A new oviraptorid from the Upper Cretaceous of Nei Mongol, China, and its stratigraphic implications

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Abstract   Here we report a new oviraptorid taxon based on a specimen collected from the Upper Cretaceous Wulansuhai Formation of Bayan Mandahu, Linhe, China. This new taxon is distinguishable from other oviraptorid species by the following unique features: the ventral extremity of the large and elongate external naris is located below the mid-height of the premaxilla, the strap-like jugal process of the maxilla extends well beyond the preorbital bar posteriorly and overlaps the jugal, and the anterodorsal process of the surangular is basally constricted in lateral view. Although diagnosable as an oviraptorid, this new taxon possesses several plesiomorphic features absent in other oviraptorids but reminiscent of more basal oviraptorosaurs, suggesting a relatively basal position within the Oviraptoridae. The infratemporal fenestra has a narrow dorsal border, the anterior and posterior processes of the lacrimal are relatively long, the ectopterygoid is located relatively posteriorly, the external mandibular fenestra is comparatively posterior in position, the scapula is relatively short and slender, the pubic peduncle of the ilium is both more ventrally extended and much wider anteroposteriorly than the ischial peduncle, the ischium is relatively short, and metatarsal III is compressed between metatarsals II and IV. This taxon, *Wulatelong gobiensis* gen. et sp. nov., is therefore inferred to be a basal oviraptorid. A preliminary analysis of the Bayan Mandahu dinosaur fauna supports the view that the Bayan Mandahu strata are the oldest Upper Cretaceous red beds exposed in the Gobi area of the Mongolian Plateau.

Key words   Bayan Mandahu, Nei Mongol, China; Upper Cretaceous red beds; Oviraptoridae, Theropoda

1   Introduction

The Bayan Mandahu area in Wulatehouqi, Nei Mongol has produced numerous Late Cretaceous fossils, including but not limited to basal neoceratopsian, ankylosaurid,

dromaeosaurid, and oviraptorid dinosaurs, multituberculate mammals, and various lizards (Jerzykiewicz et al., 1993; Gao and Hou, 1996). Previously reported dinosaurs include the ceratopsians *Protoceratops andrewsi* (Brown and Schlaikjer, 1940; Jerzykiewicz et al., 1993; Lambert et al., 2001), *Protoceratops hellenikorhinus* (Lambert et al., 2001), *Magnirostris dodsoni* (You and Dong, 2003), and *Udanoceratops* sp. (Jerzykiewicz et al., 1993), the ankylosaurians *Pinacosaurus mephistocephalus* and *P. grangeri* (Godefroit et al., 1999), the dromaeosaurid *Velociraptor osmolskae* (Godefroit et al., 2008), a small-bodied troodontid (Currie and Peng, 1994; Xu et al., 2012), the oviraptorosaurian *Oviraptor philoceratops* (Jerzykiewicz et al., 1993) and *Machairasaurus leptonychus* (Longrich et al., 2010), and the tyrannosaurid *Tarbosaurus* sp. (Jerzykiewicz et al., 1993), though the presence of *Tarbosaurus* and *O. philoceratops* in Bayan Mandahu has been questioned (Longrich et al., 2010).

Given the importance of this locality in understanding the Late Cretaceous dinosaur faunas of the Gobi area, we have recently organized several expeditions to Bayan Mandahu (Xu et al., 2010). Our expeditions have resulted in the discovery of multiple dinosaur, mammal, and lizard specimens, among which are several new dinosaurs including the dromaeosaurid *Linheraptor* (Xu et al., 2010), the parvicursorine *Linhenykus* (Xu et al., 2011a), and the troodontid *Linhevenator* (Xu et al., 2011b). In the present paper, we report a new oviraptorid based on a nearly complete skeleton collected during the 2009 field season (Figs. 1–3). This specimen represents the third oviraptorid species known from the Bayan Mandahu area (Longrich et al., 2010).

2　Systematic paleontology

Theropoda Marsh, 1881

Coelurosauria Huene, 1920

Maniraptora Gauthier, 1986

Oviraptoridae Barsbold, 1976

***Wulatelong gobiensis* gen. et sp. nov.**

(Figs. 1–3)

Etymology　The generic name derives from 'Wulate' (the area from which the specimen originated) and 'long' (Chinese Pinyin for "dragon"); the specific name refers to the Gobi desert. The approximate pronunciation of the genus name is 'Woo-la-tuh-long'.

Holotype　IVPP (Institute of Vertebrate Paleontology and Paleoanthropology, Beijing) V 18409, an articulated skeleton preserving much of the cranium and postcranial skeleton, including 11 dorsal vertebrae, 16 caudal vertebrae, much of both the right and left scapulocoracoids, a partial sternum, a partial left humerus, much of the left manus, a nearly complete right pelvic girdle, and the right hindlimb. The specimen is badly weathered: many cranial elements are only partially preserved, and the articular ends of most of the preserved

postcranial elements are eroded.

Locality and horizon   Coordinates in decimal degrees: 41.7439°N, 106.7444°E. Bayan Mandahu area, "The Gate" Locality, Wulansuhai Formation, Campanian, Upper Cretaceous (Jerzykiewicz et al., 1993).

Diagnosis   Oviraptorid that can be distinguished from other known species by the following autapomorphies: the ventral extremity of the external naris is located below the mid-height of the premaxilla, the strap-like jugal process of the maxilla extends well beyond the preorbital bar posteriorly and overlaps the jugal, and the anterodorsal process of the surangular is basally constricted in lateral view.

3   Description and comparisons

The holotype specimen is a nearly fully articulated skeleton, though the right scapulocoracoid has been displaced posteriorly and lies close to the pelvic region. Many bones are incomplete owing to severe weathering and/or insect damage, as is commonly seen in vertebrate fossils from the Upper Cretaceous eolian beds of the Gobi area, but the parts of the cranium and other preserved elements that remain intact show little or no plastic deformation. The holotype specimen is probably an adult individual as indicated by the complete closure of the neurocentral sutures of all exposed dorsal vertebrae (but see Irmis, 2007). With a femoral length of about 255 mm (Table 1), the holotype specimen is a small oviraptorid (Xu et al., 2007), though it is still considerably larger than most basal oviraptorosaurs (Zhou et al., 2000; Xu et al., 2002a). We estimate the body mass of the holotype specimen to be about 29 kg based on an empirical equation developed using measurements from complete non-avian theropod skeletons and body mass estimates based on water displacement experiments with reconstructed models (Christiansen and Fariña, 2004).

Table 1   Selected measurements of the holotype of *Wulatelong gobiensis* gen. et sp. nov., IVPP V 18409 (mm)

Metacarpal II	35*	Metacarpal III	76*
Manual phalanx II-1	78	Manual phalanx III-1	51
Manual phalanx IV-1	35	Manual phalanx IV-2	33
Ilium	225*	Femur	255
Pubis	250*	Tibiotarsus	335
Tibia	325	Metatarsal III	143
Metatarsal IV	139	Pedal phalanx II-2	27
Pedal phalanx II-3	45	Pedal phalanx III-1	43
Pedal phalanx III-2	30	Pedal phalanx III-3	24
Pedal phalanx IV-1	30	Pedal phalanx IV-2	23
Pedal phalanx IV-3	20	Pedal phalanx IV-4	16
Pedal phalanx IV-5	35		

* indicates estimated value.

The skull has a sub-trapezoidal lateral profile (Fig. 1). As in other oviraptorids (Barsbold, 1976; Osmólska et al., 2004), the snout is short, with the preorbital part accounting for only about 40% of the total skull length (measured from the estimated snout tip to the ventral end of the quadrate). The external naris is so large that the length of its long axis appears to exceed the maximum diameter of the orbit, a feature unknown in other oviraptorosaurs (Clark et al., 2002; Osmólska et al., 2004). As in all known oviraptorosaurs (Maryańska et al., 2002; Osmólska et al., 2004), the external naris is displaced dorsally. However, the ventral extremity of the external naris is located below the mid-height of the premaxilla, while in other oviraptorids and *Incisivosaurus*, it is considerably above the mid-height of the premaxilla (Osmólska et al., 2004). The external naris appears to be more elongate in *Wulatelong gobiensis* than in any other known oviraptorosaur (Xu and Han, 2010), forming an ellipse in which the long axis is posterodorsally oriented and extends posteriorly to about the level of the anterior border of the orbit. As in most oviraptorosaurs (Osmólska et al., 2004), the sub-triangular antorbital fenestra is much higher dorsoventrally than long anteroposteriorly. The orbit is rounded and its maximum anteroposterior diameter is considerably greater than that of the infratemporal fenestra, rather than subequal to it as in most oviraptorids (Osmólska et al., 2004). The sub-quadrangular infratemporal fenestra is large, but its dorsal border is much shorter than its ventral border, reminiscent of the condition in basal oviraptorosaurs such as *Incisivosaurus* (Xu et al., 2002a; Balanoff et al., 2009) and also the oviraptorid *Khaan* (Clark et al., 2001).

The premaxilla is the largest facial element as in other oviraptorosaurs (Osmólska et al., 2004). As in other derived oviraptorosaurs, the premaxilla is dorsoventrally tall and edentulous, and forms the anterior and anterodorsal borders of the antorbital fossa (Osmólska et al., 2004). The maxillary process of the premaxilla is slender and strap-like, unlike the robust process seen in some other oviraptorids such as *Citipati osmolskae* (Clark et al., 2001) and *Nemegtomaia barsboldi* (Lü et al., 2004, 2005). Its posterior margin passes smoothly into the edge of the main body of the premaxilla as in other oviraptorids. In basal oviraptorosaurs and other non-avian theropods, by contrast, this transition is more abrupt, and the posterior margin of the premaxilla is strongly concave in lateral view. The maxillary process extends posteriorly to the level of the preorbital bar as in other derived oviraptorosaurs. The main body of the premaxilla is much higher dorsoventrally than long anteroposteriorly, as in other oviraptorids (Osmólska et al., 2004). Ventrally the premaxilla forms a beak-like structure, with a crenulated tomial edge extending anteroventrally.

The maxillae are mostly eroded, but their preserved portions exhibit several oviraptorid features: the lateral surface of the maxilla is nearly fully occupied by the antorbital fossa, the maxillary portion of the secondary palate has a large exposure in lateral view, and the ventral margin of the lateral surface of the maxilla is oriented anteroventrally so that it approximates an inverted V-shape in combination with the ventral margin of the jugal. The strap-like jugal process of the maxilla extends well beyond the preorbital bar posteriorly and overlaps the jugal, different from the rod-like jugal process of the maxilla in *Khaan* and most other
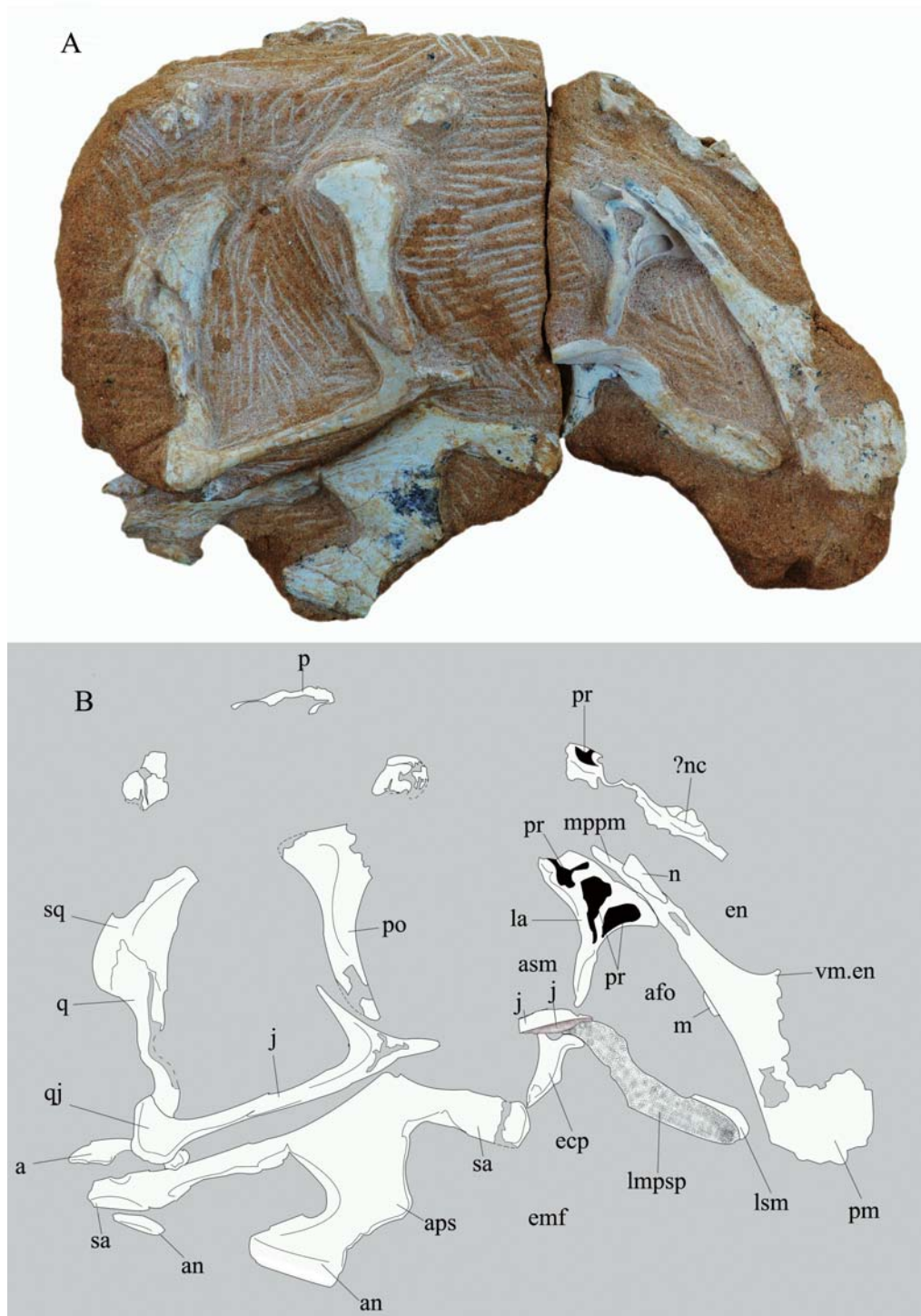
Fig. 1　Photograph (A) and line-drawing (B) of skull and mandible of holotype specimen of
Wulatelong gobiensis gen. et sp. nov. (IVPP V 18409) in right lateral view

Abbreviations: a. articular 关节骨; afo. antorbital fossa 眶前窝; an. angular 隅骨; aps. anteroventral process of surangular 上隅骨腹前突; asmj. articular surface for maxilla on jugal 颧骨的上颌骨连接面; ecp. ectopterygoid 外翼骨; emf. external mandibular fenestra 外下颌孔; en. external naris 外鼻孔; j. jugal 颧骨; la. lacrimal 泪骨; lmpsp. lateral surface of maxillary portion of secondary palate 次生腭上颌部外侧面; lsm. lateral surface of maxilla 上颌外侧面; m. maxilla 上颌骨; mppm. maxillary process of premaxilla 前上颌骨上颌支; n. nasal 鼻骨; ?nc. ?nasal crest 鼻嵴; p. parietal 顶骨; pm. premaxilla 前上颌骨; po. postorbital 眶后骨; pr. pneumatic recess 气腔隐窝; q. quadrate 方骨; qj. quadratojugal 方颧骨; sa. surangular 上隅骨; sq. squamosal 鳞骨; vm.en. ventral margin of external naris 外鼻孔腹缘

oviraptorids which terminates about the level of the preorbital bar and underlies the jugal.

The lacrimal is a roughly T-shaped element in lateral view. The anterior and posterior processes are subequal in length. Both are shorter than the ventral process, but nevertheless proportionally longer than in basal oviraptorosaurs such as *Incisivosaurus* (Xu et al., 2002a; Balanoff et al., 2009). In some oviraptorids the anterior process is much shorter than the posterior one. The mediolaterally compressed anterior process is robust, with a sub-triangular outline in lateral view. It is strongly inset from the continuous lateral surface formed by the posterior and ventral processes, a derived feature present only in oviraptorosaurs (Xu and Han, 2010). The ventral margin of the anterior process is nearly perpendicular to the ventral process as in *Citipati* (Clark et al., 2002), and the dorsal margin slopes anteroventrally in lateral view and is completely overlapped by the maxillary process of the premaxilla as in other oviraptorids. A large pneumatic recess is present on the lateral surface of the posterior half of the anterior process, and the anterior and posterior ends of the recess contain foramina that respectively penetrate the bone anteriorly and posteriorly. An equivalent pneumatic recess is present in *Citipati* (Clark et al., 2002), but appears to be absent in most other taxa. However, a more posterodorsally positioned pneumatic fossa is present on the lacrimal in all oviraptorosaurs, including *Wulatelong*, in which this region is known. The posterior process is posterodorsally oriented, and has a large dorsal exposure because its mediolateral width greatly exceeds its dorsoventral depth. It is entirely hollow. The ventral process exhibits several derived oviraptorid features: it is very broad mediolaterally and strongly compressed anteroposteriorly, its anterior margin is convex in lateral view (though the convexity is not as strong as in some other oviraptorids), and its lateral margin is convex in anterior view.

The nasal is mostly eroded, but appears to form a low crest that runs along the dorsal midline of the snout and is highly pneumatic as in *Khaan* (Clark et al., 2001). As in *Citipati* (Clark et al., 2002), the subnarial process is long and slender, and overlaps the lateral surface of the maxillary process of the premaxilla to form the dorsal half of the posterior border of the external naris.

The postorbital is a tri-radiate element. The ventrally directed jugal process is long and extends close to the ventral border of the orbit as in *Citipati* (Clark et al., 2002). As in other oviraptorosaurs, the posterior edge of the jugal process is somewhat sigmoid in lateral view. The squamosal process is about 60% as long as the frontal process. The frontal process is relatively robust and is strongly upturned as in most other oviraptorosaurs, with the exception of *Incisivosaurus* in which the frontal process is only slightly upturned (Balanoff et al., 2009).

Only the ventral portion of the squamosal is present. As in other oviraptorosaurs (Osmólska et al., 2004), the quadratojugal process is large and its long axis forms an angle of about 145 degrees with that of the postorbital process, in contrast to most other non-avian theropods in which the quadratojugal process is relatively slender and forms a sharper angle with the postorbital process. As in other derived oviraptorosaurs (Osmólska et al., 2004), the quadratojugal process is bifurcated ventrally.

The jugal is a slender element. The ventral margin of the jugal is straight in lateral view, rather than concave as in basal oviraptorosaurs such as *Incisivosaurus* (Balanoff et al., 2009). The suborbital ramus is rod-like, and its mediolateral width is greater than its dorsoventral height. Anteriorly it contributes a small portion of the posteroventral corner of the antorbital fenestra. There is a longitudinal depression on the ventral half of the lateral surface of the maxillary process of the jugal, which represents the articular surface for the jugal process of the maxilla. The dorsal border of the articular surface is sharply defined by a ridge. The quadratojugal process is long and slender, but appears to be considerably deeper dorsoventrally than wide mediolaterally. It tapers posteriorly and covers the lateral surface of the jugal process of the quadratojugal. The postorbital process is short and posterodorsally oriented, rather than long and vertically directed as in *Citipati* and *Khaan* (Clark et al., 2001, 2002).

The quadratojugal is a roughly L-shaped bone tightly appressed to the lateral surface of the quadrate, as in most oviraptorids. It is similar to those of other oviraptorids in having a long and slender jugal process that forms the posterior half of the ventral border of the infratemporal fenestra. The squamosal process is perpendicular to the jugal process and extends dorsally almost to the level of the quadrate-squamosal articulation. As in *Khaan*, *Avimimus*, and *Caudipteryx* (Zhou et al., 2000; Clark et al., 2001; Vickers-Rich et al., 2002), the body of the quadratojugal expands only slightly posteriorly beyond the squamosal process, though it appears to expand ventrally well beyond the line of the jugal process.

The quadrate is a large and robust element as in other oviraptorids. The ratio of the height of the quadrate to its transverse width (measured at the ventral end) is about 2.0, smaller than in most other non-avian theropods. As in other oviraptorids, the quadrate foramen is large, a feature also known in dromaeosaurids and some basal deinonychosaurs (Xu, 2002; Norell and Makovicky, 2004).

The ectopterygoid is anteriorly located, contacting the maxilla, jugal and lacrimal slightly posterior to the preorbital bar. In most other oviraptorids, the contact is just under or even slightly anterior to the preorbital bar (Clark et al., 2002). The ectopterygoid is vertically oriented so that the greater part of its palatal surface is visible in lateral view, resembling the condition in other oviraptorids (Osmólska et al., 2004). The anterior process of the ectopterygoid curves strongly upward and is expanded distally as in other oviraptorids.

Only the posterior half of the mandible is present, but several informative features are preserved. As in derived oviraptorosaurs (Osmólska et al., 2004), the mandible is bowed laterally in the vicinity of its mid-length in dorsal view, the external mandibular fenestra is large and anteriorly positioned, and the articular facet for the quadrate is elevated relative to the neighboring portion of the mandible and is markedly convex in lateral view. Furthermore, the mandible is similar to those of other oviraptorids in being very deep in lateral view, and in having an external mandibular fenestra that is dorsoventrally deep and partially divided by an anteroventrally oriented surangular process (Osmólska et al., 2004). However, the posterior extremity of the external mandibular fenestra is located well posterior to the coronoid process,

unlike in some oviraptorids in which the external mandibular fenestra is more anteriorly located (Xu et al., 2002a; Osmólska et al., 2004).

The surangular is the dominant element of the posterior half of the mandible in lateral view. As in most other oviraptorids (Osmólska et al., 2004), the surangular is very deep (proportionally deeper than in *Khaan*). The anterodorsal process of the surangular is long and basally constricted in lateral view, a feature unknown in other oviraptorids but seen in the caenagnathid *Chirostenostes* (fig. 8.2c in Osmólska et al., 2004). However, in most oviraptorid specimens, the surangular is covered by the dentary, and whether this constriction is present is unknown. Most of the lateral surface of the anterodorsal process is recessed to form the articular facet for the dentary. More ventrally, the surangular sends an anteroventrally directed process into the external mandibular fenestra as in other oviraptorids. The lateral surface of the surangular is depressed both below and above the level of this process, and the ventral depression extends posteriorly to form a large and deep concavity. As in other oviraptorids (Osmólska et al., 2004), the surangular forms a distinct, medially inclined coronoid process above the external mandibular fenestra. The dorsal margin of the surangular posterior to the coronoid process is transversely narrow, and this part of the surangular is hollow. In the glenoid region the surangular expands laterally to form a flange, as in other oviraptorids.

The angular forms a small portion of the lateral surface of the mandible as in some other oviraptorids (Osmólska et al., 2004), and appears long and slender in lateral view. The angular extends at least a short distance posteriorly beyond the level of the glenoid region.

The right articular is preserved, and only a small portion is exposed. As in other oviraptorids, the articular contributes to the uniquely shaped glenoid region, which is transversely wide and anteroposteriorly long, allowing anteroposterior movement of the mandible. The dorsal surface of the articular is convex in both the anteroposterior and mediolateral directions, making the glenoid articular facet convex as in other oviraptorids.

No other mandibular elements are definitively preserved. The posterior end of the splenial may be present, but this cannot be ascertained because the area is obscured by matrix.

The 11 preserved dorsal vertebrae are in full articulation, but their bone surfaces are severely eroded (Fig. 2). The dorsal vertebrae are anteroposteriorly short relative to their dorsoventral height, and the middle dorsal centra in particular are considerably taller dorsoventrally than long anteroposteriorly. All of the dorsal centra bear large oval pneumatic openings on their lateral sides, and the openings on the posterior dorsal centra are even larger than those on the anterior and middle ones. The prezygapophyses and postzygapophyses face dorsally and ventrally, respectively. The blade-like neural spines are dorsoventrally tall, those of the middle dorsal vertebrae being about twice as tall as anteroposteriorly wide. The anteriormost dorsal vertebrae bear prominent hypapophyses, and their neural spines appear to be dorsoventrally shorter than those of the middle and posterior dorsal vertebrae.

Only the anteriormost sacral centrum is visible. It bears a large pneumatic opening on its lateral side, a feature also known in other oviraptorids (Osmólska et al., 2004). The central part
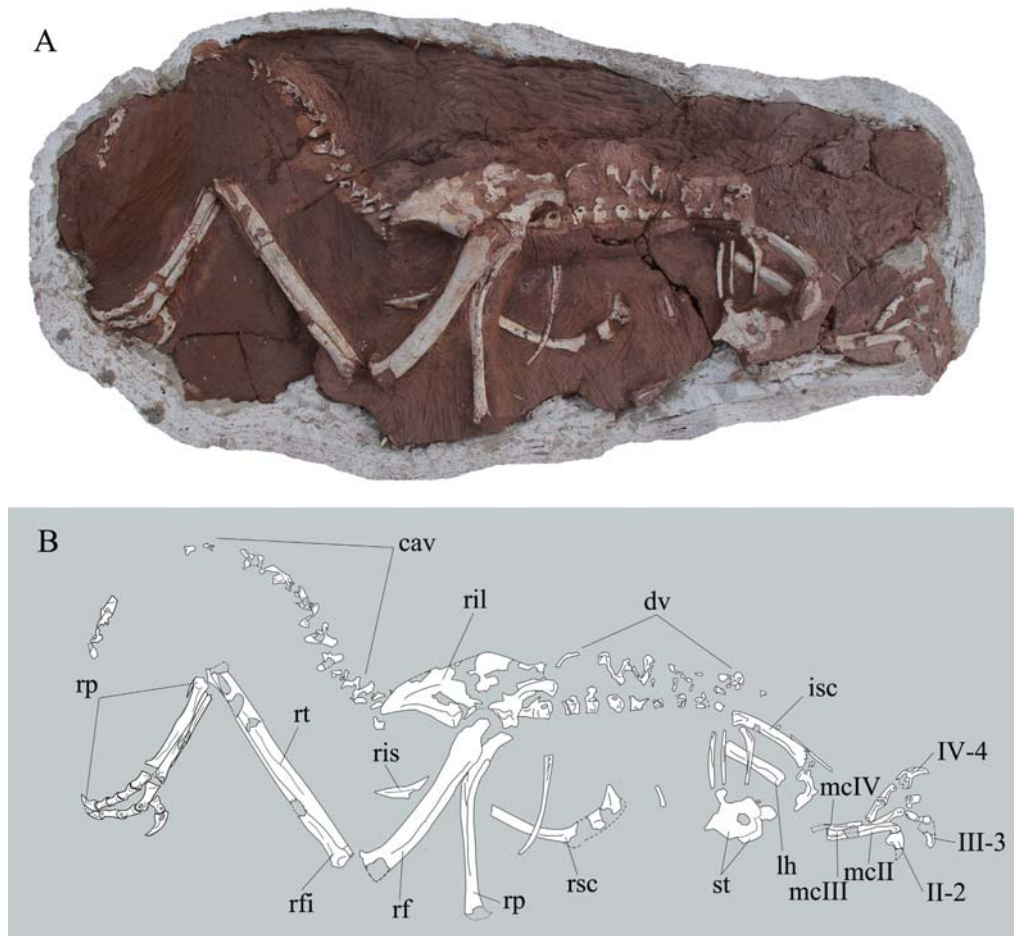
Fig. 2　Photograph (A) and line-drawing (B) of postcranial skeleton of holotype specimen of
Wulatelong gobiensis gen. et sp. nov. (IVPP V 18409)

Abbreviations: cav. caudal vertebrae 尾椎; dv. dorsal vertebrae 背椎; II-2. manual phalanx II-2 第二指第二指节; III-3. manual phalanx III-3 第三指第三指节; IV-4. manual phalanx IV-4 第四指第四指节; lh. left humerus 左侧肱骨; lsc. left scapulocoracoid 左侧肩胛乌喙骨; mcII-IV. metacarpals II-IV 第二-第四掌骨; rf. right femur 右侧股骨; rfi. right fibula 右侧腓骨; ril. right ilium 右侧肠骨; ris. right ischium 右侧坐骨; rp. right pubis 右侧耻骨; rpe. right pes 右足; rsc. right scapulocoracoid 右侧肩胛乌喙骨; rt. right tibia 右侧胫骨; st. sternum 胸骨

of the ventral surface appears to be rounded.

　　Most of the caudal vertebrae are preserved. However, only the neural arches are exposed in the anterior and middle caudals, whereas the posterior caudals are exposed only in lateral view. As in other oviraptorosaurs (Osmólska et al., 2004), the caudal series is proportionally short. *Wulatelong* is also similar to other oviraptorosaurs in that even the posterior caudal vertebrae have well-developed transverse processes and neural spines, and short and distinctly dorsally oriented prezygapophyses.

　　Some dorsal ribs are preserved. They are of typical theropod morphology.

　　The two sternal plates are badly eroded, but appear to be relatively wide transversely. The anterolateral margin of each sternal plate appears to bear a groove for the coracoid.

The scapula appears to be fused to the coracoid. As in other oviraptorosaurs and basal paravians, the rectangular coracoid is proportionally large and posteromedially inflected so that the scapulocoracoid is L-shaped in lateral view. However, the scapula is short and slender, resembling those of more basal oviraptorosaurs. Unlike those of *Wulatelong* and basal oviraptorosaurs, the scapular blades of derived oviraptorosaurs are as wide as or even wider than the humerus.

A partially exposed element is tentatively identified as the shaft of the left humerus. An oblique ridge runs along the shaft, which is much more slender than that of the femur. The tridactyl manus is robust. Metacarpal II is less than half the length of metacarpal III (note that we refer to the digits of the tetanuran hand as II-IV in this article (Xu et al., 2009)), unlike in *Ingenia yanshini* in which metacarpal II is proportionally much longer (Barsbold, 1981, 1986; Longrich et al., 2010). However, metacarpal II is longer in proportion to metacarpal III in *Wulatelong* than in the Bayan Mandahu oviraptorid specimen IVPP V 9608 (Dong and Currie, 1996), which we consider to be an indeterminate oviraptorine in agreement with Longrich et al. (2010). Metacarpal III is about 30% as long as the femur in *Wulatelong*, similar in proportional length to the same bone in other oviraptorids such as *Khaan* but much longer than in some basal oviraptorosaurs such as *Caudipteryx* (Zhou et al., 2000). Metacarpal IV is the most slender of the metacarpals, and is only slightly bowed laterally. The manual unguals are strongly curved and have strong flexor tubercles as in *Oviraptor* (Osborn, 1924), but differ strongly from the near-straight manual unguals with reduced flexor tubercles seen in *Machairasaurus* (Longrich et al., 2010). They differ from those of both *Oviraptor* and IVPP V 9608 in lacking a lip at the proximodorsal end, which is similar to the condition in *Ingenia yanshini* and *Conchoraptor gracilis* (Longrich et al., 2010).

A naturally articulated right pelvis shows that the pubis is nearly vertically directed with slight medial inclination. The ilium is about 90% as long as the femur. The ilium is most similar to that of *Oviraptor philoceratops* in being of moderate depth and dorsal convexity (Osborn, 1924; Osmólska et al., 2004; Lu and Zhang, 2005). As in *O. philoceratops* (Osborn, 1924; Osmólska et al., 2004), the preacetabular process of the ilium is dorsoventrally deep and itself bears a distinct anteroventral process, and the postacetabular process is shallow and tapers posteriorly. The pubic peduncle is ventrally directed as in all known oviraptorids other than *O. philoceratops* (Osborn, 1924; Osmólska et al., 2004). The pubic peduncle is much wider anteroposteriorly than the ischial peduncle and extends considerably farther ventrally, a feature reminiscent of the condition in basal oviraptorosaurs. As in other oviraptorosaurs, the pubis is concave anteriorly. However, most of the pubic shaft is straight as in oviraptorosaurs other than *Ingenia yanshini*, in which the shaft is curved (Barsbold, 1981; Osmólska et al., 2004). The pubic foot has a relatively large anterior expansion but appears only slightly expanded posteriorly, as in other derived oviraptorosaurs such as *I. yanshini* (Barsbold, 1981; Osmólska et al., 2004). The ischium is about 45% as long as the pubis, more similar to basal oviraptorosaurs than to more derived ones such as *I. yanshini* in which the ischium is more

than two-thirds the length of the pubis. A large obturator flange is present and appears to be placed approximately at the mid-length of the shaft.

The femur is slightly bowed anteriorly. The greater trochanter is expanded anteroposteriorly as in other derived coelurosaurs. A mound-like lateral ridge appears to be absent. The tibia is proportionally shorter than those of many other oviraptorosaurs, measuring about 110% of the femoral length. The fibula has a very slender distal shaft and extends distally to contact the proximal tarsals. The metatarsus is only moderately elongate, measuring less than half the length of the tibia as in other oviraptorids (Osmólska et al., 2004). Metatarsal II appears to be much more slender than metatarsal IV in anterior view (Fig. 3), a feature also seen in some other oviraptorids such as *Conchoraptor gracilis* (Barsbold, 1983). The proximal half of metatarsal III is transversely flattened, and the proximal end is much narrower than those of metatarsals II and IV. This is similar to the condition in basal oviraptorosaurs (Zhou et al., 2000) but unlike the condition in most other oviraptorids, in which metatarsals III and IV are similar in size. Metatarsal IV is the most robust of the metatarsals. Metatarsal V is a short, rod-like bone attached to the posterolateral surface of metatarsal IV.
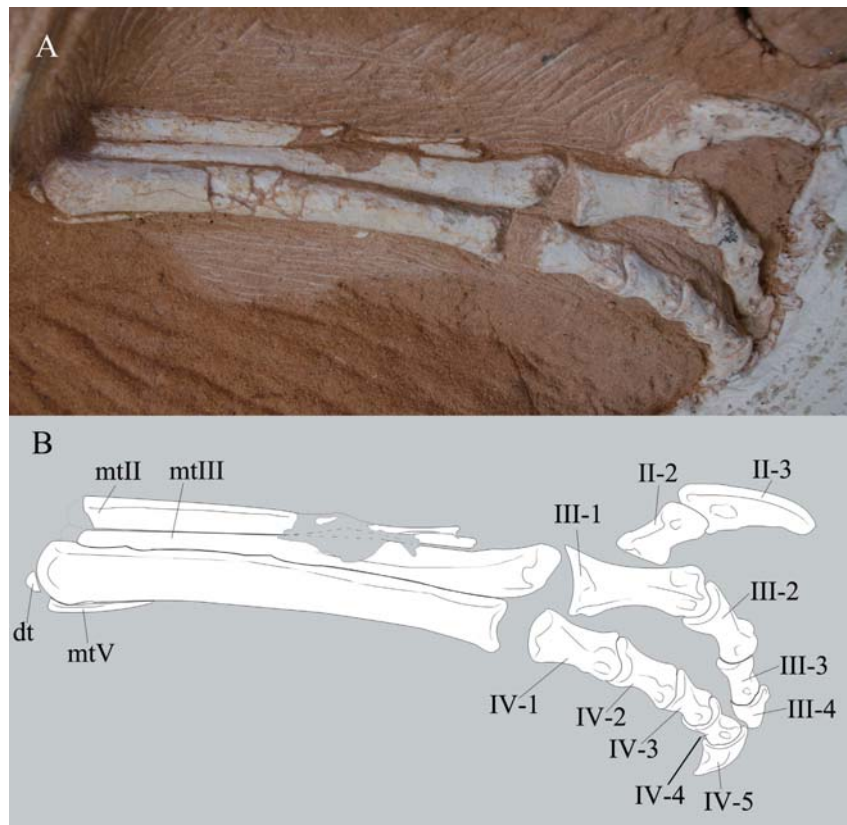

Fig. 3   Photograph (A) and line-drawing (B) of right pes of holotype specimen of *Wulatelong gobiensis* gen. et sp. nov. (IVPP V 18409)

Abbreviations: dt. distal tarsal 远端跗骨; mtII-V. metatarsals II-V 第二-第五跖骨; II-2-II-3. pedal phalanges II-2-3 第二脚趾第二-第三趾节; III-1-III-4. pedal phalanges III-1-4 第三脚趾第一-第四趾节; IV-1-IV-5. pedal phalanges IV-1-5 第四脚趾第一-第五趾节

4 Discussion

Wulatelong gobiensis can be identified as an oviraptorid based on the presence of the following derived features (Maryańska et al., 2002; Osmólska et al., 2004): rostrum short and wide, subnarial portion of premaxilla very tall, subantorbital portion of maxilla inset medially, ventral margin of maxilla sloping anteroventrally, ventral margin of jugal sloping posteroventrally, external naris extending posteriorly close to posterior border of antorbital fossa, ventral process of lacrimal anteroposteriorly flattened and laterally convex, highly pneumatized nasals and frontals, infratemporal fenestra large and subquadrate in lateral view, distal end of quadrate bears accessory lateral process for articulation with quadratojugal, ectopterygoid elongate and contacts maxilla and lacrimal, palate extends ventrally below cheek margin, very deep mandible, very deep external mandibular fenestra, anteroventral process of surangular dividing external mandibular fenestra, dentition absent, and medially inclined ilium.

However, *Wulatelong gobiensis* also resembles basal oviraptorosaurs in several features, which might be plesiomorphic for the Oviraptorosauria. As in basal oviraptorosaurs such as *Incisivosaurus* and *Caudipteryx*, the external naris of *Wulatelong* is less dorsally located than those of other oviraptorids (Lü et al., 2004; Lü, 2005). The anteroposterior diameter of the orbit is considerably greater than that of the infratemporal fenestra, similar to basal oviraptorosaurs but unlike most oviraptorids in which the two openings are subequal in anteroposterior diameter (Osmólska et al., 2004). In *Wulatelong*, the dorsal border of the infratemporal fenestra is much narrower than the ventral border as in basal oviraptorosaurs (Xu et al., 2002a) and only some oviraptorids. The anterior and posterior processes of the lacrimal are proportionally intermediate in length between those of basal oviraptorosaurs and those of other oviraptorids (Xu et al., 2002a). As in other oviraptorosaurs, the ectopterygoid is located anteriorly, but less so than most other oviraptorids. The external mandibular fenestra of *Wulatelong* is more posteriorly located than in some oviraptorids. Unlike in most other oviraptorids, the scapula is relatively short and slender in *Wulatelong*, as in basal oviraptorosaurs (Zhou et al., 2000). In *Wulatelong* the pubic peduncle of the ilium is much wider anteroposteriorly and more ventrally extended than the ischial peduncle, as in basal oviraptorosaurs (Zhou et al., 2000). The ischium is relatively short in *Wulatelong*, which resembles the condition seen in basal oviraptorosaurs. Finally, metatarsal III is highly reduced as in basal oviraptorosaurs (Zhou et al., 2000). These features suggest that *Wulatelong gobiensis* occupies a basal position within the Oviraptoridae, but this needs to be tested by including *Wulatelong* in a phylogenetic analysis of oviraptorosaurs.

A noteworthy feature is the reduced size of metatarsal III in *Wulatelong*. The reduction of metatarsal III has been suggested to be an adaptation conferring greater cursorial capability (Holtz, 1994; Snively and Russell, 2003; Xu et al., in press; Hone et al., in press). Although the pes of *Wulatelong* does not display the extreme reduction of metatarsal III seen in some theropods (Holtz, 1994), the proximal half of metatarsal III is nevertheless strongly

compressed, a condition similar to that present in several theropods including *Caudipteryx* (Xu and Wang, 2000; Zhou et al., 2000; Xu et al., 2002b). *Wulatelong* was probably less cursorial than *Caudipteryx*, as inferred from the proportionally shorter distal segment of the hindlimb (metatarsal III/femur length ratio of 0.56 compared to 0.78 in *Caudipteryx*), but might have been more cursorial than most other oviraptorids given that an unreduced metatarsal III is typical of this group (Osmólska et al., 2004). Consequently, *Wulatelong* may represent an intermediate stage in a trend involving a reduction in cursorial capability in oviraptorosaurian evolution. This recalls the situation in the sympatric dromaeosaurid *Linheraptor*, which appears to be in the middle of a trend towards reduced cursoriality in derived dromaeosaurids (Xu et al., 2010). This suggests the possibility that some environmental factor affected both taxa in similar ways, perhaps relating to the nature of the substrate.

Early surveys reported the presence of a number of non-avian dinosaurian taxa in the red beds of the Bayan Mandahu area, including the ceratopsians *Protoceratops andrewsi*, *Udanoceratops* sp., and *Bagaceratops* sp., the ankylosaurian *Pinacosaurus grangeri*, the dromaeosaurid *Velociraptor* sp., the troodontid *Saurornithoides mongoliensis*, the oviraptorid *Oviraptor philoceratops*, and the tyrannosaurid *Tarbosaurus* sp. (Jerzykiewicz et al., 1993). These taxa are known in the lithologically similar Djadokhta Formation at Bayan Zag and some other localities in Mongolia, and their presence at Bayan Mandahu was taken to provide strong evidence for a purported correlation between the Bayan Mandahu beds (the Wulansuhai Formation) and the classical Djadokhta Formation (Jerzykiewicz et al., 1993).

However, recent studies have cast doubt on some of the taxonomic identifications made by previous researchers (Longrich et al., 2010). IVPP V 10597, which was originally referred to *Saurornithoides mongoliensis* (Currie and Peng, 1994), is in fact a new troodontid species (Xu et al., 2012). Similarly, IVPP V 9608, which was referred to *Oviraptor philoceratops* (Dong and Currie, 1996), was recently suggested to be an indeterminate but probably new oviraptorine (Longrich et al., 2010). Furthermore, several new species have been erected based on Bayan Mandahu specimens, including the ceratopsians *Protoceratops hellenikorhinus* (Lambert et al., 2001) and *Magnirostris dodsoni* (You and Dong, 2003), the ankylosaurian *Pinacosaurus mephistocephalus* (Godefroit et al., 1999), the dromaeosaurids *Velociraptor osmolskae* (Godefroit et al., 2008) and *Linheraptor exqusitus* (Xu et al., 2010), the oviraptorosaurian *Machairasaurus* (Longrich et al., 2010), the alvarezsauroid *Linhenykus monodactylus* (Xu et al., 2011a), and the troodontid *Linhevenator tani* (Xu et al., 2011b). The new oviraptorid *Wulatelong gobiensis* represents yet another addition to the growing list of taxa reported for the first time from Bayan Mandahu, and distinct from their closest relatives in the Mongolian deposits. This suggests that the Bayan Mandahu dinosaur fauna differs fundamentally in composition from the classical Djadokhta fauna (Longrich et al., 2010), perhaps because of a difference in age (Makovicky, 2008; Longrich et al., 2010). However, environmental rather than temporal differences cannot be completely excluded as an explanation for the contrast between the two faunas.

There is currently no consensus on the chronological ordering of the Upper Cretaceous

red-beds in the Gobi area (Makovicky, 2008; Longrich et al., 2010). Makovicky (2008) carried out a phylogeny-based analysis whose results suggested that the Bayan Mandahu strata are the oldest of the Upper Cretaceous red-beds in the region. By contrast, Longrich et al. (2010) proposed that at least the Bayn Dzak red-beds are in fact older than Bayan Mandahu, partly because they regarded taxa from Bayan Mandahu as being consistently more derived than their closest relatives from Bayn Dzak. However, some of the evidence adduced by Longrich et al. (2010) is questionable. For example, Longrich et al. (2010) suggested that the enlarged promaxillary fenestra and elongate maxillary fenestra of *Velociraptor osmolskae* are derived features. However, these features are in fact plesiomorphic for the Dromaeosauridae (Xu and Wu, 2001) and *V. osmolskae* is therefore probably more basal than *V. mongoliensis*. Furthermore, several other recently reported dinosaurs, including *Linheraptor*, *Linhenykus* and now *Wulatelong*, also seem more basal than their close relatives found in other red-beds in the Gobi area (Xu et al., 2010, 2011a). Although our new discoveries have not been incorporated into a formal analysis like that performed by Makovicky (2008), they tentatively support this author's suggestion that the Upper Cretaceous beds at Bayan Mandahu are the oldest in the Gobi region. However, this line of evidence is rather circumstantial in that it assumes a close fit between phylogeny and stratigraphy even at the fine scale of individual Upper Cretaceous localities within the Gobi, and would be invalidated if Bayan Mandahu had acted as a refugium for some relatively basal taxa. While we believe that the currently available data favor the view that Bayan Mandahu is the oldest of the Gobi Upper Cretaceous red-bed localities, this interpretation cannot be considered well-established in the absence of firmer geochronological evidence.

内蒙古上白垩统窃蛋龙科一新属种及其地层学意义

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摘要：记述了一件发现于内蒙古临河巴彦满达呼上白垩统乌兰苏海组的窃蛋龙科新材料并建立了一新属新种——戈壁乌拉特龙(*Wulatelong gobiensis* gen. et sp. nov.)。新属种具有以

下不同于其他窃蛋龙科成员的独特特征：外鼻孔大而细长，腹端低于前上颌骨中部；上颌骨的颧骨支呈带状，并向后延伸至眶前隔之后，叠覆于颧骨外侧面；外侧视，上隅骨的前背突基部收缩。戈壁乌拉特龙具有一些其他窃蛋龙科成员不具有的近祖特征，而与更原始的窃蛋龙类接近，说明戈壁乌拉特龙代表了窃蛋龙科中一个相对原始的属种。这些近祖特征包括：下颌颞孔的背缘较窄，泪骨的前突和后突相对较长，外翼骨和外下颌孔的位置都相对靠后，肩胛骨短而纤细，肠骨的耻骨茎较坐骨茎向腹侧延伸更长并前后向更宽，坐骨较短，以及第三跖骨近端侧扁等。因此戈壁乌拉特龙的系统发育位置可能居于原始窃蛋龙类和其他窃蛋龙科成员之间。对巴彦满达呼恐龙动物群的初步分析支持巴彦满达呼红层代表了蒙古高原戈壁地区上白垩统红层中的最早沉积层位的结论。

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