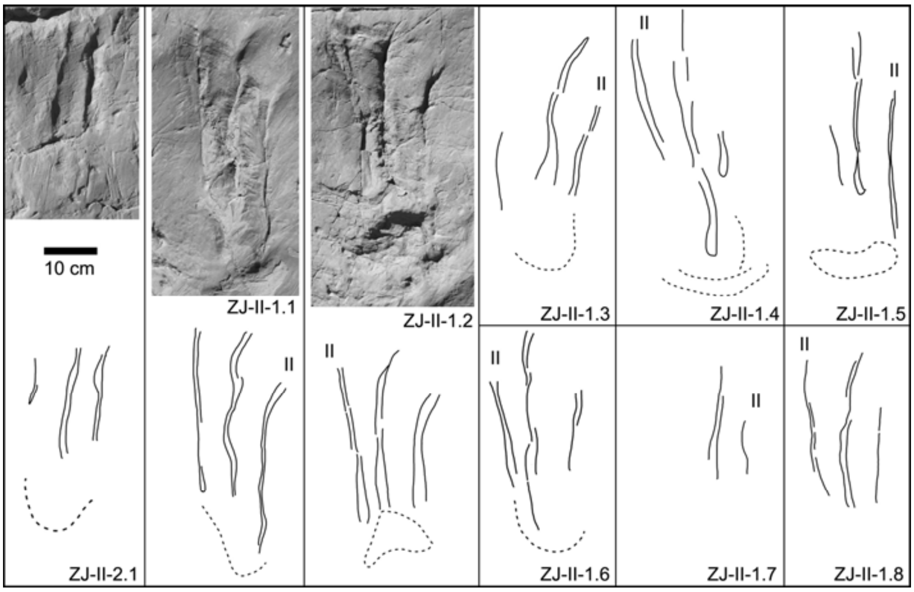

Figure 3 Photographs and outline drawing of theropod swim trackway ZJ-II-1 and ZJ-II-2.

Table 1 Measurements (in cm) of the dinosaur tracks from Sanbiluoxia tracksite II[a)]

Number	R/L	ML	MW	LD II	LD III	LD IV	II-III	III-IV	II-IV	PL	SL	PA	L/W
ZJ-II-1.1	L	46.1	19.5	31.9	31.0	31.0	–	–	–	138	280	166°	2.36
ZJ-II-1.2	R	40.9	18.9	29.9	30.1	21.6	–	–	–	144	271	156°	2.16
ZJ-II-1.3	L	44.4	19.2	17.7	28.8	14.9	–	–	–	134	–	–	2.31
ZJ-II-1.4	R	54.5	–	23.4	46.8	>8.6	–	–	–	–	–	–	–
ZJ-II-1.5	L	46.3	–	27.6	30.5	11.8	–	–	–	–	–	–	–
ZJ-II-1.6	R	42.0	15.9	20.4	37.7	15.0	–	–	–	–	–	–	–
ZJ-II-1.7	L	>21.2	–	10.3	>21.2	–	–	–	–	–	–	–	–
ZJ-II-1.8	R	>29.4	–	26.3	29.6	17.8	–	–	–	–	–	–	–
ZJ-II-2.1	–	21.5	14.3	–	–	–	–	–	–	–	–	–	–
ZJ-II-3.1	L	21.4	18.8	8.1	11.9	6.0	42°	33°	75°	83	178	146°	1.14
ZJ-II-3.2	R	23.3	18.7	8.9	12.7	7.4	31°	36°	67°	103	180	137°	1.25
ZJ-II-3.3	L	24.1	–	–	–	–	–	–	–	90	–	–	–
ZJ-II-3.4	R	20.8	16.9	–	–	–	–	–	–	–	–	–	1.23
ZJ-II-4.1m	R	–	–	–	–	–	–	–	–	90	161	118°	–
ZJ-II-4.1p	R	–	–	–	–	–	–	–	–	91	160	121°	–
ZJ-II-4.2m	L	13.0	28.5	–	–	–	–	–	–	95	154	117°	0.46
ZJ-II-4.2p	L	42.0	33.0	–	–	–	–	–	–	96	157	114°	1.27
ZJ-II-4.3m	R	14.5	22.5	–	–	–	–	–	–	89	–	–	0.64
ZJ-II-4.3p	R	43.5	32.0	–	–	–	–	–	–	88	–	–	1.36
ZJ-II-4.4m	L	14.5	28.0	–	–	–	–	–	–	–	–	–	0.52
ZJ-II-4.4p	L	42.0	34.5	–	–	–	–	–	–	–	–	–	1.22
ZJ-II-5.1	R	23.0	19.3	15.1	11.0	13.1	32°	28°	60°	99	153	147°	1.19
ZJ-II-5.2	L	24.3	17.6	14.3	9.4	12.5	25°	21°	46°	60	152	150°	1.38
ZJ-II-5.3	R	24.2	16.4	12.8	10.0	13.0	22°	18°	40°	97	–	–	1.48
ZJ-II-5.4	L	25.3	20.9	12.7	12.2	>9.9	25°	27°	52°	–	–	–	1.21
ZJ-II-7.7	R	18.2	22.4	9.3	11.3	12.8	45°	40°	85°	77	147	161°	0.81
ZJ-II-7.8	L	20.6	26.5	15.6	10.0	9.0	25°	65°	90°	–	–	–	0.78
ZJ-II-8.7	R	28.7	23.2	>9.3	15.4	>10.8	23°	30°	53°	71	143	160°	1.24

a) R/L: Right/left; LD I: length of digit I; LD II: length of digit II; LD III: length of digit III; LD IV: length of digit IV; ML: maximum length; MW: maximum width*; PA: pace angulation; PL: pace length; SL: stride length; II-III: angle between digits II and III; III-IV: angle between digits III and IV; II-IV: angle between digits II and IV; L/W: maximum length/maximum width. The "m" and "p" in the catalogue numbers refer to manus and pes imprints, respectively. * Dinosaur tracks measured as distance between the tips of digits II and IV.

ZJ-II-3.1–3.2).

Locality and horizon. Same as in section 2.1 above.

Description and comparison. Trackway ZJ-II-3 consists of four consecutive theropod tracks. The inferred walking direction of the trackway is tangential to the crests of the preserved ripples on the surface of the tracksite. Among the tracks, ZJ-II-3.1 and ZJ-II-3.2 (left and right prints respectively, Figure 4, Table 1) are the best preserved, and, because of their position low on the slope, they are the easiest to access. The mean length/width ratio, as calculated from ZJ-II-3.1–3.2 is 1.2∶1.

Track ZJ-II-3.1 serves as an example of the tracks' morphology. Digit III projects the farthest anteriorly, followed by digits IV, and II. Due to the *soft*, *wet sediments in which the tracks were made*, and exposure to later weathering and disturbance by vegetation, the track morphology is unusual. It exhibits extramorphological, substrate-based features rather than reflecting true track maker pedal morphology. There are no discernible pad impressions; however, each digit has a sharp claw mark. Evidence for sediment collapse (slumping of mud back into the depressions) was observed in each digit trace, especially digit III and IV. Ridge-like, V-shaped backfill deposits are observable in the middle of digit III. The digits have wide divarication angles; the angle between digits II and III is greater than that between digits II and IV. Distinct, convex borders demarcate the metatarsophalangeal region and part of metatarsal pad. The proximal part of the metatarsal ("heel") impression is deeply concave. The rest of the heel impression is indistinct, but a 13.3 cm-long impression remains, which is probably the trace of the heel impression collapsed by the sediments.

Such track preservation is not rare. Similar preservation is seen at the Lower Cretaceous Glen Rose tracksite from Texas, USA [19], and the mid-Cretaceous Wotoushan Formation Baoyuan tracksite from Chishui, China [20]. The ZJ-II theropod tracks are most similar to the Baoyuan theropod tracks, especially in terms of the demarcation between the metatarsophalangeal region and the metatarsal pad (such as BYA3) and their mutual wide divarication. Wide digit divarication angles are characteristic of *Kayentapus* [21–24]. Employing the method of Weems [25] to discriminate *Kayentapus* footprints at the ichnospecific level [7,22,24], the dimensional ratios of ZJ-II-3.1 are: te/fw=0.43 and (fl-te)/fw=0.64 (where te=toe extension, fw=footprint width and fl=footprint length); the ratios of ZJ-II-3.2 are: te/fw=0.48 and (fl-te)/fw=0.73. Thus, they fall inside the known range of *Kayentapus*, and are most similar to *K. soltykovensis* [20]. However, the metatarsophalangeal region of each footprint is much larger than in typical Early Jurassic theropod tracks and, together with widely divaricated digits and the V-shaped proximal track area, resembles the ichnogenus *Irenesauripus* Stenberg, 1932 [26], which is widely distributed in Early Cretaceous (and early Late Cretaceous) assemblages [20,27–29].

2.3 Sauropod tracks

Materials. Twelve natural molds of manus-pes pairs constituting a trackway, and cataloged as ZJ-II-4.1–4.12 (Figures 5 and 6, Table 1).

Locality and horizon. Same as in section 2.1 above.

Description and comparison. The ZJ-II-4 trackway is clearly wide-gauge. The inner trackway width, measured from the inside margin of the pes, is approximately 19 cm. The manus impressions lie slightly anteromedial to the pes impressions. Length/width ratios of the manus impressions range from 0.46 to 0.64. The manus impressions are oval. Impressions of digits, claws, and the metacarpophalangeal region are indistinct. The manus impressions are rotated approximately 14° *outward* from the trackway axis, nearly equal to the outward rotations of the pes impressions (about 10°). The pes impressions are oval. The metatarsophalangeal pad region is smoothly curved. Length/width ratios of the pes impressions range from 1.22 to 1.36.

Most Chinese sauropod tracks are from Cretaceous deposits, such as the Yongjing track site, Gansu Province [30,31] and the Chabu track site, Inner Mongolia, China [32]. Most sauropod trackways from China have been referred to

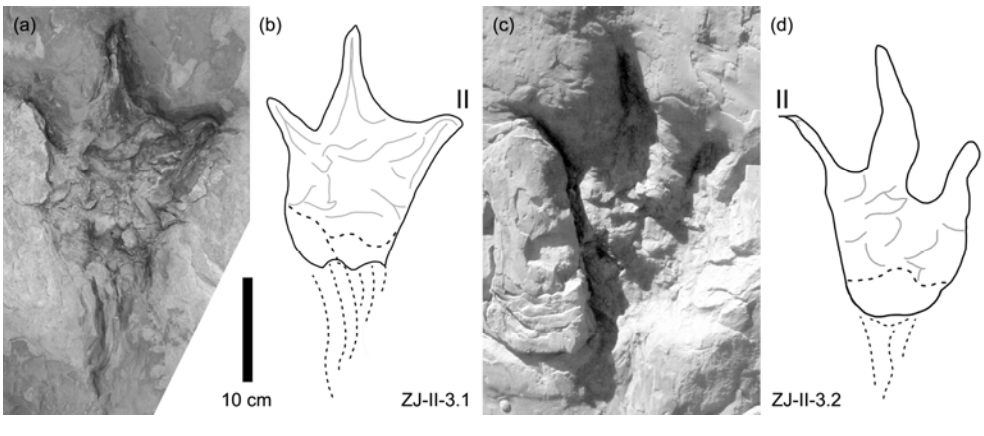

Figure 4 ZJ-II theropod footprints ZJ-II-3.1 and ZJ-II-3.2. (a) and (c) Photographs; (b) and (d) outline drawings.

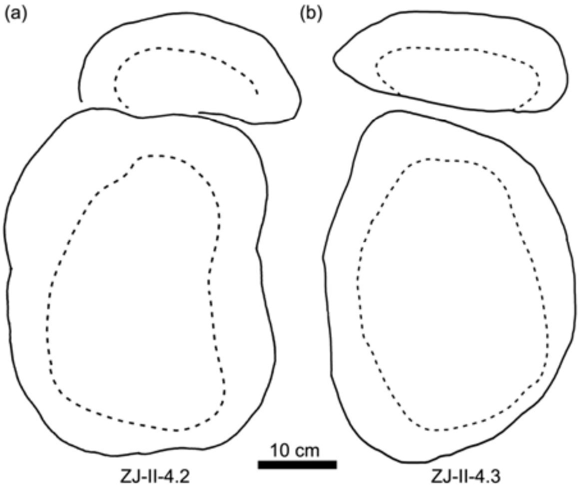

Figure 5 Outline drawing of ZJ-II sauropod tracks.

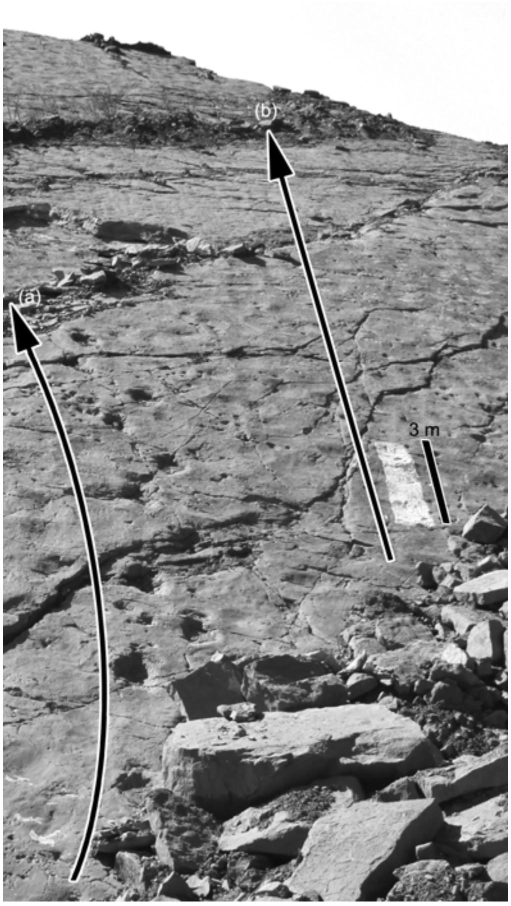

Figure 6 Sauropod trackway ZJ-II-4 (a) adjacent and parallel to theropod swim trackway ZJ-II-1 (b).

Brontopodus [32], though a few individual tracks have been referred to as *Parabrontopodus*-like [33]. The ZJ-II sauropod tracks are most similar to *Brontopodus* based on the following features: wide (or sub-wide) gauge, high heteropody, and pes prints longer than broad [34–36]. However, the manus prints of the ZJ-II sauropod tracks are crescent-shaped, a feature characteristic of some *Parabrontopodus*-type tracks [35,36].

2.4 Ornithopod tracks

Materials. At least forty complete natural molds of pes prints (Figure 7, Table 1) constituting seven trackways. However, most of the trackways are preserved high on the steep slope of the exposure, making the tracks difficult to access. The lower prints are cataloged as ZJ-II-5.1–5.4, ZJ-II-6.1–6.7, ZJ-II-7.1–7.8 and ZJ-II-8.1–8.8.

Locality and horizon. Same as in section 2.1 above.

Description and comparison. The ornithopod trackway ZJ-II-5 (Figure 7(a)–(e)) is approximately 180 cm away from the ZJ-II-3 theropod trackway, and both show the same walking orientation. The three ornithopod trackways ZJ-II-6, ZJ-II-7, ZJ-II-8, share the same walking orientation. Only the tracks low on the exposure were measured: ZJ-II-7.7 (Figure 4(f)), ZJ-II-7.8 (Figure 4(g)) and ZJ-II-8.7 (Figure 4(h)). As with the theropod tracks, the ornithopod tracks exhibit extramorphological, substrate-based features rather than reflecting track maker pedal morphology. The mean length/width ratio calculated from ZJ-II-5 is 1.32:1. Among the tracks, ZJ-II-5.1 is the best preserved.

In ZJ-II-5.1-4, digits II and IV are subequal in length, but digit II has a sharper claw mark, in 5.2-4 although otherwise digits II and IV are similar in morphology: the outline of each digit is ovoid and bears a prominent, but mediolaterally narrow, claw impression at the anterior end. Digit III is slightly shorter than digits II and IV, but protrudes farther anteriorly and is broadly U-shaped at its distal part. The metatarsophalangeal pad of the ZJ-II-5.1 is indistinct; in other specimens of this trackway, the impression is more pear- or teardrop-shaped. Due to the soft and wet sediments in which the tracks were made, metatarsophalangeal pad of the ZJ-II-5.1 lacks a distinct border separating the impression from those of digits II and IV. In other specimens of this trackway, a clearer border is observable. The divarication angles between digits II and III and between digits III and IV are approximately equal. The ZJ-II-5 trackway reveals no manus impressions.

ZJ-II-7.7, ZJ-II-7.8 and ZJ-II-8.7 are more seriously deformed. ZJ-II-7.8 preserves an ovoid to subrectangular impression between the impressions of pedal digits III and IV. This could be a manus trace. ZJ-II-8.7 is preserved in a manner common to ornithopod tracks at the tracksite: it is a shallow track forming a round depression, with the distal ends of digits II–IV discernible, while the metatarsophalangeal region is indistinct, and the axis of the foot (digit III) shows pronounced inward rotation from about 20°–25°.

The ZJ-II ornithopod tracks show typical quadripartite track morphology (i.e. three digital impressions and one heel pad). They resemble (in terms of overall morphology and the specific length/width ratio and the divarication angles between the digits) the trackways that have been named

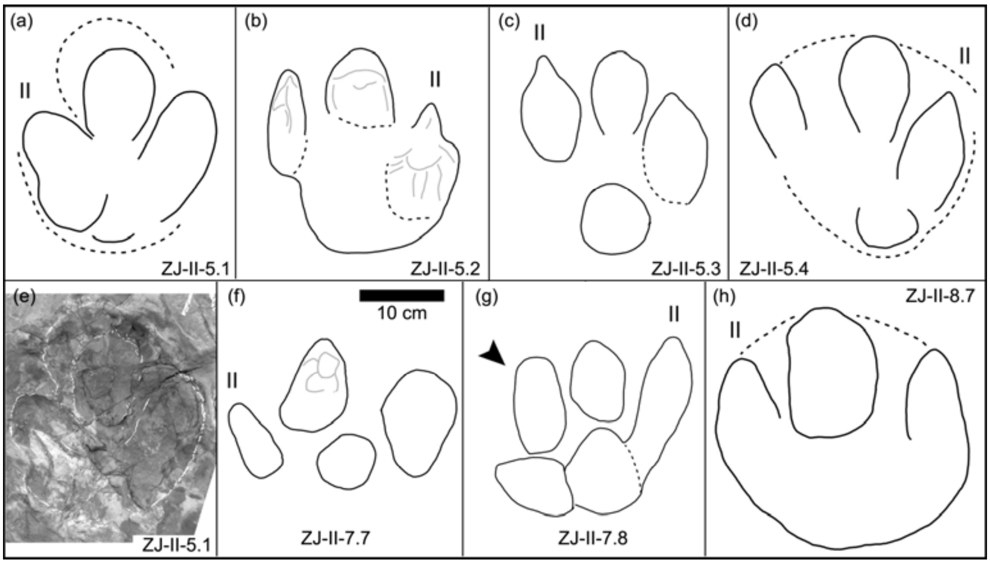

Figure 7 Outline drawings of ZJ-II ornithopod tracks and the photograph of ZJ-II-5.1.

Caririchnium. *Caririchnium* may have been made by either bipeds or quadrupeds [37] and is a common ichnogenus, typically attributed to iguanidontiforms and hadrosauriforms and widely distributed across North America [38–41]. *Caririchnium* has also been reported from Brazil [42], Korea [43], Japan [44], and China [37,45].

Caririchnium lotus from Chongqing includes presumed adult tracks (tracks 37–40 cm in length), subadult tracks (25–30 cm in length), and tracks of young individuals (19–23 cm in length) [37]. The ZJ-II ornithopod tracks are similar to subadult *Caririchnium* tracks in size. However, the poor preservation of the tracks, attributable to the wet and slippery sediments in which they were made, limits further comparison.

3 Paleoecological implications

3.1 Water depths

The trackway of the walking sauropod and the swimming theropod occur on the same surface. This co-occurrence has several potential implications. Either the trackways were made at different times, when the water depths were different, or at the same time when the water depth was more or less the same. Assuming a foot length/hip height ratio in the range of 4.0–5.9 for a sauropod [46,47], and a ratio of 4 for large theropods [4,48], the hip height of the ZJ-II-4 sauropod track maker would have been approximately 1.7–2.5 m, and the ZJ-II-3 theropod track maker hip height would have been approximately 0.9 m.

The width of theropod swim tracks ZJ-II-1 (average 19.2 cm, ZJ-II-1.1–3) is nearly equal to that of the walking theropod tracks ZJ-II-3 (average 18.8 cm, ZJ-II-3.1–2). ZJ-II-1 and ZJ-II-3 are, therefore, assumed to have been made by a track maker of similar-size. At the time the theropod swim traces were made, the water depth must have been roughly equivalent to the hip height of the theropod track maker (i.e. approximately 0.9 m), because while swimming, the kicking motion would register tracks at full leg/digit extension [6,49]. The co-occurrence of walking tracks made by a theropod of roughly equivalent size affirms that the water depth was not consistent throughout the history the tracksite. Further, the presence of mud cracks records the aerial exposer of the substrate and the disappearance of water from the site's environment completely.

The sauropod track maker is estimated to have well exceeded the theropod trackmakers in hip height and to have been tall enough to wade through 0.9 meters of water. Thus it is possible that the sauropod tracks were made under the same approximate conditions as either the theropod swim tracks or the theropod walking tracks.

The orientation of the ZJ-II-1 theropod trackway is oriented northwest to north. However, unlike the case reported by Ezquerra et al. [8] there are no independent indicators to help infer the direction of the current relative to the motion of the track maker.

3.2 Ornithopod herd

The ZJ-II ornithopod trackways ZJ-II-6, ZJ-II-7, and ZJ-II-8 all follow parallel paths (the inter-trackway spacing ranges from 0.8 m to 1.3 m). In this way, they are similar to numerous other ornithopod tracksites that have been interpreted as recording possible evidence of herding behavior, such as at sites like the Lower Cretaceous Dakota Group Dinosaur Ridge tracksite in Colorado, USA [50], the Lower Cretaceous Hekou Group No.6 (ornithopod) tracksite from Gansu, China [31], and the Lower Cretaceous Jiaguan Formation lotus tracksite from Chongqing, China [37]. All tracks comprising ZJ-II-6, ZJ-II-7, and ZJ-II-8 are equally deep and, based on footprint dimensions, all the track makers were roughly similar in size, and this likely indicates that the trackways were made under similar conditions and conceivably at the same time. The trackways potentially record the passing of a hadrosauriform herd moving east, and the inter-trackway spacing ranges from 0.8 to 1.3 m. Ornithopod trackways at this site may therefore indicate gregarious behavior.

3.3 Cretaceous sauropod tracks from Sichuan

The dinosaur track record from the Cretaceous Sichuan Basin is dominated by theropods and ornithopods [20]. Rare bird tracks [51] have also been discovered. The discovery of sauropod footprints at ZJ-II is the first record of sauropod tracks from Cretaceous Sichuan. The wide-gauge stance of the *Brontopodus*-type trackways suggests that the tracks were those of titanosaurian sauropods [32,52], and scattered titanosaur fossils have been unearthed in Qianjiang District, Chongqing [53]. The sauropod trackway follows the same orientation as the theropod trackways. This situation is not uncommon (the most famous example is the purported and much debated theropod-sauropod “chase sequence” from the Lower Cretaceous Glen Rose Formation Glen Rose tracksite of Texas, USA [54]). Regardless, the Zhaojue trackways are the first time that theropod swim tracks have been found on the same surface as tracks of a walking sauropod.

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