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Mid-Cretaceous dinosaur track assemblage from the Tongfosi Formation of China: Comparison with the track assemblage of South Korea

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A B S T R A C T

A Yanji Basin tracksite in the Cretaceous Tongfosi Formation in the Yanbian Korean Autonomous Prefecture, Jilin Province was reinvestigated twenty years after the original study.

The re-examination confirms the presence of tracks tentatively referred to ornithopods and theropod tracks including several not previously reported. In addition to the main track-bearing level, a second footprint horizon was identified from which a probable ornithopod track was collected. Some of the formerly identified tracks were documented using photogrammetry, whereas others that had been collected, eroded, buried or obscured by dense vegetation. The age of the track-bearing beds is inferred to be late Albian to early Cenomanian. Comparison with track-bearing units of the same age in Shandong, China, and Korea indicated quite different compositions of track assemblages. In the case of the Korean sites the differences may be facies related. While the Korean ichnofauna is characterized by the co-occurrence of ornithopod, sauropod and tridactyl theropod tracks with didactyl dromaeosaurid, *Minisauripus* (small theropod), pterosaur and avian tracks, the latter four are absent in the Tongfosi assemblage. This could reflect a restricted environment being not favourable for activities of these trackmakers or simply a preservational bias.

1. Introduction

The Early Cretaceous dinosaur faunas of northeast China are best represented by the Jehol Biota, which is known from exposures of the Jehol Group of western Liaoning, adjacent Inner Mongolia, and northern Hebei. They range in age from Barremian to Aptian (130–120 Ma) (Zhou and Wang, 2010; Pan et al., 2013). Faunal assemblages similar to the Jehol Biota also exist in contemporary deposits in northeast China, Mongolia, Transbaikalia of Russia, and the Korean Peninsula (Chen, 1988). However, late Early Cretaceous (Albian, 113–105 Ma) fossil records are relatively scarce in northeast China, and dinosaur tracks have significantly helped to provide data to fill this gap.

Yanji Basin is a small fault basin in Yanbian Korean Autonomous Prefecture, Jilin Province (Fig. 1). It stretches 50 km north to south and 40 km west to east, occupying a total area of 1670 km^2. Cretaceous strata dominate in this basin, including exposures of hundreds of meters in thickness of sandstones and dark mudstones belonging to the Tongfosi Formation (15.2 m–516.09 m) and the Dalazi Formation (79.5 m–552.57 m) (Yao et al., 1991; Yuan, 2015).

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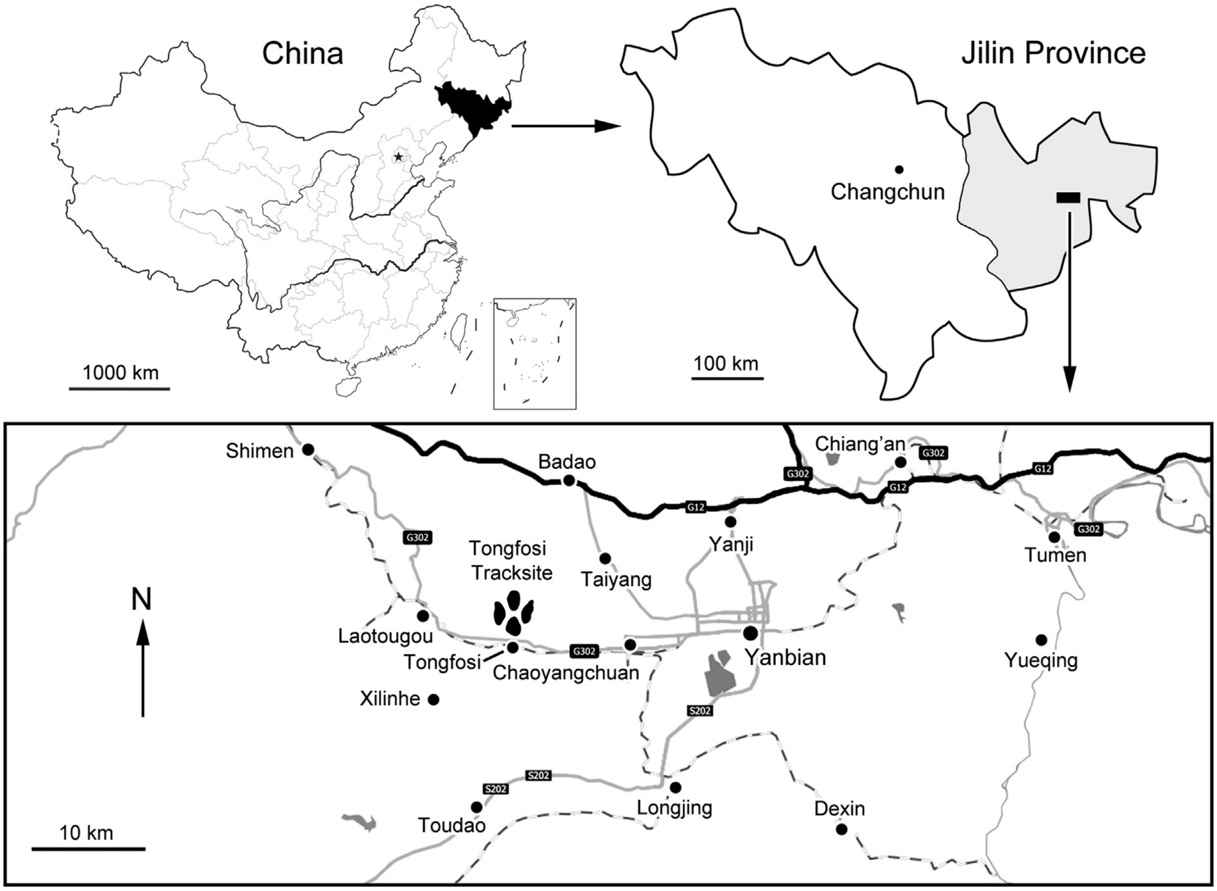

Fig. 1. Geographical setting showing the location (star icon) of the Tongfosi tracksite in Yanji County, Jilin Province, China.

Matsukawa et al. (1995) described a group of ornithopod and theropod tracks from Tongfosi site in the Tongfosi Formation (Fig. 1). When investigating the Tongfosi site in August 2015, the authors (LX and ML) found additional tracks.

1.1. Institutional abbreviations and acronyms

TFS = Tongfosi site, Jilin Province, China.

NIGPAS = Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China.

2. Geological setting

In eastern Jilin Province, the Yanji Basin includes excellent outcrops formed in the middle-late Early Cretaceous. There are two sets of red beds and two sets of ash beds which are unconformable with the underlying coal bearing beds. From top to bottom, these four beds are the Tongfosi, Longjing, Dalazi formations and an unnamed unit labelled "upper red bed" (Zhou et al., 1980).

According to Nichols et al. (2006) angiosperm palynomorphs from the Tongfosi Formation indicate an Early Cenomanian age. *Nipponanain yanjiensis*, *Tulotomoides* sp., and *Orthestheria pecten–Orthestheriopsis tongfosiensis* assemblages have been found in the lower part of the Tongfosi Formation, indicating a comparable fauna to that of the Sunjiawan Formation in western Liaoning (Chen et al., 1998; Wang et al., 2013) and a probable late Albian age (Wang et al., 2013). Based on the angiosperm palynomorphs and conchostracans records, the age of the track assemblage is considered late Albian to early Cenomanian.

The Tongfosi Formation consists of fan delta-lacustrine depositional environments, with well-developed sandstones. Cumulative sandstone thickness is 1.52 m–516.09 m, averaging 190 m (Yuan, 2015). The formation is subdivided from bottom to top into three sections: (1) First Member consisting of grey-black mudstone, argillaceous siltstone, grey sandstone, grey-green glutenite, and conglomerate; (2) Second Member comprising dominant dark grey-black mudstone interbedded with grey siltstone, fine sandstone and varicoloured glutenite in varying thicknesses; (3) Third Member consisting of interbedded dark grey-black mudstone, grey siltstone, fine sandstone and varicoloured glutenite, which contains gastropod fossils (Yuan, 2015). All known dinosaur tracks are from the First Member of the Tongfosi Formation.

3. Materials and methods

As shown in Figs. 2 and 3, tracks at the Tongfosi site occur in situ in a steep cliff exposure and on fallen blocks along the slope beneath. At the time of the study by Matsukawa et al. (1995) the exposure was relatively free of vegetation: see sketch (Fig. 2A) based on Matsukawa et al (1995, fig. 3). During the present study, in 2015, when much thick vegetation was covering tracks, including some studied by Matsukawa et al. (1995) were traced, photographed for 3D imaging and selected casts were collected. The 3D photogrammetry image (Fig. 2D) was taken with a Canon EOS 5D Mark III using Agisoft Photoscan Professional (v.1.0.4) and Cloud Compare (v.2.5.3). Anterior triangle (mesaxony) values (AT) were plotted against maximum length/maximum width (ML/MW) (Fig. 4; Table 1) in order to demonstrate morphological differences

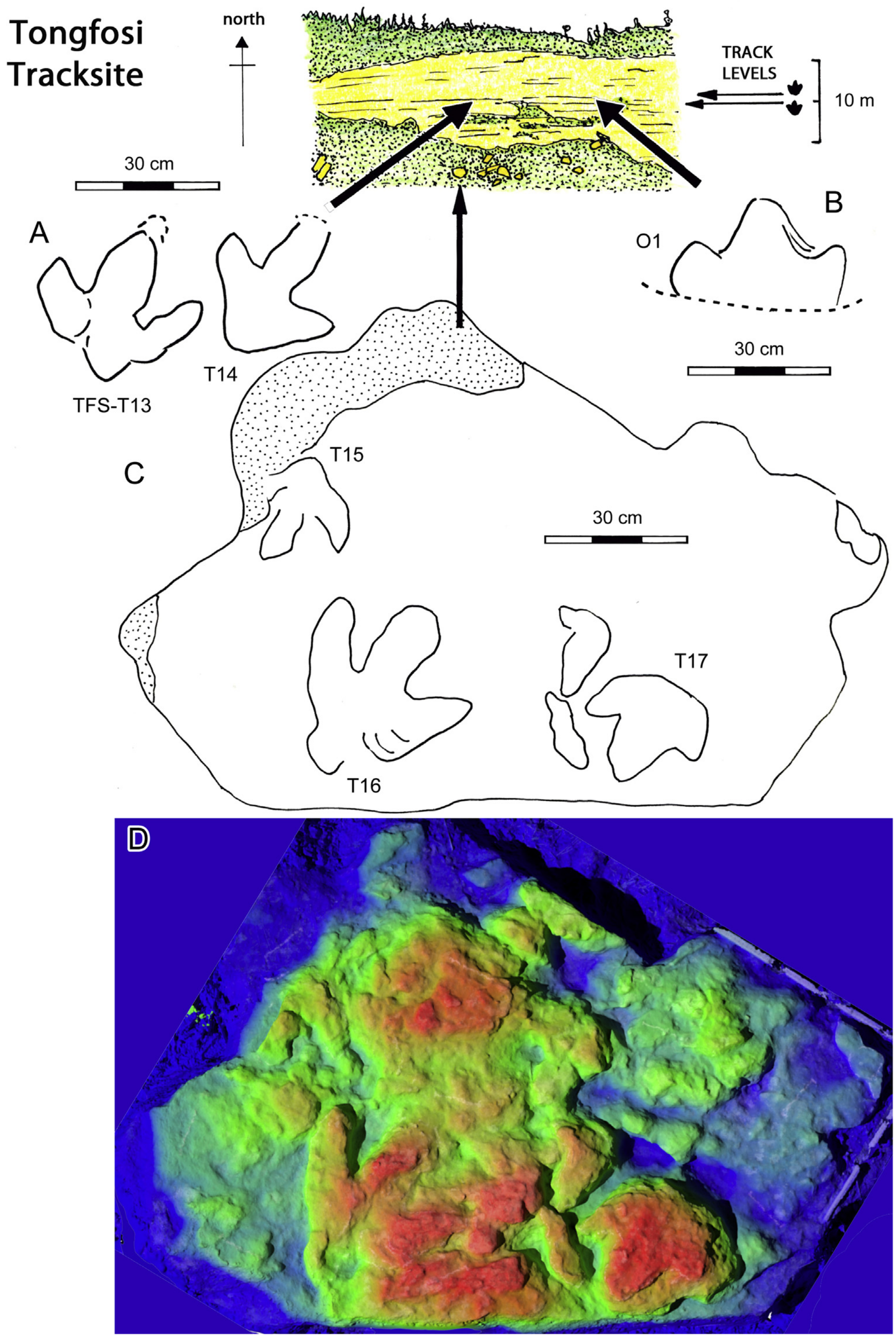

Fig. 2. Six tracks (A–D) from the Tongfosi Formation, Yanji area, shown in relation to sketch of outcrop. A: two in situ tridactyl tracks from lower level, with north orientation shown, B: partial ornithopod track cast from upper level, C and D: fallen slab with tridactyl tracks, C: sketch, D: coloured depth model (elevation map) with red colours showing high elevation (deep) and dark blue and green colours showing low parts (shallow). All tracks are natural casts reversed to positive, impression view, and all shown at same scale. Outcrop sketch redrawn with reference to Matsukawa et al. (1995, fig 3). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

of the tracks. AT was calculated following the methods of Weems (1992).

Some tracks from the Tongfosi site, which were previously described by Matsukawa et al. (1995), were reinvestigated by the authors (LX and ML) who discovered tracks either not seen or not reported in detail by Matsukawa et al. (1995). These included three tracks found in situ from two different levels only 2 m apart (Fig. 2). Two of these tracks preserved as natural casts on the underside of a sandstone bed (Fig. 2A) are oriented towards the north northwest. The third track is the anterior portion of a natural sandstone cast of a blunt-toed tridactyl trackmaker (Fig. 2B), probably an ornithopod. This track cast, which was collected, originated from about 2 m

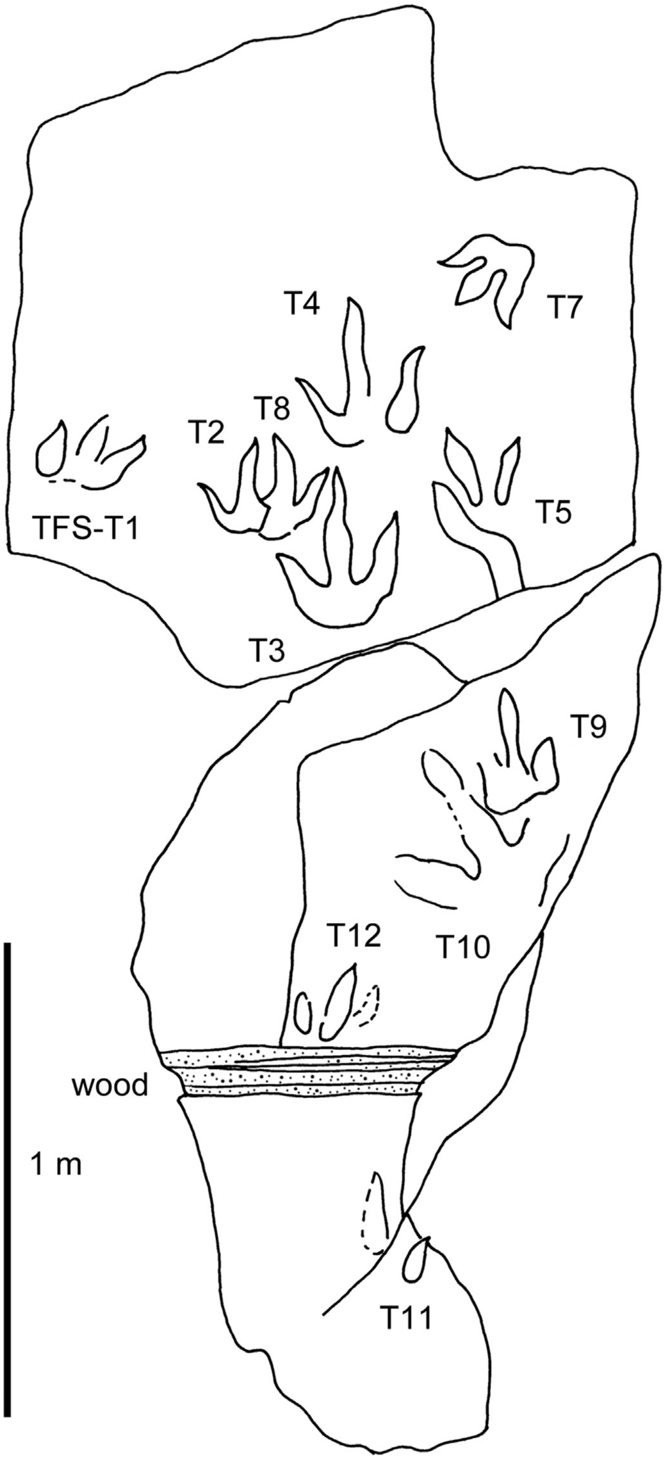

Fig. 3. Interpretative outline drawing of theropod tracks from the Tongfosi tracksite. Modified from Matsukawa et al. (1995, fig 5).

above the level with the north northwesterly oriented tracks. The section was not re-measured as the detailed section measured by Matsukawa et al. (1995) provides a perfectly good reference for locating the track-bearing levels. Several natural casts of tridactyl tracks also occur on a fallen block (Fig. 2C). One of the tridactyl tracks illustrated by Matsukawa et al (1995, fig. 3, lower right). and labelled as a theropod track is the same track shown here as the largest tridactyl on the fallen slab (Fig. 2C).

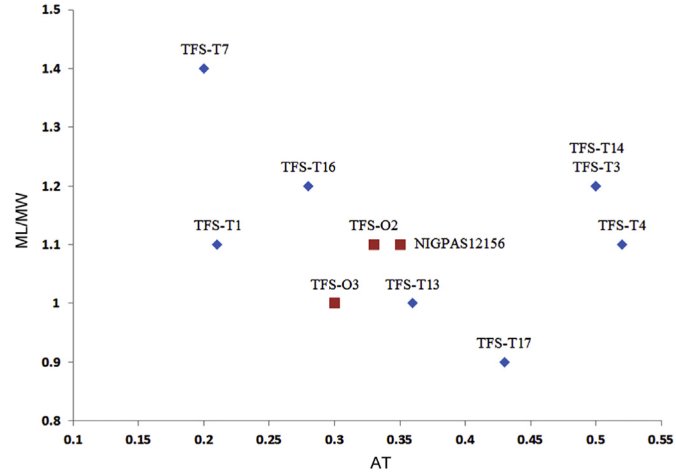

Fig. 4. Bivariate analysis of maximum length/maximum width ratio (ML/MW) vs. AT (anterior triangle length-width ratio) of Tongfosi tridactyl tracks (Lockley, 2009).

Table 1
Measurements (in cm) of dinosaur tracks from Tongfosi tracksite, Jilin Province, China.

Number	ML	MW	II–IV	AT	ML/MW
TFS-T1	21.0	19.5	58°	0.21	1.1
TFS-T3	34.8	28.8	75°	0.50	1.2
TFS-T4	31.0	28.6	85°	0.52	1.1
TFS-T7	31.2	22.4	80°	0.20	1.4
TFS-T8	20.5	–	–	–	–
TFS-T9	28.8	20.8	55°	–	1.4
TFS-T10	43.5	–	–	–	–
TFS-T13	32.6	31.2	70°	0.36	1.0
TFS-T14	32.8	28.5	76°	0.50	1.2
TFS-T15	23.9	–	–	–	–
TFS-T16	40.5	35.2	60°	0.28	1.2
TFS-T17	23.4	25.2	88°	0.43	0.9
TFS-O1	–	36.0	–	0.33	–
TFS-O2	50.0	45.7	50°	0.33	1.1
NIGPAS12156	33.6	30.0	67°	0.35	1.1
TFS-O3	24.4	24.4	60°	0.30	1.0
TFS-F1	45.0	–	–	–	–
TFS-F2	23.6	24.4	90°	–	1.0
TFS-F3	49.7	46.8	–	–	1.1
TFS-F4	39.4	30.6	–	–	1.3
TFS-F5	39.1	29.7	–	–	1.3
TFS-F6	36.5	30.0	–	–	1.2
TFS-F7	21.9	35.0	–	–	0.6
TFS-F8	49.3	42.7	–	–	1.2

Abbreviations: ML: Maximum length; MW: Maximum width (measured as the distance between the tips of digits II and IV); II–IV: angle between digits II and IV; AT: anterior triangle length-width ratio; ML/MW is dimensionless.

In contrast to new and reinvestigated tracks illustrated here, the two part fallen block illustrated by Matsukawa et al. (1995, fig. 5; Fig 3) with 13 complete and partial tridactyl track casts (Fig. 3), all attributed to theropods, are no longer visible. One of us (MM) visited the site three times beginning in the early 1990s. This slab was then situated on the west, down-slope side of the road along the cliff base (Fig. 2) in a field east of the river. However on a second visit (by MM) there had been a major eastward expansion of the river close to the road that had removed any sign of this specimen.

4. Tracks tentatively referred to ornithopods

All probable ornithopod tracks from the Tongfosi site are isolated casts. Of the three tracks described by Matsukawa et al. (1995), one was collected and stored in Nanjing Institute of

Geology and Palaeontology, where it can be observed. The other two were left in situ and appear to have been lost by erosion, or buried or obscured by dense vegetation. Newly recorded TFS-O1 and O2 were both collected from in situ outcrops, with TFS-O1 being from the upper level indicated in Fig 2. None of the Tongfosi tracks referred here tentatively to ornithopods are manus impressions, and, therefore, appear to represent bipedal trackmakers.

TFS-O1 (Figs. 2B, 5C, 6) is 36 cm in width and the distal portion is well preserved. Its mesaxony (length/width ratio for the anterior triangle) is 0.33. The pes cast TFS-O2 (Figs. 5D, 6) is very rounded, and evidently indicates suboptimal preservation; it nevertheless reflects a mesaxonic, functionally tridactyl and digitigrade-foot with a length of about 50 cm. The ML/MW ratio is 1.1. The distal digit III of TFS-O2 was somewhat distorted and damaged during lithification and collection. The mesaxony is similar to that of TFS-O1. The TFS-O2 pes cast shows some degree of quadripartite morphology. There is an ambiguous border between the metatarsophalangeal pad impression and the three digits. The trace of digit III is the longest, while traces of digits II and IV are almost equal in length. Each digit trace has a strong and blunt claw or ungual mark. The heel pad is subrounded to oval in shape. The interdigital divarication angle II–IV is about 50°. Additionally, numerous track casts protrude from the undersides of sandstone beds into the underlying sediment layer, such as TFS-F1 (Fig. 5E). These also display some degree of quadripartite morphology. We tentatively refer to the traces as ornithopodan in origin based on their broad shape, wide digit divarication, robust

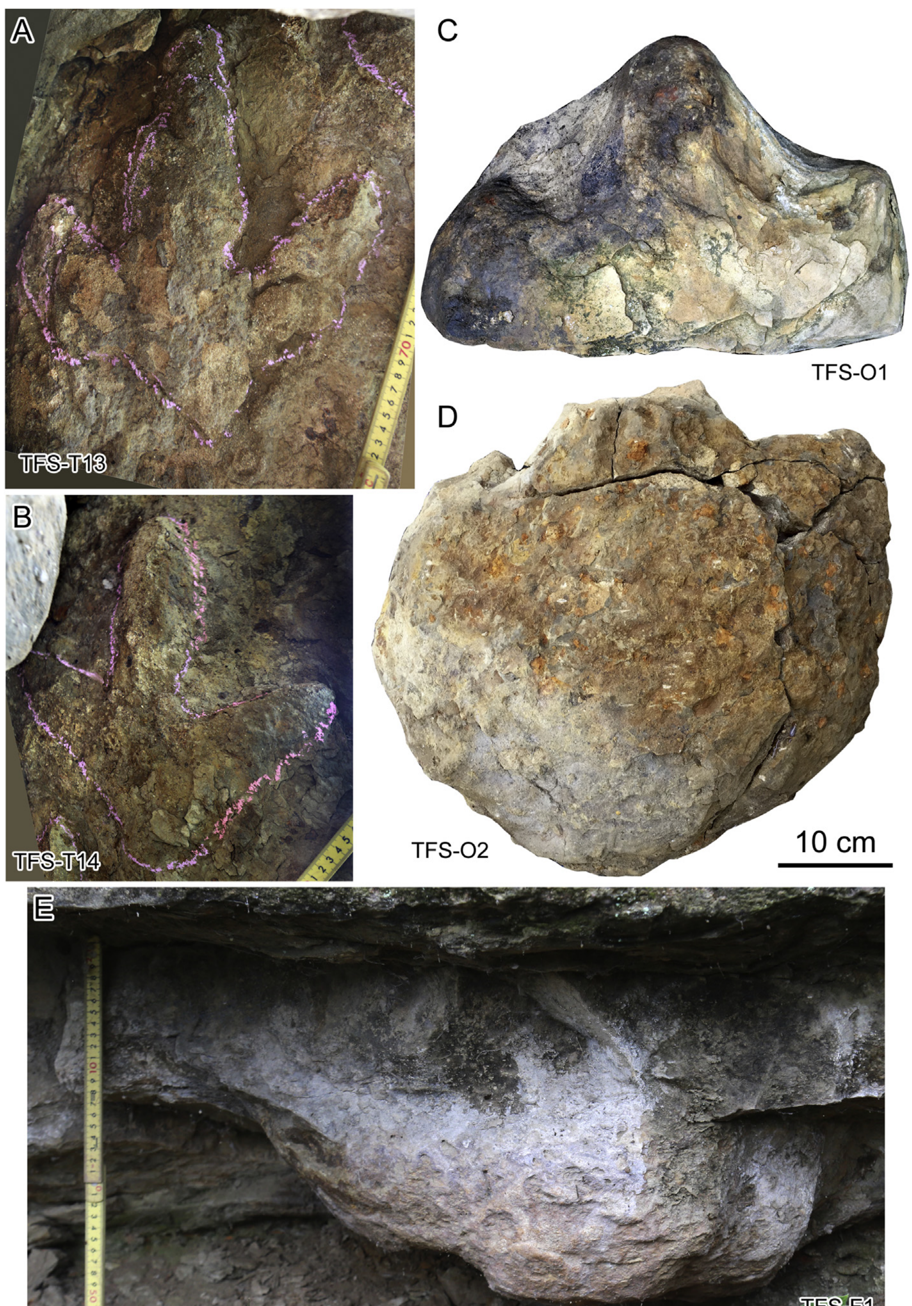

Fig. 5. Photographs of theropod tracks (A, B) and tracks tentatively referred here to ornithopods (C, D, E) from the Tongfosi tracksite.

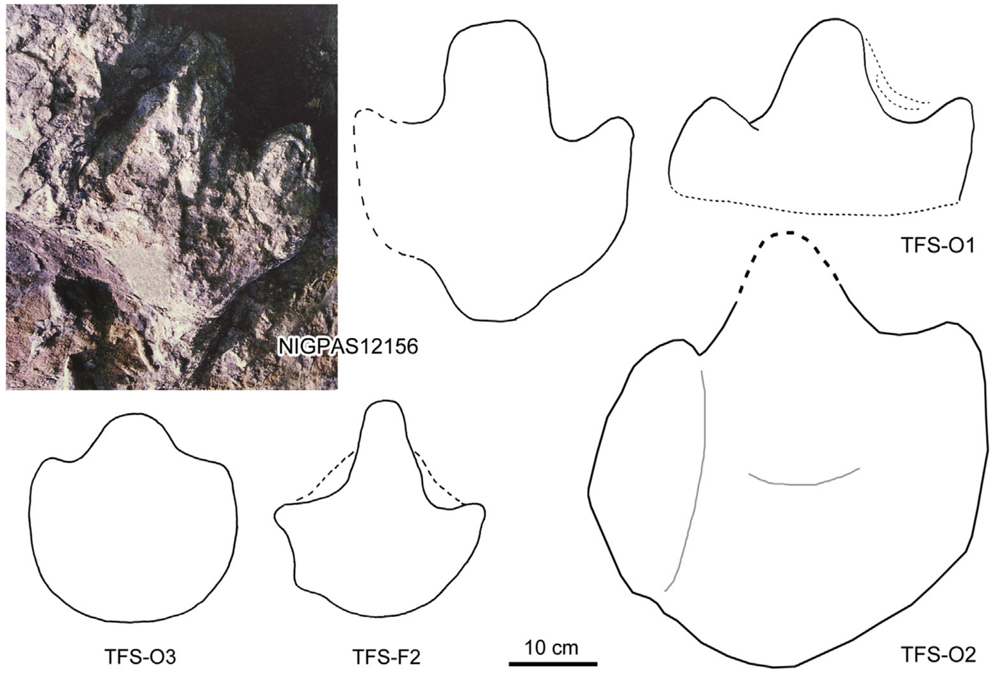

Fig. 6. Photograph and interpretative outline drawings of tracks tentatively referred here to ornithopods from the Tongfosi tracksite. NIGPAS12156, TFS-O3, and TFS-F2 are modified from Matsukawa et al. (1995, fig 6).

digits with well-rounded distal ends and the massive metatarsophalangeal pad giving the track a slightly quadripartite appearance.

NIGPAS12156 (Fig. 6) was described by Matsukawa et al. (1995). It has an incomplete lateral digit and is 33.6 cm in length. TFS-O3 (Fig. 6) may be partially weathered with a relatively low mesaxony (0.30). TFS-F2 (Fig. 6) is tridactyl but poorly preserved, and thus cannot be definitely referred to as an ornithopod track.

TFS-O1, O2, and NIGPAS12156 are morphologically similar to *Caririchnium* isp. tracks which are common in China's Lower Cretaceous formations (Xing et al., 2015c). Like *Caririchnium*, TFS-O1, O2, and NIGPAS12156 are large, subsymmetric tridactyl pes tracks lacking digital phalangeal pad traces but are sometimes divided by creases between digits and along their proximal margin separating a metatarsophalangeal area. This can be considered as a quadripartite configuration, indicating three, fleshy, sub-oval digits and a metatarsophalangeal pad. These tracks have broad ungual traces, and heels that may be rounded or posteriorly bilobed. The mesaxony of most Chinese *Caririchnium* as measured by the anterior triangle l/w ratio is 0.3–0.4 (Lockley et al., 2014; Xing et al., 2016). TFS-O2 is somewhat larger than other *Caririchnium* tracks from China, but comparable in size to *Caririchnium magnificum* from the Lower Cretaceous of Brazil (Leonardi, 1984). However the preservation of TFS-02 is not good enough to draw further conclusions.

Caririchnium is usually attributed to iguanodontid trackmakers (Sternberg, 1932; Currie and Sarjeant, 1979; Lockley, 1985, 1986, 1987). Hadrosauridae are only known from the late Late Cretaceous (Santonian–Maastrichtian) (Prieto-Márquez et al., 2016). During the late Early Cretaceous and early Late Cretaceous (so-called "mid" Cretaceous), large ornithopods were represented by more basal Hadrosauriformes and Hadrosauroidea (e.g. Prieto-Márquez and Norell, 2010; McDonald et al., 2010a, b). Because the Tongfosi Formation is considered late Albian in age, the trackmakers of these *Caririchnium* could be inferred to represent hadrosauriform species or possibly hadrosauroids.

Despite the limited number of ornithopod tracks from the Tongfosi site, a diverse size range is represented. The tracks are between 24.4 and 50 cm long, implying different hadrosauriform trackmakers.

5. Theropod tracks

The theropod tracks with slender digits described by Matsukawa et al. (1995) were not found during this investigation and may have been destroyed or buried by river erosion, (MM personal observation) or possibly by collecting. The specimens described in 1995 were preserved in a fallen slab and catalogued as TFS-T1–T12 (Fig. 3). Most were poorly preserved, probably showing distortion due to wet and soft sediments at the time of track formation, which have elsewhere been reported in dense and disordered theropod track assemblages (e.g. Xing et al., 2014).

Among TFS-T1–T12, T3 appears to be a well preserved and representative track. It is 34.8 cm in length (Matsukawa et al., 1995: table 1) and has a ML/MW ratio of 1.2, a weak mesaxony of 0.50, and slender digit traces. The proximal region of digits II and IV form an indistinct U-shaped metatarsophalangeal region in line with the axis of digit III. TFS-T4 is also similar to T3 in morphology.

Another fallen slab preserves at least three intact tracks and several isolated digit traces. Like TFS-T1–T12, these tracks appear to have been morphologically altered by registration in wet and soft sediments at the time of track formation. TFS-T16 (Fig. 2C) is an isolated tridactyl track and the largest theropod track in Tongfosi site. It is 40.5 cm in length (remeasured by LX and ML), has a ML/MW ratio of 1.2, and a very weak mesaxony of 0.28.

Two newly recorded in situ tracks are catalogued as TFS-T13 and T14 and shown here in their original outcrop orientations (Fig. 2A). Track T13 is the most representative of the track morphology. Digit III projects the farthest anteriorly. The digit impressions reveal indistinct pads. The claw impressions are relatively sharp. The proximal region of digit IV forms an indistinct U-shaped metatarsophalangeal region in line with the axis of digit III. It has a wide divarication angle (70°) and weak mesaxony (0.36).

Based on the tridactyl morphology, claw marks, and length/width ratio, TFS-T1–T17 can be easily identified as typical theropod tracks. The ichnology of theropods is more complicated and convoluted than other groups (especially in China), and we are struggling to remove redundant ichnogenera and ichnospecies (e.g. Lockley et al., 2013). Most tracks from the Tongfosi site cannot be assigned with confidence to known ichnogenera due to their sub-optimal or extramorphological preservation.

TFS-T3 and T4 are similar to large tracks similar to *Grallator* known from the Huanglonggou site (Lower Cretaceous Yangjiazhuang Formation), near Zhucheng, in Shandong Province (Lockley et al., 2015). Olsen (1980) introduced the term *Grallator–Anchisauripus–Eubrontes* plexus (GAE) and suggested that all three ichnogenera could be considered sub-ichnogenera in the super ichnogenus *Grallator*. However this "lumping" ichnotaxonomic approach, although occasionally mentioned in the literature, has not been adopted by subsequent theropod track workers.

TFS-T13 represents another morphotype which at first sight is similar to *Therangospodus*, from the Upper Jurassic of North America and Asia and the Lower Cretaceous of Europe (Lockley et al., 2000), based on its overall-shape with the slightly asymmetric appearance and digit IV longer than II, and the lack of distinct phalangeal pads (see diagnosis of the ichnogenus by Lockley et al., 2000). However, the lack of clearly-separated digital pad impressions may indicate that the foot of the trackmaker was fleshier. However, this could also be an extramorphological feature and indicate for example that these are undertracks. TFS-T13 and T16 have wider digital divarication angles and relatively sturdy metatarsophalangeal pads which resemble *Asianopodus* (Matsukawa et al., 2005). However, digit traces in TFS-T13 and T16 are more robust than in *Asianopodus* type tracks.

All theropod tracks from the Tongfosi site can temporarily be characterized as large *Grallator*-like forms, while different morphologies with slender and strong digits attest to trackmaker diversity.

6. Isolated tracks of possible quadrupeds

The Tongfosi site also yields six poorly preserved tracks without digits impressions (Fig. 7). These tracks are preserved as casts under a sandstone ledge and might possibly be undertracks. However, this cannot be proven by sedimentological features presently. They are catalogued as TFS-F3–F8. TFS-F3 and F8 have an aligned axes and similar sizes (longest diameters ~49.0–49.0 cm) and ML/MW ratios (~1.1–1.2), and were probably left by the same trackmaker. TFS-F4, F5 and F6 are similar in size (36.5–39.4 cm) and ML/MW ratio (1.2–1.3) but their long axes point in different directions and could belong to three different trackmakers of the same type of dinosaur.

TFS-F7 is oval—to sub-rectangular-shaped with a ML/MW ratio of 0.6. It is anterior to TFS-F6 and in combination with TFS-F7 indicates a morphological pattern similar to some quadrupedal dinosaurs, such as sauropods and thyreophorans. However the extremely low heteropody (ratio of manus to pes size) (1:1.1) is different from the high heteropody (1:2.2–1:3.5) typical of small-sized sauropod tracks, which are common in China's Lower Cretaceous sediments (Xing et al., 2015a). Instead, this low heteropody is more similar to some *Brontopodus* from China, such as the Jishan specimens (1:1.5) described by Xing et al. (2013a). Nevertheless, the size of these quadruped (? undertracks) may differ from the true size of the original tracks. Different depths of pes and manus impressions often lead to different amplitudes of variation in the undertracks (Xing et al., 2015b). Furthermore, Thyreophora cannot

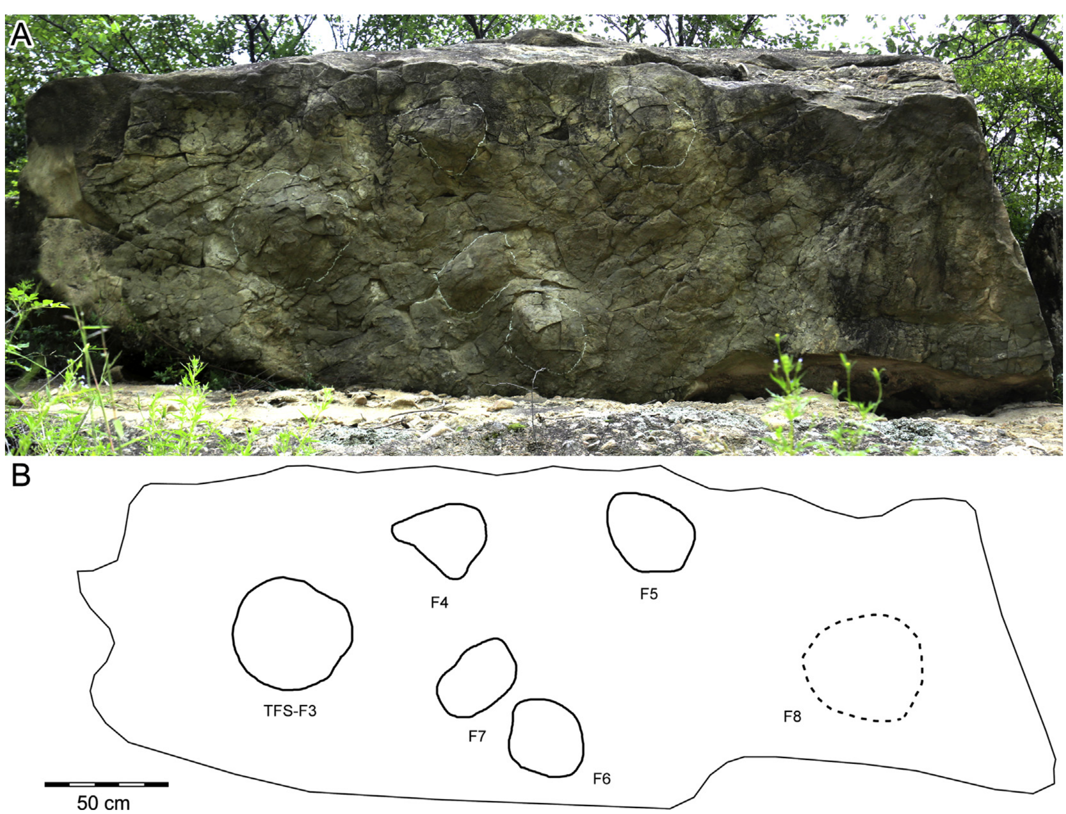

Fig. 7. Photograph and interpretative outline drawing tentatively attributed here to possible quadruped (?sauropod, ?thyreophoran) from the Tongfosi tracksite.

be ruled out, although thyreophoran tracks are rare or absent in most Early Cretaceous assemblages from China (Xing et al., 2013b).

7. The dinosaur faunas from the Tongfosi and Sunjiawan Formations

Nonmarine Cretaceous strata are abundant in North China. The Liaoxi (western Liaoning) Stage (119–100.5 Ma) comprises the Shahai, Fuxin, and Sunjiawan Formations (Wang et al., 2013). Typical components of Jehol Biota, with fishes and insects such as *Lycoptera* and *Ephemeropsis trisetalis*, are abundant in the Jehol Stage, while these are absent in the Liaoxi Stage (Chen et al., 1998). Chen et al. (1998) collectively named animal and plant fossils from the Tongfosi, Longjing, and Dalazi formations as the Yanji Biota. Included in the Yanji Biota is the Teleostean: *Manchurichthys* (Chang and Lui, 1977).

The Tongfosi Formation, in eastern Jilin Province, and the Sunjiawan Formation, in northern Hebei Province and western Liaoning, are comparable in lithostratigraphy and biostratigraphy (Chen et al., 1998; Wang et al., 2013). The Sunjiawan Formation is an important "mid" Cretaceous dinosaur fossil bearing bed that has yielded Ankylosauria (*Crichtonsaurus bohlini* Dong, 2002; *C. benxiensis* Lü et al., 2007), primitive quadrupedal Iguanodontia (*Shuangmiaosaurus gilmorei* You et al., 2003; Norman, 2004); Titanosauria (*Borealosaurus wimani* You et al., 2004); and teeth of Iguanodontia, Titanosauria, and Theropoda (Xie, 2015). The Tongfosi site preserves theropod, iguanodontian, and possible sauropod tracks - an assemblage similar to that in the Sunjiawan Formation. However, due to the presence of isolated imprints, a possible quadrupedal gait of the ornithopod trackmakers cannot be proven. Nevertheless, dinosaur faunas were evidently successful in Northeast China during the post Jehol Biota period of the late Albian.

8. Late Albian dinosaur faunas from North China and South Korea

The Gyeongsang Supergroup, nonmarine Cretaceous strata, divided into the Sindong, Hayang, and Yucheon groups in ascending order (Chang, 1975) has become well-known for abundant and diverse tetrapod footprints including dinosaur tracks/trackways in South Korea (Lockley et al., 2012). Many authors have reported and described vertebrate footprints such as dinosaur, bird, pterosaur, lizard and crocodile tracks/trackways from the supergroup (Lockley et al., 2012, 2014 and others).

Among the formations of the Supergroup, the Jindong and Haman formations (lower Albian – lower Cenomanian) of the Hayang Group (Kim et al., 2005) have been intensively studied and shown to contain abundant "mid" Cretaceous dinosaur footprints, eggs, skin impressions and other vertebrate footprints. The Haman Formation, for example, is characterized by abundant red to purple layers mainly composed of tabular sandstone with thin mudstone drapes which were deposited by sheet flooding on an alluvial plain; lake margin deposits in the uppermost part, and tuffaceous deposits are intermittently intercalated (Paik et al., 2012).

Well-known dinosaur footprints sites in the Haman Formation include the Gajin, Gainri, Adu Island, Godu village, Buyunri, Chu Island, and Sangchonri tracksites in Gyeongsangnamdo Province, Korea. Dinosaur track assemblages from the Haman Formation contain theropod tracks such as the diminutive theropod ichnogenus *Minisauripus* ichnosp., didactyl dromaeosaurid (Deinonychosauria) tracks (*Dromaeosauripus hamanensis*), *Grallator*-like theropod tracks, small scale theropod scrapes, ornithopod tracks *Caririchnium* ichnosp., and sauropod tracks *Brontopodus* cf., *birdi* and *Brontopodus pentadactylus* (Lockley et al., 2008; Kim et al., 2008; Huh et al., 2011; Kim and Lockley, 2012; Kim, J.Y. et al., 2012a; Kim, K.S. et al., 2012c, 2014,; Kim et al., 2014). These are associated with diverse bird (*Koreanaornis hamanensis, Ignotornis yangi, Ignotornis gajinensis*; *Goseongornipes markjonesi*, *Jindongornipes kimi*, and cf. *Aquatilavipes* ichnosp. indet.) and pterosaur tracks (*Pteraichnus* ichnosp. and *Haenamichnus gainensis*) assemblages (Kim, 1969; Baek and Yang, 1997; Kim et al., 2006; Kim, J.Y. et al., 2012a, b). Dinosaur skin impressions have been documented from four localities (Yang et al., 2003; Lockley et al., 2006; Kim et al., 2010; Paik et al., 2010; Huh et al., 2011) and over 120 dinosaur eggs from two egg sites which are Sinsu and Adu islands (Yun et al., 2004; Huh et al., 2011). Although bone fragments have been found in Sinsu, Adu, and Chu islands, most dinosaur bones occur as scattered, broken, and isolated pieces which have not been identified. Only one sauropod bone, about 30 cm in length, discovered at the Chu Island dinosaur tracksite, (where *Dromaeosauripus hamanensis* occurs), was identified as a dorsal rib bone fragment from a sauropod (Huh et al., 2011).

The aforementioned dinosaur ichnofauna (with *Minisauripus*, *Dromaeosauripus*, *Grallator*-like theropod tracks, *Caririchnium*, and *Brontopodus*) is similar to that of the Tianjialou Formation, Houzoushan Dinosaur Park, Junan County, Shandong Province (Li et al., 2015), although the latter lacks pterosaur tracks and abundant bird footprints. Thus the Tongfosi and Sunjiawa track assemblages are quite different from those found in other "mid" Cretaceous Korean and Chinese assemblages in this region, because they lack didactyl dromaeosaur tracks as well as those of the ichnogenus *Minisauripus* and above all, when compared to the Korean ichnofaunas, they lack pterosaur and bird tracks. This may be due primarily to differences in sedimentary facies and environment. Compositions of mid-Cretaceous assemblages vary widely. For example in North America, additional dinosaur and other tetrapod groups such as ankylosaurs crocodylians or turtles can be present by their footprints and co-occur with those of ornithopods, sauropods, theropods, pterosaurs or birds (McCrea et al., 2014). The Tongfosi assemblage may indicate a restricted environment with lower tetrapod diversity or, alternatively, simply reflect a preservational bias. The track bearing Tongfosi sequence described here consists mainly of fluvial sandstones, which although similar to the Houzoushan Dinosaur Park facies in Shandong Province, is quite different from the track rich, thinly bedded lacustrine basin sedimentary facies of the Haman Formation. Especially bird and pterosaur tracks are often found in lacustrine sediments (Kim et al., 2012a, b).

9. Conclusions

1. Restudy of a Yanji Basin tracksite, in Jilin Province, confirms the presence of theropod tracks and tracks tentatively attributed to ornithopods, as reported by Matsukawa et al. (1995).
2. A previously unreported track-bearing level was discovered, from which a specimen was collected.
3. The age of the track assemblage is considered late Albian to early Cenomanian.
4. The track assemblage is unlike assemblages from similar fluvial facies in Shandong Province, which are probably the same age, by the lack of didactyl dromaeosaur and *Minisauripus* (small theropod) tracks.
5. The track assemblage is also unlike assemblages from different facies, but of similar age in Korea, by the lack of didactyl dromaeosaur, *Minisauripus* (small theropod), and especially the lack of pterosaur and bird tracks.

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