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ORIGINAL RESEARCH

Large Scale Dinoturbation in Braided Stream Deposits: Evidence from the Cretaceous Tugulu Group of the Hami Area, Eastern Xinjiang, China

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ABSTRACT

Large dinosaur tracks were recently reported from locations in the Pterosaur-Yadan National Geological Park situated about 100 km south of Hami in Xinjiang Province, China. The park comprises a substantial area in a much larger arid region comprising and an extensive spectrum of Cretaceous, siliciclastic, Tugulu Group, lithofacies representing proximal, basin margin, alluvial fan and braided stream deposits, grading into alluvial plain, deltaic and lacustrine facies near the depocenter. Due to the difficulties of conducting detailed geological surveys in such a vast and inhospitable area, definitive resolution of the litho-, bio- and chrono-stratigraphy is challenging in some areas, and yet to be published in detail. Nevertheless, the occurrence of large dinosaur tracks and dinoturbated units, here interpreted as sauropodan, in association with root casts, dinosaur bone and fossil wood, points to the potential of this frontier area to yield valuable paleontological information, and show that flora and fauna were found in arid braided stream systems away from the lacustrine depocenters where body fossils are more abundant and better known.

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Introduction

Xinjiang Province is a vast semi-arid area at the heart of the Asian continent. It has a complex geological history, representing several major cycles of basin development from Jurassic to Recent, with some localities better known than others. However, the regional geology of the Jurassic-Cretaceous has been studied in some detail. As noted by Wang *et al*. (2019)

> "Basin type and evolution are closely associated with the regional tectonic setting (Hendrix et al., 1992). During the Latest Triassic, Late Jurassic, Late Cretaceous, and Late Cenozoic, the basins were mainly

> foreland basins associated with the reactivation of the Tian Shan [Mountains ... with] Late Jurassic–Early Cretaceous reactivation related to the far-field effect of accretion between Lhasa Block and south Asian …uplift and denudation of the Tian Shan was accompanied by the flexural subsidence of the nearby crust, sediment filling, and formation of sedimentary basins within and adjacent to the Tian Shan range …including the Junggar, Tarim, Turupan, and Yili basins. The southern Junggar and northern Tarim basins are separated by the Tian Shan, while the Turupan and Yili basins are intermontane basins" (p. 3).

As noted by Li *et al*. (2014), "during the Late Jurassic, collision of the Lhasa and Qiangtang blocks (…) a major change in climate from semi-humid and semi-arid to arid condition took place, and reddish strata of the Upper Jurassic were developed across the Junggar Basin (p. 145)". They show (Li et al. 2014: fig. 11) the desertification of the region due to the cutting off of monsoon rains by the uplift of the Tian Shan Mountains. This resulted in the deposition of coarse grained depositional systems "with rare fossils only developed locally in the Junggar Basin due to lack of continuous rainfall and discharge." (Li et al. 2014).

The Lower Cretaceous Tugulu Group of the Junggar Basin was formed under fluviolacustrine conditions (Wang et al., 2014). In Xinjiang, the group has yielded many important vertebrate fossils, including the Early Cretaceous *Dsungaripterus-Psittacosaurus* fauna (Dong, 2001). There are also abundant records of tetrapod tracks known from the Tugulu Group. However, the record is concentrated in the Wuerhe area, Kelamayi, in the southern margin of the Junggar Basin. There are two main tracksites in Wuerhe. The Huangyangquan site is one of them, and includes bird-dominated, non-avian dinosaur (stegosaur, theropod), pterosaur and turtle footprint assemblages (Xing et al., 2011; 2013a; 2014; He et al., 2013). Dinosaur, bird and pterosaur footprints are also known from the Lower Cretaceous asphaltite site (Xing et al., 2013b). The degree of correspondence between body fossils and tracks (Lockley, 1991; Lockley et al., 1994) makes Wuerhe a Type 2b deposit, where the fossil track record dominates and bone evidence is inconsistent with the track fauna.

The Lower Cretaceous Tugulu Group is also exposed in local basins within the greater Junggar Basin, such as the Turpan-Hami Basin, south of the Tian Shan Mountains in Xinjiang, northwestern China (See Gu *et al*. (2003) for lithofacies descriptions). Wang *et al*. (2014; 2017) described hundreds of skeletons and eggs from the pterosaur *Hamipterus* from the Tugulu Group of Turpan-Hami Basin. In September 2018, The First Team of Hydrogeology and Engineering Geology, Xinjiang Bureau of Geo-Exploration & Mineral Development and the Geophysical Team of Sichuan Bureau of Geological and Mineral Investigation and Exploration, discovered dinosaur tracks in the Shennvfeng (Goddess Peak) area (GPS: 42° 43′10.23" N, 92° 37′50.39" E) of Pterosaur-Yadan National Geological Park, in Hami, Xinjiang province. The Shennvfeng location is 667 km southeast of the Wuerhe tracksite, and ~100 km west of Hami city (Fig. 1). The main authors (LX and ML) examined this track site in November 2019 and documented a batch of dinosaur natural track casts.

Institutional abbreviations

SNF, Shennvfeng tracksite, Hami, Xinjiang Uygur Autonomous Region, China

Local Geological setting

The Pterosaur-Yadan National Geological Park is situated in the northern margin of Lop Nur (Luobupo), about 100 km west of Hami and 20 km from Wubao Town. It is about 400 km long from east to west and 20 km wide from south to north. Dinosaur tracks were found in the lower part of Shennvfeng (= The Goddess Peak) in the east of the geopark. Our observations of the sedimentary facies in the study area is consistent with the general suite of lithofacies described by Gu *et al*. (2003) for the Junggar basin from alluvial fans, braided streams alluvial plain to delta and lake from basin margin to depocenter. More specifically the description of the typical braided streams deposits as consisting of gravelly sandstone and moderately fine sandstone is consistent with the lithofacies in the study area.

The sedimentary facies in the study area consist of medium-thick bedded poorly sorted, coarse to very coarse, cross bedded fluvial sandstones with local pebble-filled channels. The coarser sandstones and conglomerates contain angular rip up clasts of finer sandstone, large disarticulated dinosaur bone fragments and fossil wood (Figs. 2–4). There are local water escape structures, and rare root casts. Locally one may observe tabular flat topped units of fine sand, some of which have been trampled or "dinoturbated" (sensu Lockley, 1991) by large trackmakers.

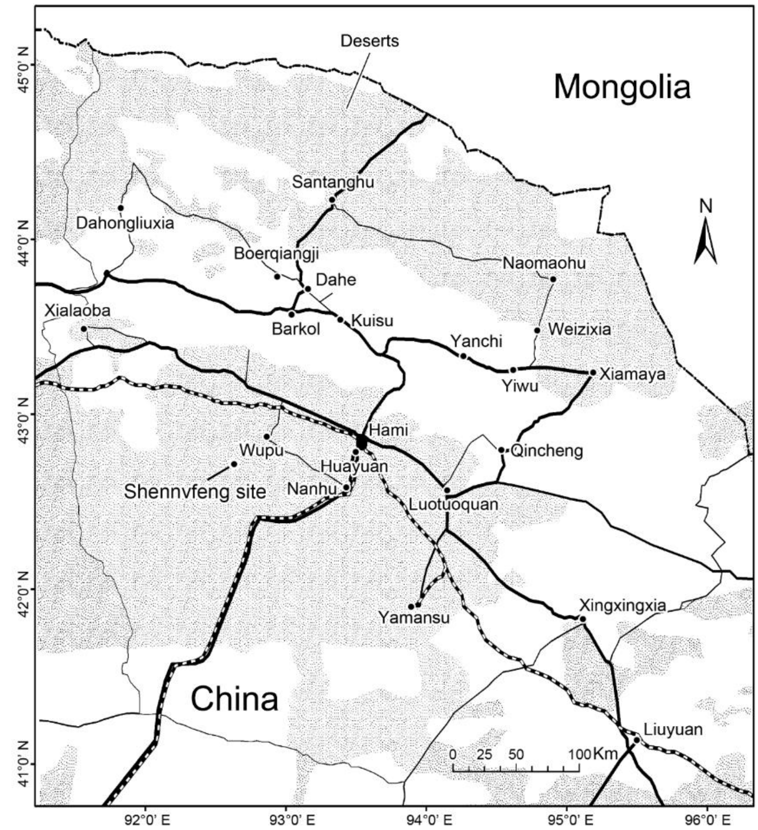

Fig. 1. Locality map of north central Xinjiang showing the Shennvfeng site ~100 km west of Hami.

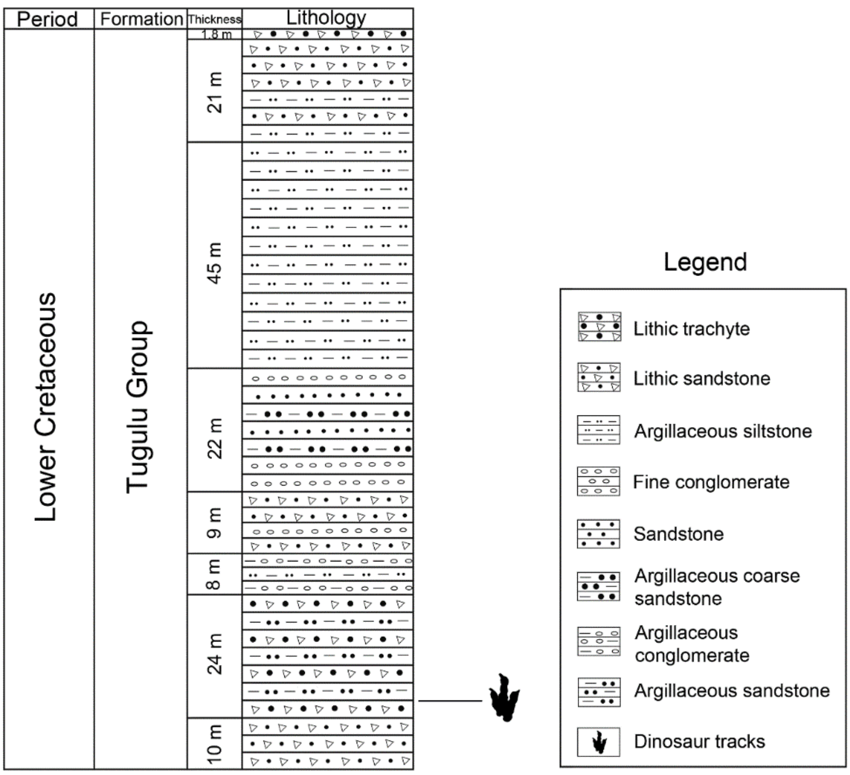

Fig. 2. Stratigraphic section showing position of track-bearing levels in the Tugulu Group at the Shennvfeng site. Based on original data from the geological report of the Paleocene Taizicun Formation (1–7 layers) by the Xinjiang Institution Geological Survey (2003). The discovery of vertebrate fossils and dinosaur footprints indicates that this area should belong to Cretaceous sediments.

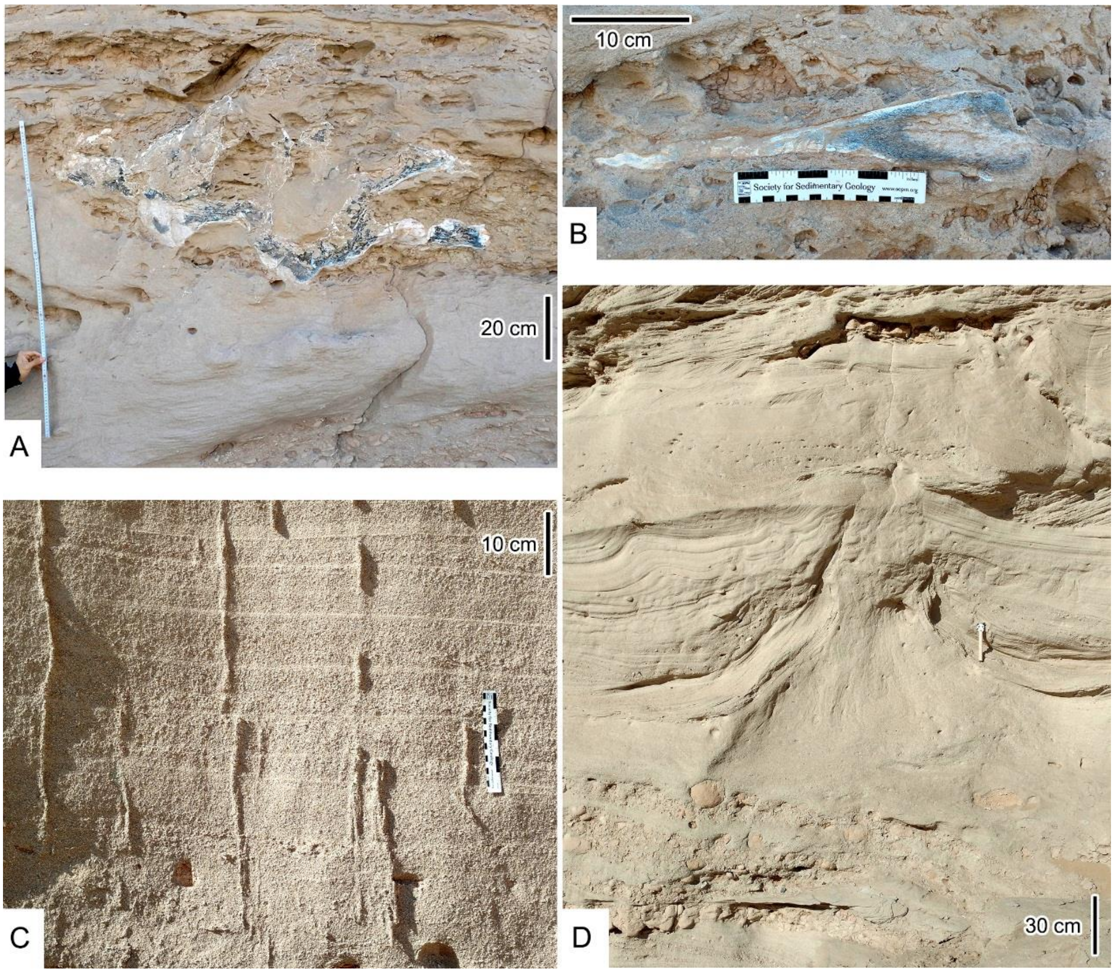

Fig. 3. **A**: large vertebra, and **B**: long bone embedded in sand containing large rip up clasts. **C**: narrow vertical root casts. **D**: water escape structure. Scale in A 1.0 m, scales in B–D 15 cm.

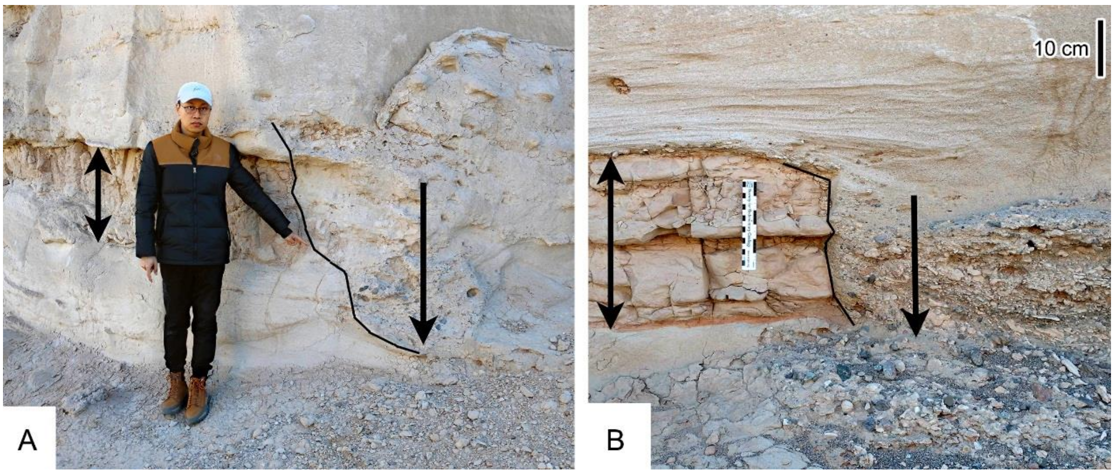

Fig. 4. **A**: The sedimentary facies at the Shennvfeng track site IV show a 70 cm thick pink siltstone (double-ended vertical arrow), abruptly cut by pebble conglomerates (downward facing arrow). Black lines indicate channel margins. The local stratigraphic sequences consist of coarse and very coarse poorly sorted cross-bedded fluvial sandstone with granule (2–4 mm) and pebble (4–64 mm) components especially in channel fills. **B**: A similar pink silty unit cut by a pebble filled channel: compare with A.

According to the Xinjiang East Tianshan 1: 250000 geological map and regional geological survey report (Wupu unit, No. K46C002002), the strata of the Shennvfeng tracksite area belongs to the Paleocene Taizicun Formation–the Eocene Bakaner Formation (Xinjiang Institution Geological Survey, 2003). However, the presence of pterosaur fossils demonstrates that the strata originally attributed to the Paleocene Taizicun Formation instead belongs to the Cretaceous Tugulu Group, shown as lying unconformably on Late Jurassic sediments throughout the region (Li et al., 2014, Table 1 and Fig. 2; Wang et al. 2019, Fig. 3). Due to the incompleteness of detailed geological surveys, in the vast area that constitutes Xinjiang province, and the scarcity of diagnostic fossils hitherto reported (Li et al., 2014), the age of terrestrial strata in some areas of the province remains uncertain.

The Taizicun Formation (sensu Mateer & Chin, 1992) was described as fluvial clastic sediments, dominated by yellow-brown and orange conglomerate, coarse to medium grained feldspathic lithic sandstone, medium-fine grained lithic sandstone, coarse siltstone and argillaceous siltstone. These authors were the first to recognize that Cretaceous sediments were present in the area (*contra* Xinjiang Institution Geological Survey, 2003) although they did not correlate these sediments with the Tugulu Group, which only became possible when new pterosaur fossils and tetrapod footprints were found at the sites mentioned above. However, we are still not sure whether the Paleocene Taizicun Formation-the Eocene Bakaner Formation is completely or partly equivalent to the Cretaceous Tugulu Group in Hami, or whether Paleocene and Eocene strata also exist here (see Zhou & Dean (1996) for list of Paleogene mammals from the Turfan Basin).

Along the southern and eastern margin of the Junggar Basin, the Tugulu Group can be divided into four formations, in ascending order: the Qingshuihe, Hutubihe, Shengjinkou, and Lianmuqin. These are clearly part of a basin margin to depocenter facies spectrum as follows: Qingshuihe Fm: alluvial fans, braided rivers, alluvial plains, deltaic, shore-shallow lake, Hutubihe Fm: deltaic, shore-shallow lake, Shengjinkou Fm: deltaic, Lianmuqin Fm: deltaic, shore-shallow lake (Gu et al., 2003). In the northwestern margin of the basin, the Tugulu Group can only be divided into Upper, Grey-green, and Lower layers (Academy of Prospecting and Developing, Xinjiang Bureau of Petroleum, 1977; 1996; 1997). A detailed stratigraphic comparison of the Tugulu Group exposures at the Pterosaur-Yadan National Geological Park and the Junggar Basin is needed, but will not be discussed here.

Materials and Methods

Based on field observations, there are about 20 features than can reasonably be interpreted as large tracks, exposed in cross section. Although most have to be treated as individual features, not related to identifiable trackways, they are concentrated in a few levels where finer sediments were deposited in tabular units. Thus, they are concentrated in a few "dinoturbated" units. For the description of the natural track casts, we follow the terminology recently proposed by Xing *et al*. (2015a) (including the definitions of upper surface, lower surface, length, width, depth, striations, entry and exit).

Due to all the track bearing units being exposed in cross section, with no horizontal surfaces of any extent, it is only possible to measure the depth and width of tracks. These casts, are visually spectacular (Figs. 5–7) but not suitable for determining foot morphology: i.e., they rank low (0-0.5) on the four point (0-1-2-3) quality of preservation scale proposed by Belvedere & Farlow (2016) and refined by Marchetti *et al*. (2019). For these reasons it was not deemed useful to obtained 3D photogrammetric images for morphometric analysis.

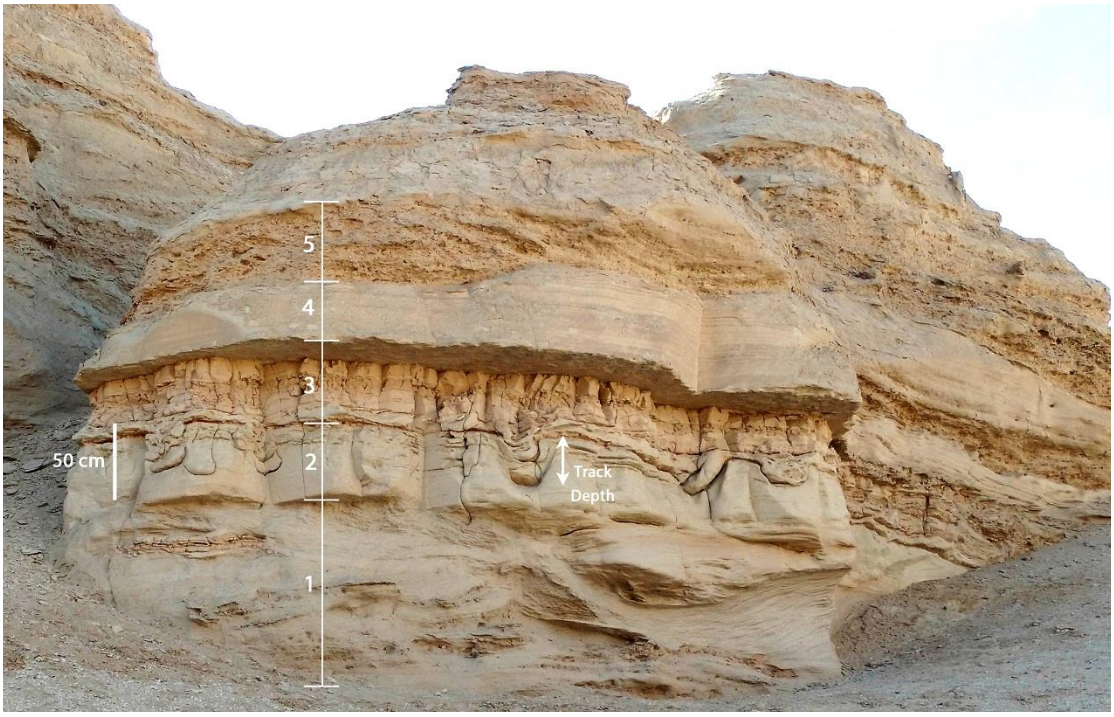

Fig. 5. The main outcrop of the Shennvfeng site I is divided into five distinct predominantly sandstone layers. Among the five dinoturbated sites, it reveals the largest, most obvious concentration of large tracks visible in cross section.

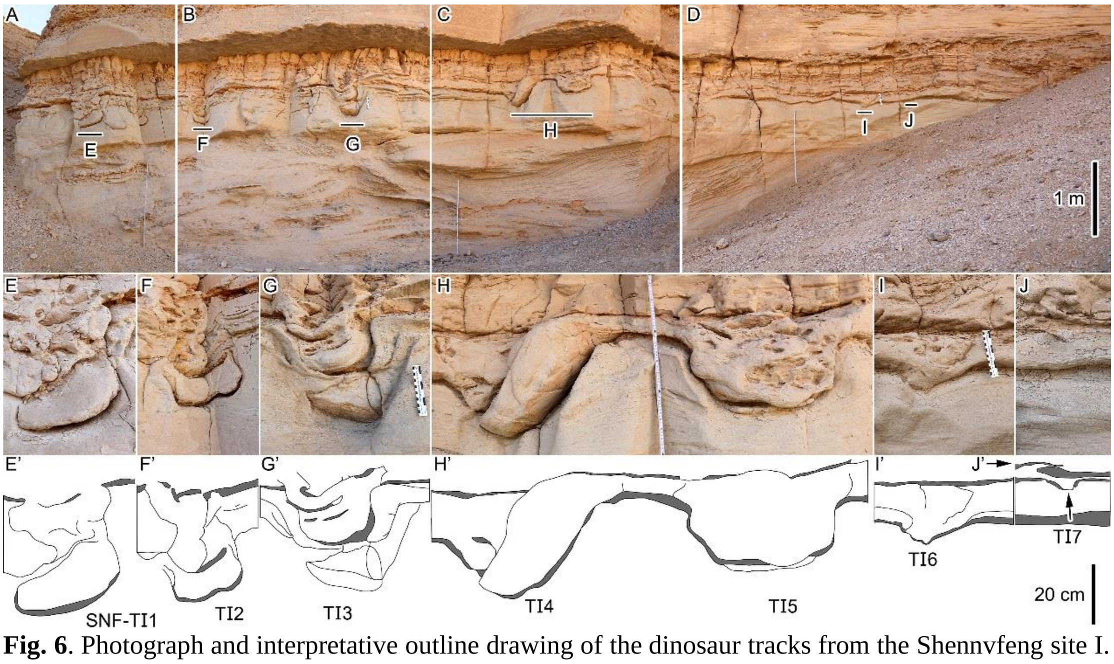

Fig. 6. Photograph and interpretative outline drawing of the dinosaur tracks from the Shennvfeng site I. **A–D**: Overview, compare with Fig. 5; **E–J**: Close-up photographs of the individual tracks, **E'–J'**: Corresponding interpretative outline drawings.

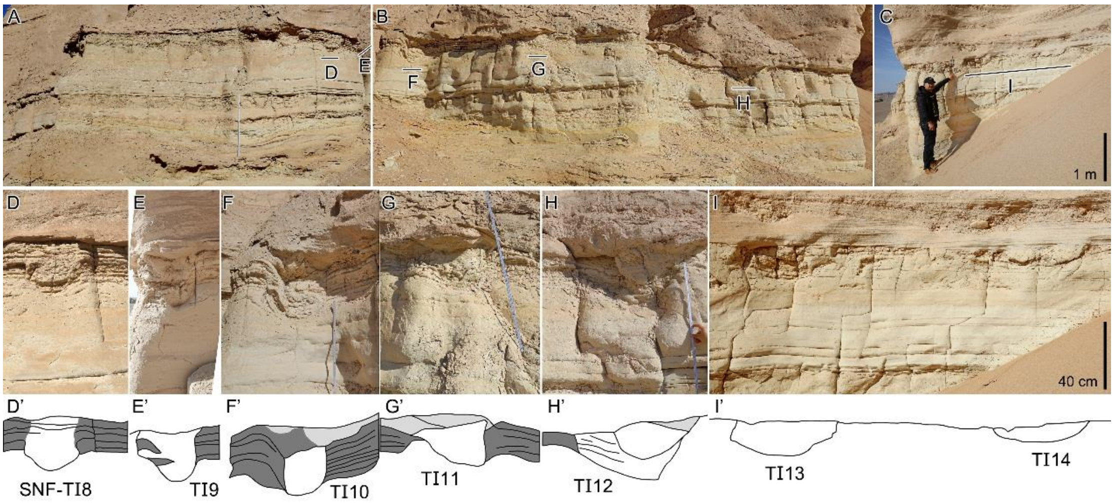

Fig. 7. Photograph and interpretative outline drawing of the dinosaur tracks from the Shennvfeng site II. **A–C**: Overview, **D–I**: Close-up photographs of the tracks, **D'–I'**: Corresponding interpretative outline drawings.

Ichnology

The tracks are not well preserved, and the information they provide is limited. The tracks we observed are mostly exposed in cross section at a minimum of five sites (Track area I–V), containing 7, 7, 1, 1 and 1 recognizable discrete tracks, respectively, and designated SNF-TI1–7, SNF-TI8–14, SNF-TI15, SNF-TI16 and SNF-TI17, where SNF denotes Shennvfeng. The tracks can be divided into three size categories, small (≤10 cm) including 2 pes prints, mid-sized (≤35 cm) including 8 pes prints, and the large (＞35 cm) with 6 pes prints.

Track area I

The main outcrop with the most visually-spectacular track-bearing strata yields the tracks designated as SNF-TI1–7. The main outcrop is here divided into five distinct predominantly sandstone layers (1–5 of Fig. 5). In ascending stratigraphic order these consist of: Layer 1: coarse grained cross and trough cross bedded sandstone with a few pebbles and resistant layers, Layer 2: thinly, planar bedded sandstone, about 50–60 cm thick, grading up into a thin mudstone layer (~ 2 cm thick). Layer 2 is penetrated by up to at least half its thickness (35–40 cm) by conspicuous cylindrical tracks (SNF-TI1–7), all sandstone filled. Layer 3 consists of 50–60 cm of blocky fine silty sandstone with a planar upper surface; Layer 4 consists of horizontally bedded sandstone 60–100 cm thick; Layer 5 consists of cross bedded mud chip conglomerate 60–100 cm thick which incises unit 4.

Working in the above listed order SNF TI1–7, from left to right these seven tracks have been given the labels E through J, with H representing both TI4 and TI5. (Fig. 6). In general, the tracks display either horizontal or inclined floors. However, as the orientation of the individual tracks cannot be determined, the inclination of the track floor can only be described in relation to the sub vertical face of the outcrop as left or right or inclined inwards or outwards relative to the regional dip of the strata which is nearly horizontal.

Beginning with the larger and generally deeper tracks, a common feature of tracks TI1–TI4 is that the lower portion of the fill is represented by a pillow- or pancake-shaped disk ~15 cm thick and ~25–30 cm in diameter. The underside of these pillow shaped discs is separated from the matrix of layer 2 by fine grained muddy sediment, which appears to have been pushed down from the mud layer separating layers 2 and 3. There is no sign that the underside of these casts is differentiated into separate digit traces. For this reason, the morphology is matched only by sauropod pes prints, such as *Brontopodus* (Lockley et al., 2002), of which the length-width ratio is generally 1:2. The floor of track TI1 is inclined to the left and slightly outwards relative to the outcrop surface. The floor of track TI4 and the pillow-shaped fill is steeply inclined to the left.

TI2 and TI5 have similar depths of ~ 33.0 cm, SNF-TI2 has a concavity in the middle of the undersurface, suggesting that it may be a sauropod manus print. This feature is similar to the interval between digit I and digit V in the heel of the sauropod manus track for example, YSI-S3-LM12A from the Yanguoxia No.1 track site (Xing et al., 2015a). The floor of track TI2 is inclined to the left, but the floor of TI5 is horizontal.

The middle-sized cast TI3 is ~35.0 cm deep, and appears to be two track casts, one directly above the other with a total depth of at least 35 cm. The base of the lower fill is at least 25 cm in diameter and inclined slightly to the right and the floor of the upper fill, situated ~20.0 cm above the floor of the lower cast, and inclined slightly to the left. The flat floor of the casts represents a foot sole with no preserved toe marks. This trait is again most similar to that of sauropod tracks, such as *Brontopodus*, which are widely distributed in the Early Cretaceous strata of China (Lockley et al., 2002).

The small-sized SNF-TI6 is similar to SNF-TI7, but larger, approximately 18 cm deep and 8 cm in length. SNF-TI7 is approximately 4 cm deep and 4 cm in length, and is the smallest track at the Shennvfeng site. The bottom surface of SNF-TI6 did not register a planar surface, as in TI1-TI5 suggesting that the irregular surface might represent heel or toe pads. Based simply on their relatively small sized, SNF-TI6 and SNF-TI7 were most likely not made by large sauropods as inferred for SNF-TI1–TI5. So, the possibility of another dinosaurian trackmaker cannot be ruled out.

Track area II

The track-bearing strata containing infilled footprints of SNF-TI8–14 can be divided into three layers, in ascending order: an approximately 80 cm thick sandstone (layer 1); a 25 cm thick interbedded sand-mudstone (layer 2) containing thin-bedded (2–3 cm) sandstone layers and a 1–2 cm thin-bedded mudstone layer; overlain by a thick (>1 m) coarse cross bedded sandstone containing rip up clasts (Fig. 7). Thus, the thin-bedded middle unit appears like a sandwich layer between two more massive sandstone units. It is this layer that contains the tracks SNF-TI8–14 which appear to have been registered after layer 2 was deposited.

SNF-TI8–12 have similar depths, 26–32cm, and similar lengths, 20–29 cm. The interval between these tracks is fairly regular (2–3 m) and based on track size may have been made by similar trackmakers. There are many possibilities, but based on the similarity with tracks SNF-TI1–TI5 sauropods appear to have been the most likely trackmakers. SNF-TI13 and 14 are larger tracks, ~50.0 and 53.0 cm in length, respectively, with compressed oval-shapes, and are consistent with the general form expected of sauropod pes traces. The two tracks are 1.6 m cm apart.

Track area III

There is only one track, designated SNF-TI15, in track area III (Fig. 8). Track area III is adjacent to track area II, and the track was again registered after the deposition of layer 2, by a large animal. The footprints is ~ 43 cm deep, penetrating into the upper part of layer 1. The footprint is about 1.0 m in maximum diameter, strongly suggesting it can only have been made by a sauropod pes. However, there are no digit traces or other morphologically diagnostic features, to allow further characterization.

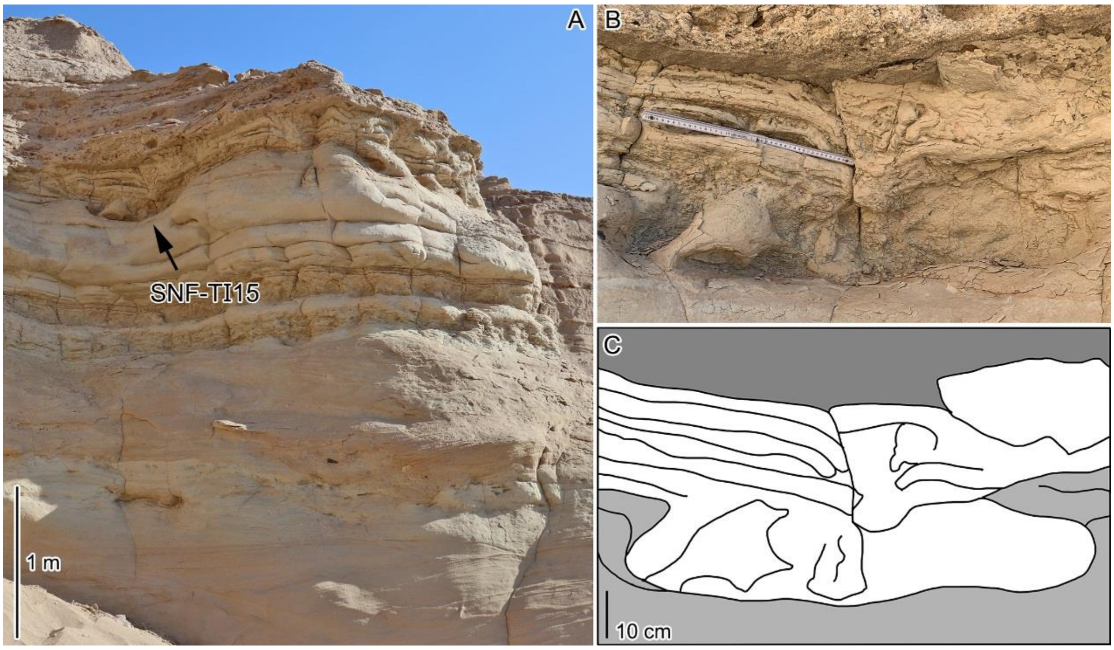

Fig. 8. Photograph and interpretative outline drawing of the dinosaur tracks from Shennvfeng site III. **A**: Overview, **B**: Close-up photograph of the track, **C**: Corresponding interpretative outline drawing.

Track area IV

There is only one track designated SNF-TI16 in the track area IV (Fig. 9). It is located in the lower part of a 70 cm thick pinkish siltstone, above a sandstone of over 70 cm (Fig. 4). SNF-TI15 is 20.0 cm deep. The whole length, including the footprint (32.0 cm) and front and rear sandy mounds (sediment displacement rims), is ~68.0 cm. SNF-TI16 is not a cast, but a mold, and the preservation is extraordinary. It is probable that the trackmaker's foot penetrated the softer fine silty sand layer causing plastic deformation which makes any interpretation of track morphology difficult.

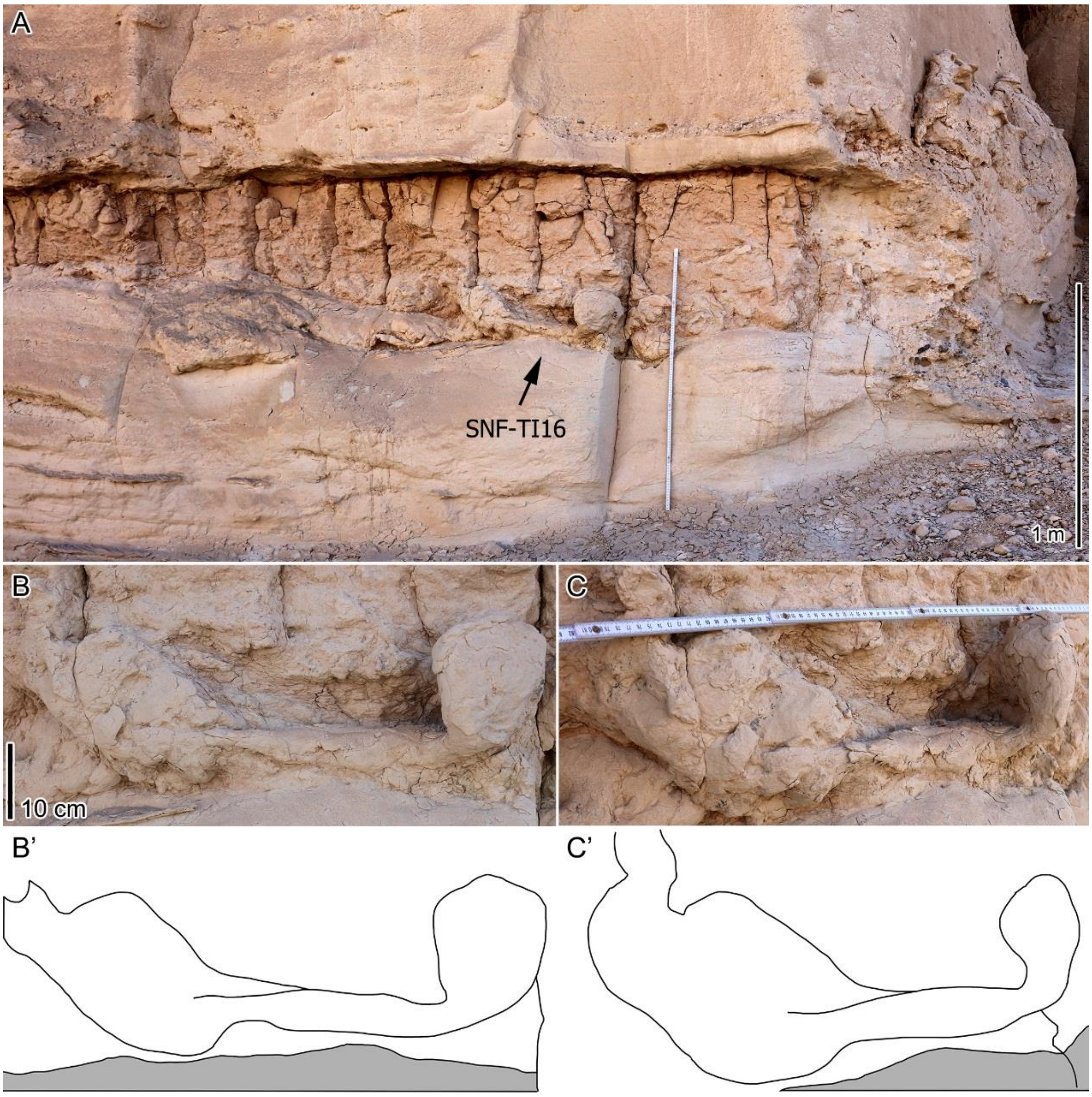

Fig. 9. Photograph and interpretative outline drawing of the dinosaur tracks from Shennvfeng site IV. **A**: Overview, compare with Figure 4; **B and B'**: Cross sectional view of a track, **C and C'**: The track at an oblique angle. Note sediment bulges forming a rim around the track.

Track area V

Area V reveals several pillow like features resembling the casts found at site I. Some are still in situ as pendant protuberances above a notch were finer sediment has eroded away. Others are separated as loose pillow shaped casts up to ~35 cm in diameter. An appropriate collective term for these features is "dinoturbation" (Fig. 10)

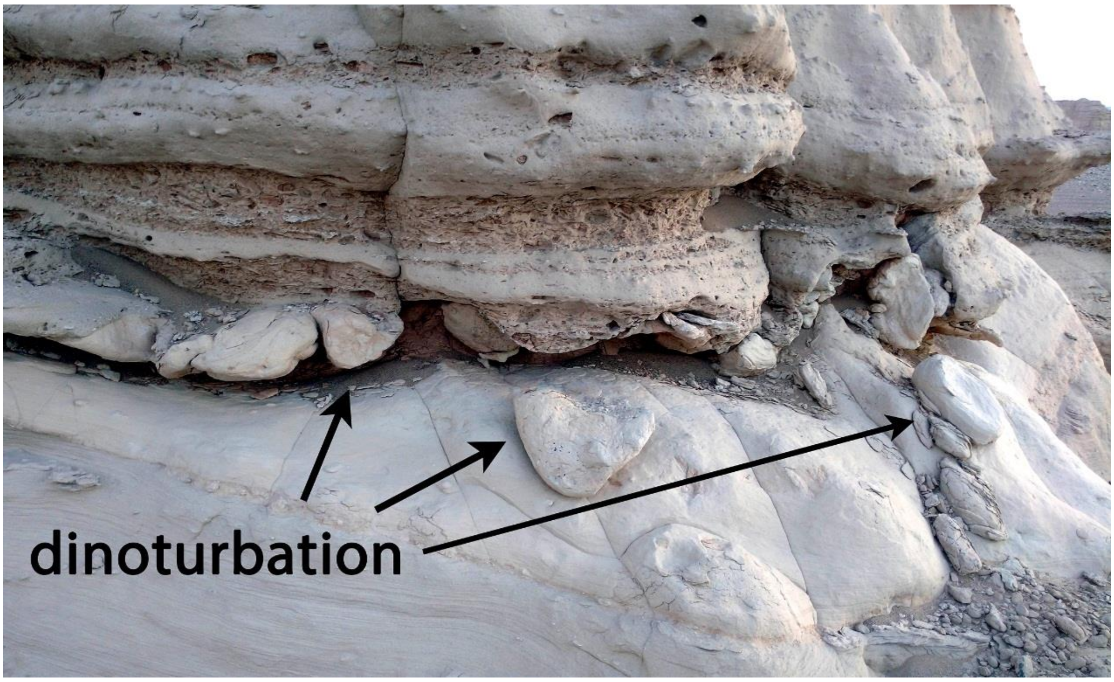

Fig. 10. Photograph of the dinosaur tracks from the Shennvfeng site V. The pillow like features interpreted as poorly preserved dinosaur track casts.

Discussion

The Shennvfeng specimens are all isolated and poorly preserved filled tracks and casts, although the track fill at site V appears to have been eroded out. The absence of any distinct toe morphology makes the identification of specific trackmakers (even simply distinguishing between bipeds and quadrupeds) virtually impossible.

Similar dinosaur track casts of uncertain affinity, but probably representing large ornithischians, have been described from the Maastrichtian of Utah (Difley & Ekdale, 2002). Similar large track preservation has also been reported from the Early Cretaceous Jiaguan Formation Lotus tracksite in Qijiang, Chongqing (Xing et al., 2015b; 2015c). Likewise, sauropod tracks from the Early Cretaceous Hekou Group Zhongpu and Yanguoxia sites in Gansu (Xing et al., 2015a), and deep natural sauropod and ornithopod track casts from the Lower Cretaceous Xiagou and Zhonggou Formations, Gansu Province (Xing et al., 2017) are comparable.

Nonetheless, the dinoturbated levels indicate the presence of a relatively active and perhaps diverse dinosaur fauna, that probably included large sauropods and possibly other medium and small dinosaurs. Moreover, it is the first record of dinosaur tracks in the Turpan-Hami Basin in which Wang *et al*. (2014; 2017) described pterosaur fossils, but no documentation of dinosaur material was published.

Most sauropod trackways in China are wide- (or medium-) gauge and are therefore referred to the ichnogenus *Brontopodus* (Lockley et al., 2002), which, pending further study, may be a suitable label for the large-sized tracks from the Shennvfeng site, such as TI13, 14, 15. Records of sauropod from the Cretaceous of Xinjiang are very rare, including the large-sized Euhelopodidae cf. *Asiatosaurus mongoliensis* and a possible camarasaurid from the Upper or Grey-green Layer of the Tugulu Group (Dong, 1973). *Asiatosaurus* is consistent with the Cretaceous *Brontopodus* type trackways left by Titanosauriformes (brachiosaurids+Titanosauria) sauropods (Wilson & Carrano, 1999; Lockley et al., 2002; Xing et al., in review).

The medium-sized tracks from the Shennvfeng site may be referred to other dinosaurs. Among those known as body fossils from the Tugulu Group, are the stegosaur *Wuerhosaurus homheni* (Dong, 1973; 1990), which could correspond to the ichnospecies *Deltapodus curriei* (Xing et al., 2013). The large carcharodontosaurid *Kelmayisaurus petrolicus* (Dong, 1973; Brusatte et al., 2012) and small the theropod Coelurosauria *Xinjiangovenator parvus* (Rauhut & Xu, 2005), are also known. Tracks that likely correspond to theropod skeletal records were recorded at the Huangyangquan tracksite (Xing et al., 2011). Lockley (1991) and Lockley *et al*. (1994) discussed the categorization of formations and facies according to the relative abundance (proportions) of trace (tracks) and body fossils. They defined Type 1 deposits as containing only tracks, Type 2 as track dominated, Type 3 as having tracks and bones in more or less equal abundance, Type 4 as bone-dominated, and Type 5 as containing only bones. Deposits of Type 2, 3 and 4 may be subcategorized as "a" where the track and bone evidence is consistent regarding faunal composition or "b" where the evidence is inconsistent. This scheme has the flexibility to be used locally or regionally based on comparable lithostratigraphic units. In the case of the immediate study area we can only conclude that there are a few tracks and a few dinosaur bones. Thus, it its locally a type 3 deposit.

It is of interest that the tracks, here inferred to represent sauropods, and possibly other groups of unknown affinity, are associated with braided stream deposits. In general, braided stream deposits are not conducive to extensive, or high-quality track preservation. There are two reasons for this. The main reason is that tracks, especially small tracks, do not register or preserve well in coarse sand and gravel that is subject to reworking under fluctuating and intermittent flow regimes with shifting, down cutting channels, and only a few small areas of fine grained sediment deposition. The second reason, in the case of the Tugulu Group in the study area, is that it appears to represent an arid environment close to the basin margins: i.e., some distance from the lake deposits in the basin depocenter where remains of pterosaurs and other fauna are more frequently found. However, the tracks are useful as they are not transported and indicate that dinosaurs frequented these more marginal areas. It is also noteworthy that these tracks are found in association with local, finer grained silty deposits that appear to represent locally flooded, small wet areas in the braided stream system. Arguably, such local wet areas would be more attractive to fauna in an arid area, and it would also be the most suitable area to register and preserve tracks.

Our observations in the study area reveal dinosaur tracks were the facies is suitable for their preservation as well as scattered, transported dinosaur bone (Fig. 3). Perhaps most significantly, these natural dinosaur casts indicate the potential for more dinosaur tracks to be found in Pterosaur-Yadan National Geological Park in Hami and the Turpan-Hami Basin, Xinjiang Province. Fossil wood and root casts (Fig. 3C) indicate that this area supported plant life. However, the scarcity of root casts and their narrow, but deep penetration, suggests relatively small plants that needed to send their roots deep to reach a low water table below porous sediment. The dinosaur track casts, bones, wood and plant traces indicate the potential for more dinosaur tracks to be found in Pterosaur-Yadan National Geological Park in Hami and the Turpan-Hami Basin, Xinjiang Province, and supplement the information that can be drawn on to enhance the geotourism already favored by the spectacular Yardang landscapes.

Conclusions

Multiple dinoturbated units in the predominantly coarse sandy and pebbly sandstones of the Pterosaur-Yadan National Geological Park indicate the activity of large dinosaurs in braided stream settings in the Hami and the Turpan-Hami Basin. The larger tracks are attributed to sauropods, but trackmaker affinity is difficult to determine as all tracks are preserved in cross section, with no examples of exposed track bearing surfaces. These sediments are considered part of the Cretaceous Tugulu Group which has hitherto been difficult to date and correlate in this vast arid region. The presence of dinosaur tracks, dinosaur bone and fossil wood indicates that coarse, high energy basin margin sediments, representing arid settings, also show paleontological potential in a region where finer grained, low energy, basin-center depocenter deposits have already proved moderately rich in tetrapod body fossils and tracks representing lacustrine basin faunas.

Disclosure statement

No potential conflict of interest was reported by the authors.

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