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First record of *Deltapodus* tracks from the Early Cretaceous of China

Lida Xing [a,b,*], Martin G. Lockley [c], Richard T. McCrea [d], Gerard D. Gierliński [e,f], Lisa G. Buckley [d], Jianping Zhang [a], Liqi Qi [g], Chengkai Jia [g]

[a] School of the Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
[b] Key Laboratory of Evolutionary Systematics of Vertebrates, Chinese Academy of Sciences, PO Box 643, Beijing 100044, China
[c] Dinosaur Tracks Museum, University of Colorado at Denver, PO Box 173364, Denver, CO 80217-3364, USA
[d] Peace Region Palaeontology Research Centre, PO Box 1540, Tumbler Ridge, British Columbia, V0C 2W0, Canada
[e] JuraPark, ul. Sandomierska 4, 27-400 Ostrowiec Świętokrzyski, Poland
[f] Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland
[g] Research Institute of Petroleum Exploration and Development, Karamay, Xinjiang 834000, China

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ABSTRACT

Despite being widely distributed in the Middle–Late Jurassic and earliest Cretaceous of Europe and sparsely distributed in the Late Jurassic of North America, the thyreophoran ichnotaxon *Deltapodus* is represented largely by morphologically suboptimal material. In particular, manus tracks are poorly defined in almost all previously reported specimens, likely due to preservational factors. Nonetheless, two ichnospecies, *D. brodericki* and *D. ibericus*, have been erected based on European material. Here we report the first Chinese examples of *Deltapodus* from the Cretaceous of Xinjiang Uyghur Autonomous Region, China. These specimens are also the youngest unambiguous occurrence of this ichnogenus, and the second reported occurrence from Asia. The specimens have well-defined manus traces with readily identifiable traces of digits I and II, enabling their placement in a new ichnospecies: *Deltapodus curriei* ichnosp. nov. Although not unequivocal in all cases, *Deltapodus* is likely of stegosaurian affinity, given the occurrence of stegosaurian body fossils in related deposits in Xinjiang. *Deltapodus* tracks are far more common and widespread than *Stegopodus* or *Apulosauripus*, the only other ichnogenera with tridactyl pes prints that have been attributed to large thyreophorans.

1. Introduction

Stegosaurian thyreophorans were widely distributed in western China: remains have been discovered in Middle Jurassic–Lower Cretaceous strata in Sichuan (Sichuan basin), Xinjiang (Junggar basin), Tibet (Mangkang basin), and Nei Mongol (Ordos basin) (Maidment and Wei, 2006; Dong, 2009). However, despite reports of ostensibly stegosaurian (cf. *Deltapodus*) tracks from near the Jurassic–Cretaceous boundary, Beijing, China (Zhang et al., 2012) and a poorly described, unattributed but *Deltapodus*-like track from the Upper Cretaceous of India (Mohabey, 1986), unequivocal stegosaur tracks have not previously been reported from Asia. This is partly because distinguishing stegosaurian tracks from those of other thyreophorans is not straight forward, as a recent study of thyreophoran tracks from near the Triassic–Jurassic boundary of the Shenmu area demonstrated (Li et al., 2012). In that study, the well-defined, *Moyenosauripus*-like ichnogenus *Shenmuichnus*, based on shallow tracks, appears *Deltapodus*-like when preserved as deep tracks registered in softer substrates. Therefore, based on present knowledge, confidently attributing many presumably thyreophoran ichnogenera—*Deltapodus*, *Stegopodus*, *Apulosauripus*, and *Shenmuichnus*—to any particular well-defined thyreophoran subgroup is difficult.

The Upper layer of Tugulu Group (unit "c", a lateral equivalent of the Lianmuqin Formation, ?Berriasian –Barremian, Eberth et al., 2001) in the Wuerhe (formerly Wuerho or Urho) District of the Junggar Basin in Xinjiang Uyghur Autonomous Region, China have produced elements of the well-known, Early Cretaceous *Dsungaripterus–Psittacosaurus* fauna (Dong, 2001). This fauna is characterized by an abundance of *Psittacosaurus* (Ceratopsia) and dsungaripterid pterodactyloid pterosaurs; the stegosaurian genus *Wuerhosaurus* and several theropods were also recovered from the same unit (Dong, 1973, 1990; Maidment et al.,

* Corresponding author. Key Laboratory of Evolutionary Systematics of Vertebrates, Chinese Academy of Sciences, PO Box 643, Beijing 100044, China.
E-mail address: xinglida@gmail.com (L. Xing).

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2008). However, the vertebrate fossils assemblage from the Lower Layer of the Tugulu Group is sparse, consisting only of *Dsungaripterus* isp., *Wuerhosaurus* isp. (Dong Z.M., pers. comm.). In 2009, abundant dinosaur and bird tracks were discovered from this unit near the Huangyangquan reservoir (Xing et al., 2011). Herein, we describe tracks that are stegosaurian in origin, discovered during a subsequent expedition to this same locality in the Wuerhe District.

2. Institutional abbreviations

MGCM = Moguicheng Dinosaur and Bizarre Stone Museum, Xinjiang, China; **MNHM** = Morrison Natural History Museum, Morrison, Colorado, USA; **USNM** = United States National Museum, Washington, USA; **ZDM** = Zigong Dinosaur Museum, Sichuan, China.

3. Geological setting

The Huangyanquan track site is located in the Wuerho district, approximately 110 km northeast of downtown Karamay. The fossil track site lies along the shore of Huangyangquan reservoir (46°4′25″N, 85°34′57″E, WGS 84) (Fig. 1). The Huangyangquan track site is in the Lower layer of the Lower Cretaceous Tugulu Group. Along the southern and eastern margins of the Junggar basin, the Tugulu Group can be divided, in ascending order, into the Qingshuihe, Hutubihe, Shengjinkou, and Lianmuqin formations. However, along the northwestern margin of the basin, including the Wuerhe district, the Tugulu Group is difficult to divide into subunits. Presently, it can only be divided as Upper, Grey-green, and Lower layers, for which correlations with the four southern and eastern units are uncertain (Academy of Prospecting and Developing, Xinjiang Bureau of Petroleum, 1977, 1996, 1997), although Eberth et al. (2001) provided a hypothetical basis. The Lower layer may correlate with the better-defined, stratigraphically low Qingshuihe and/or Hutubihe formations in the southern and eastern portions of the basin (Fig. 2). Lower layer sediments, which are grey, sandy mudstones and light green–grey sandstones, were deposited in deltaic, and lakeshore–semi-deep lake environments (Gu et al., 2003).

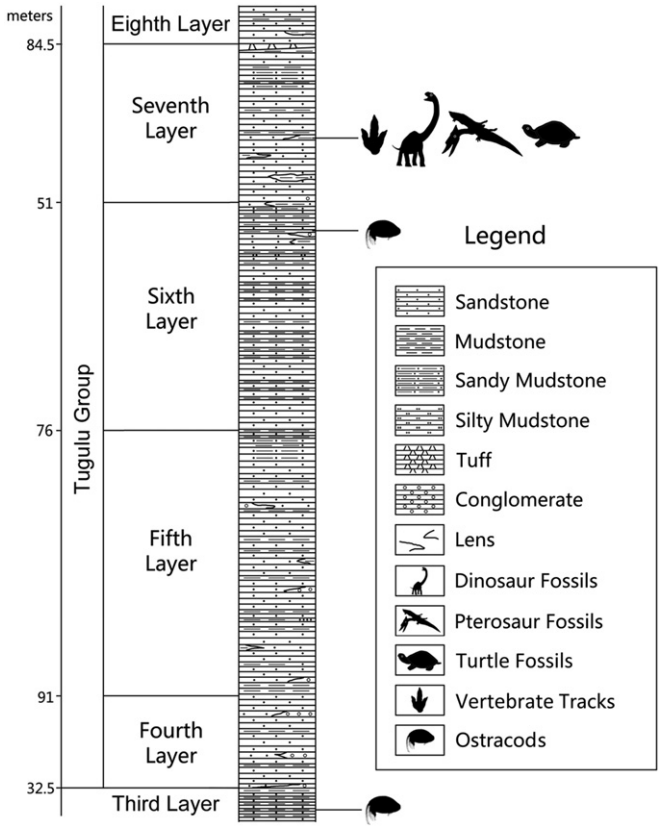

Fig. 2. Stratigraphic section of the Lower layer of the Tugulu Group at the Huangyangquan track site (emended from Qi et al., 1995; Xing et al., 2011).

4. Systematic ichnology

Dinosauria Owen, 1843
Ornithischia Seeley, 1888
Thyreophora Nopcsa, 1915
Deltapodus Whyte and Romano, 1994
Deltapodus curriei ichnosp. nov.

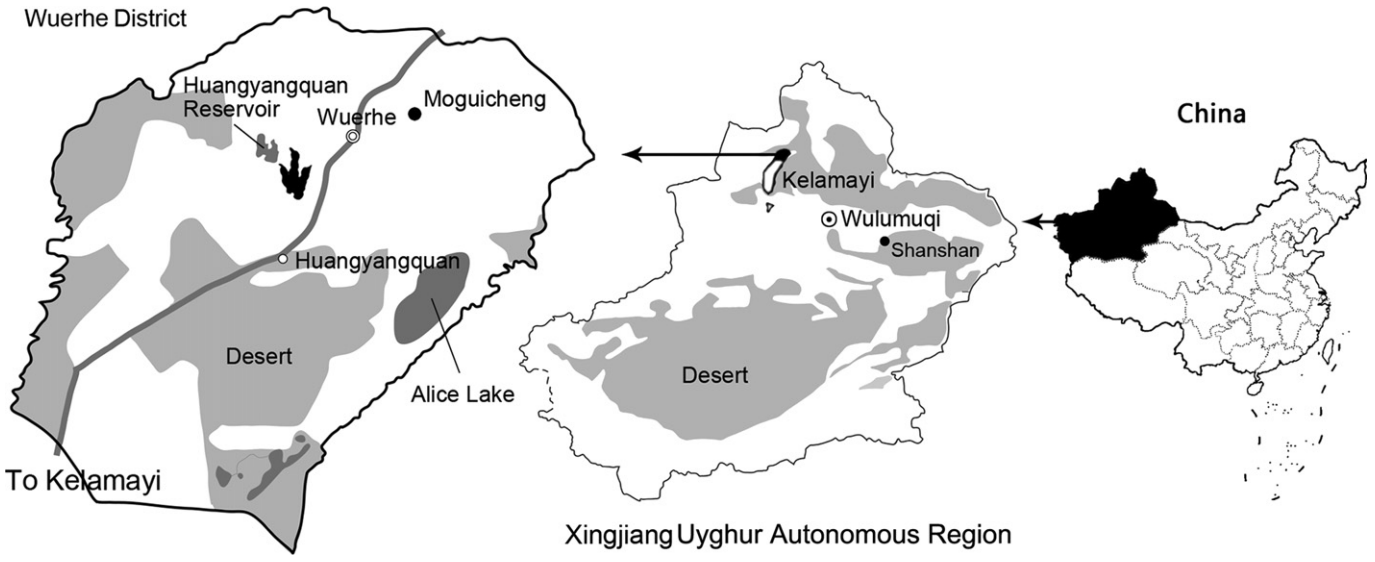

Fig. 1. Map of the Huangyangquan track locality (track icon), Wuerhe District, Xinjiang Uyghur Autonomous Region, China.