

Alma Mater Studiorum Università di Bologna Archivio istituzionale della ricerca

Rediscovery of the type localities of the Late Cretaceous Mongolian sauropods Nemegtosaurus mongoliensis and Opisthocoelicaudia skarzynskii: Stratigraphic and taxonomic implications

This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

Published Version:

Currie, P.J., Wilson, J.A., Fanti, F., Mainbayar, B., Tsogtbaatar, K. (2018). Rediscovery of the type localities of the Late Cretaceous Mongolian sauropods Nemegtosaurus mongoliensis and Opisthocoelicaudia skarzynskii: Stratigraphic and taxonomic implications. PALAEOGEOGRAPHY PALAEOCLIMATOLOGY PALAEOECOLOGY, 494, 5-13 [10.1016/j.palaeo.2017.10.035].

Availability:

This version is available at: https://hdl.handle.net/11585/622592 since: 2021-12-03

Published:

DOI: http://doi.org/10.1016/j.palaeo.2017.10.035

Terms of use:

Some rights reserved. The terms and conditions for the reuse of this version of the manuscript are specified in the publishing policy. For all terms of use and more information see the publisher's website.

This item was downloaded from IRIS Università di Bologna (https://cris.unibo.it/). When citing, please refer to the published version.

(Article begins on next page)

This is the final peer-reviewed accepted manuscript of

Currie, Philip J.; Wilson, Jeffrey A.; Fanti, Federico; Mainbayar, Buuvei; Tsogtbaatar, Khishigjav: Rediscovery of the type localities of the Late Cretaceous Mongolian sauropods Nemegtosaurus mongoliensis and Opisthocoelicaudia skarzynskii: Stratigraphic and taxonomic implications. PALAEOGEOGRAPHY PALAEOCLIMATOLOGY PALAEOECOLOGY, 494. 0031-0182

DOI: 10.1016/j.palaeo.2017.10.035

The final published version is available online at: http://dx.doi.org/10.1016/j.palaeo.2017.10.035

Rights / License:

The terms and conditions for the reuse of this version of the manuscript are specified in the publishing policy. For all terms of use and more information see the publisher's website.

This item was downloaded from IRIS Università di Bologna (<u>https://cris.unibo.it/</u>)

When citing, please refer to the published version.

Rediscovery of the type localities of the Late Cretaceous Mongolian sauropods *Nemegtosaurus mongoliensis* and *Opisthocoelicaudia skarzynskii*: Stratigraphic and taxonomic implications

Philip J. Currie^{a,*}, Jeffrey A. Wilson^b, Federico Fanti^c, Buuvei Mainbayar^d, Khishigjav Tsogtbaatar^d

^a University of Alberta, Biological Sciences Building CW405, Edmonton, Alberta T5N 2E9, Canada

^b Museum of Paleontology and Department of Earth & Environmental Sciences, University of Michigan, 1109 Geddes Avenue, Ann Arbor, MI 48109–1079, USA

^c Dipartimento di Scienze Biologiche, Geologiche e Ambientali, University of Bologna, Via Zamboni 67, 40126 Bologna, Italy

^d Institute of Paleontology and Geology, Academy of Sciences of Mongolia, P.O.B: 46/650, Ulaanbaatar, Mongolia

ARTICLE INFO

Keywords: Upper cretaceous Nemegt formation Baruungoyot formation Sauropoda Titanosauria

ABSTRACT

In 1965, the Polish-Mongolian Palaeontological Expeditions recovered two sauropods from the Nemegt Formation of the Nemegt Basin, Mongolia (Kielan-Jaworowska and Dovchin 1968). One specimen, a nicely preserved, complete skull that in 1971 became the holotype of Nemegtosaurus mongoliensis, was found in Central Sayr at the Nemegt Locality. The other was found at Altan Uul IV and is a nearly complete postcranial skeleton lacking only the skull and neck. In 1977, this skeleton became the holotype of Opisthocoelicaudia skarzynskii. Nemegtosaurus and Opisthocoelicaudia were initially assigned to different sauropod higher taxa, Dicraeosaurinae and Camarasauridae respectively. However, since the late 1990s, both genera have been recognized as members of Titanosauria. Their coincident spatiotemporal distribution and non-overlapping skeletal parts have led to the persistent suspicion that they belong to the same species. Rediscovery of the original quarries and discovery of the postcranial remains attributable to the Nemegtosaurus holotype provides the first opportunity to directly compare these two taxa. Seven additional sites at the Nemegt locality preserve sauropod remains (including vertebrae, humeri, femora, pelvic elements, pedal phalanges, and unguals), and more than 20 sauropod footprint sites have been mapped. None of this material suggests that there is more than one sauropod taxon present in the Nemegt Formation. All localities occur within a discrete stratigraphic interval encompassing the uppermost Baruungoyot (footprints), Baruungoyot-Nemegt interfingering interval (Nemegtosaurus type), and lowermost Nemegt formations. Stratigraphic comparisons indicate the Opisthocoelicaudia locality at Altan Uul IV is within the lower beds of the Nemegt Formation. As sauropod remains are now documented for a total of 34 sites in the Nemegt Formation, a more refined stratigraphic framework may shed new light on the taxonomic inclusiveness of the sample.

1. Introduction

R. Gradziński discovered what became the holotype of the sauropod dinosaur *Opisthocoelicaudia skarzynskii* Borsuk Bialynicka, 1977 at Altan Uul IV in early June 1965. The huge excavation, which was undertaken between June 25th and July 7th, 1965, was complicated because it had been found on an elevated shelf of rock surrounded by deep canyons and even higher badlands (Kielan Jaworowska and Dovchin 1968). The closest the team could get vehicles to the site was more than half a kilometer, which meant that equipment, supplies, tools and fossils had to be carried or dragged by expedition members. Twelve tonnes

of bone with the adhering hard sandstone were dragged on stone boats (made from empty fuel drums) to 'the Café', where they could be crated and loaded on trucks.

While that specimen was being excavated, a side trip to Nemegt led to the discovery of another sauropod. Kielan Jaworowska (1969, p. 115) recounted in her expedition narrative that Dovchin, Gradziński, Kuczyński, Maryańska and a driver left on June 15th for a two day fieldtrip to Nemegt. There, Kuczyński found a sauropod skull encased in the wall of one of the Nemegt canyons. They did not have the tools to remove more than a metre of dense sandstone above the skull. How ever, Walknowski drove another truck past the site a few days later en

^{*} Corresponding author.

E-mail address: pjcurrie@ualberta.ca (P.J. Currie).

route to Gurvan Tes. He took along Kuczyński the discoverer of the skull and Skarżyński so that they could excavate the skull. They re turned three days later with the skull cushioned by wood shavings in a spacious wooden box.

The unpublished field notes of Gradziński provide a little more information. Apparently, the members of the initial team left Altan Uul for Nemegt on June 15th at midday, Kuczyński discovered the skull on the 16th at midday, and they returned to Altan Uul IV on the 17th. The skull became the holotype of *Nemegtosaurus mongoliensis* Nowinski, 1971.

Opisthocoelicaudia skarzynskii is a nearly complete postcranial skeleton lacking only the skull and neck, whereas *Nemegtosaurus mon-goliensis* is a skull and lower jaws that lack a postcranial skeleton. *Nemegtosaurus* and *Opisthocoelicaudia* were initially assigned to different sauropod subfamilies with vastly different tooth shapes, Dicraeosaurinae and Camarasauridae respectively. However, since the 1990s (Gimenez, 1992; Salgado and Calvo, 1992, 1997; Wilson and Sereno, 1998), both genera have been recognized as members of Tita nosauria. Their coincident spatiotemporal distribution and non over lapping skeletal parts have led to the persistent suspicion that they belong to the same species. The only way to determine if they are sy nonymous is to find a specimen that has skeletal parts that overlap both of the holotypes.

Here we report on recent field explorations that relocated the Opisthocoelicaudia quarry in 2007 and the Nemegtosaurus quarry in 2016. The Nemegtosaurus locality has produced additional bones that are compatible in size with the holotype skull of *Nemegtosaurus* and likely pertain to the same individual, providing the first opportunity to evaluate the relationship between Nemegtosaurus and Opisthocoelicaudia. Thirty two Nemegt sites (in addition to the holotype quarries, Table 1) preserve sauropod remains (including vertebrae, humeri, pelvic elements, femora, pedal phalanges, and unguals), and more than six sauropod footprint sites have been mapped (Stettner et al., 2017 this volume). These numbers do not include other sauropod material collected by the Soviet (Rozhdestvensky in Nowinski, 1971), Russian Mongolian (Kurzanov and Bannikov, 1983) and Polish Mon golian expeditions (Madzia and Borsuk Bialynicka, 2014). All localities occur within a discrete stratigraphic interval encompassing the upper most Baruungoyot (footprints), Baruungoyot Nemegt interfingering interval (Nemegtosaurus type), and lowermost Nemegt formations (Eberth, 2017, this volume; Fanti et al., 2017, this volume). Strati graphic comparisons indicate the Opisthocoelicaudia locality at Altan Uul IV is within the lower beds of the Nemegt Formation. Now that sauropod remains are documented for a total of 34 sites in the Nemegt Formation across the Nemegt Basin, a more refined stratigraphic fra mework may shed new light on the taxonomic inclusiveness of the sample.

1.1. Institutional abbreviations

MPC D, Institute of Paleontology and Geology of the Mongolian Academy of Sciences, Ulaan Baatar; ZPal, Palaeozoological Institute, Polish Academy of Sciences, Warsaw.

2. Localities

2.1. Opisthocoelicaudia type locality

The location of the quarry for the sauropod skeleton that ultimately became the holotype of *Opisthocoelicaudia skarzynskii* is marked on the map of Altan Uul IV (Gradziński et al., 1969, their Fig. 4). The hand drawn map was skillfully drawn through triangulation of cairns constructed at strategic points at Altan Uul IV. However, the small scale of the map made it impossible to relocate the quarry between 2006 and 2008. Fortunately, Gradziński was still alive at that time and provided additional information and photographs that led to the rediscovery of the quarry in 2009 (Currie, 2016). The excavation site was huge as would be expected for a sauropod quarry, but had been filled in by blowing sand. The infilling has made it impossible to determine if any additional bones of the holotype remain in the quarry. Nevertheless, the relocation of the quarry now permits a re evaluation of the stratigraphic level of the holotype. Gradziński et al. (1969, their Fig. 5) positioned the quarry high in the 75 m of Cretaceous fluvial strata at Altan Uul IV. Some taphonomic details of the specimen were provided by Gradziński (1970) and in the published quarry map (Borsuk Bialynicka, 1977, her Fig. 1). The specimen was initially housed at the Institute of Paleobiology (Warsaw), where it was catalogued as ZPAL MgD I/48. How ever, it was subsequently transferred to the Institute of Paleontology and Geology (Ulaan Baatar) where it has the catalogue number of MPC D100/404.

2.2. Nemegtosaurus type locality

Gradziński et al. (1969: their Fig. 2) provided the first map of the Nemegt locality that documented the primary quarries of the 1964 and 1965 expeditions. The figure caption of Gradziński et al. (1969: their Fig. 2) refers to an almost complete, 65 cm long sauropod skull marked on the map with the number 6 (Nem006 in Currie, 2016). The corresponding number on the map is located on the west side of Central Sayr near the mouth of a small *sayr* about 500 m to the northwest of the 1965 camp area (see Fanti et al., 2017, this volume). That specimen would later become the holotype of *Nemegtosaurus mongoliensis* (ZPal MgD I/9; Nowinski, 1971). Additional data on the stratigraphic oc currence, taphonomy, and completeness of this *Nemegtosaurus* in dividual were not available for more than 50 years after its discovery.

A systematic survey and relocation of stone cairns (used by the Polish geologists during mapping activities to triangulate points) near the Nemegtosaurus type area led to the fortuitous discovery of sauropod elements about 25 m from the estimated 'number 6' locality of Gradziński et al. (1969: their Fig. 2). Although we had attempted to find the quarry for more than eight years, we were in fact looking for it in the wrong place because the hand drawn maps had suggested it was in the adjacent sayr. No photographs have been relocated of the excava tion of the Nemegtosaurus skull, although a poor quality clip was found in a home movie taken by Gradziński in 1965 that seems to confirm that we have found the correct site. Several postcranial bones were re covered in 2016, mostly in situ, at the bottom of a steep cliff in the immediate vicinity of the Nemegtosaurus quarry (Figs. 1, 2, 3). These included a caudal centrum and a pedal ungual that were no longer *in situ*. The two ends of a right femur were found at the bottom of the sayr, but the shaft of the bone was found in situ in the cliff. In the same layer, an articulated tibia, fibula, and astragalus were found. The identity of the site was confirmed by discovery of quarrying material (plaster and burlap), packing material (wood shavings), and an empty can stamped with the same numbers as cans found in the 1965 Polish Mongolian camp. In addition, a small stone cairn commonly used during the Polish expeditions to mark important localities was found on top of the cliff directly facing the quarry. New, high resolution aerial photos acquired during the 2016 expedition provided accurate data for this location, documenting how remarkably accurate were the hand drawn maps of Gradziński and colleagues.

Measured sections at the site place *in situ* elements within a 2 m thick interval of red beds characterized by repeated centimeter to decimeter thick alternations of sandstone and siltstone layers (Figs. 2, 3). Despite overall tabular geometry of beds, load and water escape deformation are almost ubiquitous, suggesting high content of water in the sediment at the time of deposition. In addition, finer graded layers display evidence of early pedogenesis. Based on larger scale observation along the *Nemegtosaurus* sayr, this interval is interpreted as a splay washover area related to fluvial flood events. Facies analysis places the *Nemegtosaurus* quarry within the lowermost tongues of the Nemegt Formation. However, the section is representative of a stratigraphic

Table 1

Table 1 Table 1 Table of sauropod specimens found in recent years in the Nemegt and Baruungoyot Formations for which there are good locality data (on record at the MPC). Numbered sauropod sites (such as MPC-D Sauropod 01) usually refer to places where there are multiple bones belonging to single individuals. Only six of the footprint sites are listed, although most of the forty that have been identified probably have sauropod footprints. Abbreviations: FS, footprint site; KID, Korea-Mongolia International Dinosaur Project; MPC, Institute of Paleontology and Geology, Academy of Sciences of Mongolia; NEE, Nemegt Educational Expedition; PIN, Russian Academy of Sciences; PJC, Dinosaurs of the Gobi Expedition of Nomadic Expeditions and the MPC.

MPC:D100/402NengtNengtMPC:D100/402Sul, manübiseSul, manübiseNengt, Khad tolgoiMPC:D100/402MC:D1Bolotype skeletonNan UalNan UalPN 300/2MPC:D Sauropol 3, NemeHolotype, partial skullNemegt, Central Skyr, IDZPal MgD:D,25MPC:D Sauropol 01Partial ItalNemegt, Central Skyr, IDMPC:D Sauropol 02Partial ItalNemegt, Central Skyr, IDNan UalMPC:D Sauropol 03Farial ItalNan UalNan UalMPC:D Sauropol 04Farial ItalNan UalNan UalMPC:D Sauropol 05Farial SkyrNan UalNan UalMPC:D Sauropol 05Farial SkyrNan UalNan UalMPC:D Sauropol 06Farial SkyrNan UalMPC:D Sauropol 07HangesNan UalNan UalMPC:D Sauropol 06Farial SkyrNan UalNan UalMPC:D Sauropol 10Nanegt, North SkyrNanegt, North SkyrMPC:D Sauropol 11Farial Skeleton (ribs, pelvis)Nanegt, North SkyrMPC:D Sauropol 12Farial Skeleton (ribs, pelvis)Nan UalMPC:D Sauropol 13Sauropol 14Nan UalMPC:D Sauropol 14Farial Skeleton (ribs, pelvis)Nan UalMPC:D Sauropol 15Sauropol 15Nan UalMPC:D Sauropol 16Sauropol 16Nan UalMPC:D Sauropol 17Sauropol 16Nan UalMPC:D Sauropol 20Sauropol 20Nan UalMPC:D Sauropol 21Sauropol 20Nan UalMPC:D Sauropol 21Sauropol 20N	15
MPC-1010/402Skull, andiblesNenegt, Khada tolgoiMPC-1010/40 (originally Zpal Mg/b-1/9, Mg/C 10Holotype skullAlna Uul 4PIN 3906/2Petoral grifueNenegt, Cantral Say, 190Zral Mg/b-1/9, MPC/D 10Petoral grifueNenegt, Cantral Say, 190MPC D Sauropod 01Petoral grifueNenegt, Mex Say, 100MPC-D Sauropod 02Alna Uul 4Alna Uul 4MPC-D Sauropod 04Alna Uul 4Alna Uul 4MPC-D Sauropod 05Alna Uul 4Alna Uul 4MPC-D Sauropod 04Alna Uul 4Alna Uul 4MPC-D Sauropod 05Alna Uul 4Alna Uul 4MPC-D Sauropod 05Alna Uul 4Alna Uul 4MPC-D Sauropod 05Alna Uul 4Alna Uul 4MPC-D Sauropod 06Alna Uul 4Alna Uul 4MPC-D Sauropod 07Alna Uul 3Alna Uul 3MPC-D Sauropod 07Alna Uul 3Alna Uul 3MPC-D Sauropod 10Alna Uul 3Alna Uul 3MPC-D Sauropod 11Alna Uul 3Alna Uul 3MPC-D Sauropod 12Alna Uul 3Alna Uul 3MPC-D Sauropod 13Alrat Uul 3Alna Uul 3MPC-D Sauropod 14Alna Uul 3Alna Uul 3MPC-D Sauropod 15Alrat Uul 3Alna Uul 3MPC-D Sauropod 16Forde partial skeleton (ribs pelvis)Alna Uul 3MPC-D Sauropod 18Forde partial skeleton (ribs pelvis)Alna Uul 3MPC-D Sauropod 19Forde partial skeleton 19Alna Uul 3MPC-D Sauropod 20Sauroput 4Alna Uul 3MPC-D Sauropod 20Sauroput 4 <td< td=""><td>5</td></td<>	5
MPC-D100/404 (originally Zpall MgD:1/48)Holotype skeletonAlar Uui 4PIN 3906/2MPC-D Sauropol 34, Nem00Holotype skullNemegt, Central Sayn, 196ZPal MgD-1/25Pertoral girdleNemegt, Vest SayrMPC-D Sauropol 02Partial tal IalAlaru Uui 4MPC-D Sauropol 03Alaru Uui 4Alaru Uui 4MPC-D Sauropol 04MPC-D Sauropol 05Alaru Uui 4MPC-D Sauropol 05Alaru Uui 4Alaru Uui 4MPC-D Sauropol 05MPC-D Sauropol 05Alaru Uui 7MPC-D Sauropol 05MPC-D Sauropol 06Merce, North SayrMPC-D Sauropol 05MPC-D Sauropol 07Verce Sauropol 07MPC-D Sauropol 05MPC-D Sauropol 07Verce Sauropol 07MPC-D Sauropol 05MPC-D Sauropol 06Nemegt, North SayrMPC-D Sauropol 10MPC-D Sauropol 12Nemegt, North SayrMPC-D Sauropol 12Nemegt, North SayrNemegt, North SayrMPC-D Sauropol 12MPC-D Sauropol 14Nemegt, North SayrMPC-D Sauropol 15VercebraNemegt, North SayrMPC-D Sauropol 16Eroded rail skeleton (ribs, pelvis)Nemegt, North SayrMPC-D Sauropol 17MPC-D Sauropol 18Nemegt, North SayrMPC-D Sauropol 18MPC-D Sauropol 18Nemegt, North SayrMPC-D Sauropol 18MPC-D Sauropol 18Nemegt, North SayrMPC-D Sauropol 19Forded partial skeletonNemegt, North SayrMPC-D Sauropol 20Sartial skeleton, 25 caudalsNemegt, North SayrMPC-D Sauropol 21MPC-D Sauropol 23Sartial skeleton, 25 caudals<	5
PIN 390/2Hotopyee, partial skullShar TsavZPah MgD-19, MPC-D100/MPC-D Sauropod 34, Mem06, Corral girdleNemegt, Corral Sayr, 196ZPah MgD-12,5MPC-D Sauropod 01Partial tailNemegt, Corral Sayr, 196MPC-D Sauropod 02Altan Uul 4Altan Uul 4MPC-D Sauropod 03Kentopic Corral girdleAltan Uul 4MPC-D Sauropod 04Kentopic Corral girdleAltan Uul 4MPC-D Sauropod 05Kentopic Corral girdleAltan Uul 2MPC-D Sauropod 06MPC-D Sauropod 06Guriliin TsavMPC-D Sauropod 07WPC-D Sauropod 07Ualaa KlushuuMPC-D Sauropod 07Ualaa KlushuuMPC-D Sauropod 07Ualaa KlushuuMPC-D Sauropod 10Ualaa KlushuuMPC-D Sauropod 11Nemegt, North SayrMPC-D Sauropod 12Nemegt, Sact SayrMPC-D Sauropod 14Partial skeleton (ribs, pelvis)MPC-D Sauropod 15Eroded tailMPC-D Sauropod 16Eroded tailMPC-D Sauropod 17MPC-D Sauropod 18MPC-D Sauropod 18Fride giral skeletonMPC-D Sauropod 19Fride giral skeletonMPC-D Sauropod 12Altan Uul 2MPC-D Sauropod 23Sartun, pelvisMPC-D Sauropod 24Long bonesMPC-D Sauropod 25Sauropic Sact SayrMPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Altan Uul 2MPC-D Sauropod 28Sact Marchi SayrMPC-D Sauropod 29Partial skeleton, 25 caudalsMPC-D Sauropod 28Altan Uul 2MPC-D Sauropod 28Al	55
ZPal MgD-1/2, MPC-D Sauropod 34, Nem06 Holotype skull Nemegt, Central Sayr, 196 Petton MgD-1/25 Petton al gridle Petton al gridle MPC. D Sauropod 01 Partial tail Nemegt, West Sayr MPC-D Sauropod 03 Altan Uul 4 MPC-D Sauropod 04 Altan Uul 4 MPC-D Sauropod 05 Altan Uul 4 MPC-D Sauropod 06 Guriliin Tsav MPC-D Sauropod 06 Guriliin Tsav MPC-D Sauropod 07 Nemegt, North Sayr MPC-D Sauropod 07 Uaan Khushuu MPC-D Sauropod 07 Nemegt, North Sayr MPC-D Sauropod 10 Uaan Khushuu MPC-D Sauropod 12 Altan Uul 3 MPC-D Sauropod 14 Partial skeleton (ribs, pelvis) Nemegt, North Sayr MPC-D Sauropod 15 Vertebra Nemegt, North Sayr MPC-D Sauropod 16 Eroded tail Hermiin Tsav MPC-D Sauropod 15 Vertebra Nemegt, North Sayr MPC-D Sauropod 16 Eroded partial skeleton Bugiin Tsav MPC-D Sauropod 12 Altan Uul 2 Nemegt, North Sayr MPC-D Sauropo	5
APail angle 7/25 Pector a groue MPC D 100/406 MPC-D Sauropod 02 Altan Uul 4 MPC-D Sauropod 02 Altan Uul 4 MPC-D Sauropod 03 Altan Uul 4 MPC-D Sauropod 04 Altan Uul 4 MPC-D Sauropod 05 Altan Uul 2 MPC-D Sauropod 05 Garilin Tsav MPC-D Sauropod 06 Phalanges Gurilin Tsav MPC-D Sauropod 07 MPC-D Sauropod 07 Meregt, North Sayr MPC-D Sauropod 10 Nemegt, North Sayr Meregt, North Sayr MPC-D Sauropod 13 Nemegt, North Sayr Meregt, North Sayr MPC-D Sauropod 13 Nemegt, North Sayr Meregt, North Sayr MPC-D Sauropod 14 Partial skeleton (ribs, pelvis) Nemegt, North Sayr MPC-D Sauropod 15 Vertebra Nemegt, North Sayr MPC-D Sauropod 16 Eroded tail skeleton (ribs, pelvis) Nemegt, North Sayr MPC-D Sauropod 17 Partial skeleton (ribs, pelvis) Nemegt, North Sayr MPC-D Sauropod 18 Altan Uul 2 Merch Sauropod 19 Nemegt, North Sayr MPC-D Sauropod 19 Forded partial skeleton, 25 caudals Altan Uul 2 <td></td>	
MPC D Sauropod 02 Artian Marian Article Articl	
MPC-D Sauropol 03Altan Uul 4MPC-D Sauropol 04Altan Uul 4MPC-D Sauropol 05Altan Uul 2MPC-D Sauropol 06Gurilin TsavMPC-D Sauropol 07PhalanesMPC-D Sauropol 10Uana KhushuuMPC-D Sauropol 10Uana KhushuuMPC-D Sauropol 12Altan Uul 3MPC-D Sauropol 12Altan Uul 3MPC-D Sauropol 12Altan Uul 3MPC-D Sauropol 12Nemegt, North SayrMPC-D Sauropol 13Nemegt, North SayrMPC-D Sauropol 15VertebraMPC-D Sauropol 16Forded tailMPC-D Sauropol 17Hermiin TsavMPC-D Sauropol 18Altan Uul 2MPC-D Sauropol 19Forded tailMPC-D Sauropol 19Forded tailMPC-D Sauropol 19Altan Uul 2MPC-D Sauropol 19Altan Uul 2MPC-D Sauropol 19Forded partial skeletonMPC-D Sauropol 19Sacrun, pelvisMPC-D Sauropol 19Altan Uul 2MPC-D Sauropol 19Altan Uul 2MPC-D Sauropol 2015 articulated caudalsMPC-D Sauropol 23Sacrun, pelvisMPC-D Sauropol 24Long bonesMPC-D Sauropol 25Altan Uul 2MPC-D Sauropol 26Altan Uul 2MPC-D Sauropol 27Gurilin TsavMPC-D Sauropol 28Gurilin TsavMPC-D Sauropol 29Attai skeletonMPC-D Sauropol 29Attai skeletonMPC-D Sauropol 29Attai skeletonMPC-D Sauropol 29Attai skeletonMPC-D Sauropol 30Caudals	
MPC-D Sauropd 04Altan U4MPC-D Sauropd 05Altan U4MPC-D Sauropd 07Gunlin TsavMPC-D Sauropd 07Gunlin TsavMPC-D Sauropd 07Uana KinsuMPC-D Sauropd 10Uana KinsuMPC-D Sauropd 11HangesMPC-D Sauropd 12MPC-D Sauropd 12MPC-D Sauropd 13KinsuMPC-D Sauropd 14Haleston (risp. pelvis)MPC-D Sauropd 15VerebraMPC-D Sauropd 16VerebraMPC-D Sauropd 17Hermin TsavMPC-D Sauropd 18Hermin TsavMPC-D Sauropd 17Hermin TsavMPC-D Sauropd 18Hermin TsavMPC-D Sauropd 17Hermin TsavMPC-D Sauropd 18Hermin TsavMPC-D Sauropd 19Foded tailMPC-D Sauropd 19Sauropd Sauropd 19MPC-D Sauropd 19Herdin Sauropd 19MPC-D Sauropd 19Herdin Sauropd 19MPC-D Sauropd 19Sauropd Sauropd 19MPC-D Sauropd 19Herdin Sauropd 19MPC-D Sauropd 19Herdin Sauropd 19MPC-D Sauropd 20Sauropd Sauropd 19MPC-D Sauropd 21Herdin Sauropd 19MPC-D Sauropd 23Sauropd Sauropd 19MPC-D Sauropd 24Herdin Sauropd 19MPC-D Sauropd 25Altan U12MPC-D Sauropd 26Herdin Sauropd 19MPC-D Sauropd 27Altan U12MPC-D Sauropd 28Altan U12MPC-D Sauropd 29Pati Altan Herdin Sauropd 19MPC-D Sauropd 29Pati Altan Herdin Sauropd 19MPC-D Sauropd 29Altan U12M	
MPC-D Sauropod 05Kalan Uul 2MPC-D Sauropod 06Gurilin TsavMPC-D Sauropod 07Gurilin TsavMPC-D Sauropod 10Uana KhushuuMPC-D Sauropod 10Uana KhushuuMPC-D Sauropod 11Nemegt, North SayrMPC-D Sauropod 12Altan Uul 3MPC-D Sauropod 13Nemegt, North SayrMPC-D Sauropod 14Partial skeleton (ribs, pelvis)MPC-D Sauropod 15VertebraMPC-D Sauropod 16Nemegt, North SayrMPC-D Sauropod 17Nemegt, North SayrMPC-D Sauropod 18Nemegt, North SayrMPC-D Sauropod 19Forded tailMPC-D Sauropod 16Hermiin TsavMPC-D Sauropod 17Altan Uul 2MPC-D Sauropod 18Nemegt, North SayrMPC-D Sauropod 19Forded partial skeletonMPC-D Sauropod 10Forded partial skeletonMPC-D Sauropod 10Sauropod 17MPC-D Sauropod 11Bugin TsavMPC-D Sauropod 12Forded partial skeletonMPC-D Sauropod 14Fordia skeleton, 25 caudalsMPC-D Sauropod 20Sarcum, pelvisMPC-D Sauropod 21Altan Uul 2MPC-D Sauropod 23Sacrum, pelvisMPC-D Sauropod 24Long bonesMPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Gurilin TsavMPC-D Sauropod 28Altan Uul 2MPC-D Sauropod 29Partial skeleton, 25 caudalsMPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Gurilin TsavMPC-D Sauropod 28 <td></td>	
MPC-D Sauropod 06Gurilin TsavMPC-D Sauropod 07PhalangesGurilin TsavMPC-D Sauropod 09PhalangesUlaan KhushuuMPC-D Sauropod 10Uanan KhushuuNemegt, North SayrMPC-D Sauropod 12Altan Uul 3Nemegt, North SayrMPC-D Sauropod 12Nemegt, North SayrNemegt, North SayrMPC-D Sauropod 13VertebraNemegt, North SayrMPC-D Sauropod 15VertebraNemegt, North SayrMPC-D Sauropod 15VertebraNemegt, North SayrMPC-D Sauropod 16Eroded tailHermiin TsavMPC-D Sauropod 17Hartial skeleton (ribs, pelvis)Nemegt, North SayrMPC-D Sauropod 18Korth SayrNemegt, North SayrMPC-D Sauropod 19Eroded partial skeletonBugiin TsavMPC-D Sauropod 19Eroded partial skeletonBugiin TsavMPC-D Sauropod 2015 articulated caudalsBugiin TsavMPC-D Sauropod 21Sacrung, pelvisNemegt, North SayrMPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrung, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 28Gurilin TsavMPC-D Sauropod 29Partial skeletonGurilin TsavMPC-D Sauropod 28Gurilin TsavMPC-D Sauropod 28Gurilin TsavMPC-D Sauropod 29Partial skeletonBugeen TsavMPC-D Sauropod 29Partial skeleton, Cecipital condyle, alveoli, metacapla, blan Bugg	
MPC-D Sauropod 07Gurilin TsavMPC-D Sauropod 10Venegt, North SayrMPC-D Sauropod 11Venegt, North SayrMPC-D Sauropod 12Altan Uul 3MPC-D Sauropod 13Nemegt, North SayrMPC-D Sauropod 14Partial skeleton (ribs, pelvis)Nemegt, North SayrMPC-D Sauropod 15VertebraNemegt, North SayrMPC-D Sauropod 16Eroded tailHermiin TsavMPC-D Sauropod 17Hermiin TsavHermiin TsavMPC-D Sauropod 18Kode partial skeletonBugin TsavMPC-D Sauropod 19Eroded partial skeletonBugin TsavMPC-D Sauropod 2015VertebraBugin TsavMPC-D Sauropod 18Kendet partial skeletonBugin TsavMPC-D Sauropod 21MPC-D Sauropod 20Altan Uul 2MPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2Altan Uul 2MPC-D Sauropod 26Guriliin TsavGuriliin TsavMPC-D Sauropod 27Guriliin TsavGuriliin TsavMPC-D Sauropod 28Altan Uul 2Altan Uul 2MPC-D Sauropod 31Guriliin TsavSugen TsavMPC-D Sauropod 31Tsagan KhushuuTsagan KhushuuMPC-D	
MPC-D Sauropod 09 Phalanges Menegr, North Sayr MPC-D Sauropod 10 Ulaa Khushuu MPC-D Sauropod 11 Ala Uul 3 MPC-D Sauropod 13 Ala Uul 3 MPC-D Sauropod 14 Partial skeleton (ribs, pelvis) Menegr, North Sayr MPC-D Sauropod 15 Vertebra Menegr, North Sayr MPC-D Sauropod 16 Eroded tail Hermiin Tsav MPC-D Sauropod 16 Eroded tail Hermiin Tsav MPC-D Sauropod 17 Hermiin Tsav MPC-D Sauropod 19 Eroded partial skeleton MPC-D Sauropod 20 I 5 articulated caudals Bugiin Tsav MPC-D Sauropod 21 Barticulated caudals Alaru Uul 2 MPC-D Sauropod 23 Sacrum, pelvis Alaru Uul 2 MPC-D Sauropod 23 Sacrum, pelvis Alaru Uul 2 MPC-D Sauropod 24 Long bones Altan Uul 2 MPC-D Sauropod 25 Harticulated Caudals Altan Uul 2 MPC-D Sauropod 26 Harti Skeleton MPC-D Sauropod 27 Altan Uul 2 MPC-D Sauropod 28 Sacrum, pelvis Altan Uul 2 MPC-D Sauropod 29 Partial skeleton MPC-D Sauropod 30 Caudals Bugeen Tsav MPC-D Sauropod 30 Caudals Altan Uul 2 MPC-D Sauropod 30 Caudals Altan Uul 2 MPC-D Sauropod 30 Caudals Bugeen Tsav MPC-D Sauropod 30 Caudals Altan Uul 2 MPC-D Sauropod 30 Caudals Altan Uul 2 MPC-D Sauropod 30 Caudals Bugeen Tsav	
MPC-D Sauropod 11 MPC-D Sauropod 12 MPC-D Sauropod 12 MPC-D Sauropod 12 MPC-D Sauropod 13 MPC-D Sauropod 14 MPC-D Sauropod 14 MPC-D Sauropod 15 Vertebra MPC-D Sauropod 15 Vertebra MPC-D Sauropod 16 MPC-D Sauropod 16 MPC-D Sauropod 16 MPC-D Sauropod 17 MPC-D Sauropod 17 MPC-D Sauropod 17 MPC-D Sauropod 18 MPC-D Sauropod 18 MPC-D Sauropod 19 MPC-D Sauropod 19 MPC-D Sauropod 19 MPC-D Sauropod 20 MPC-D Sauropod 21 MPC-D Sauropod 22 Partial skeleton, 25 caudals MPC-D Sauropod 23 Sacrum, pelvis MPC-D Sauropod 25 MPC-D Sauropod 25 MPC-D Sauropod 26 MPC-D Sauropod 27 MPC-D Sauropod 27 MPC-D Sauropod 28 MPC-D Sauropod 29 Partial skeleton MPC-D Sauropod 29 MPC-D Sauropod 29 Partial skeleton MPC-D Sauropod 20 MPC-D Sauropod 27 MPC-D Sauropod 28 MPC-D Sauropod 29 Partial skeleton MPC-D Sauropod 29 Partial skeleton; Cceipital condyle, alveoli, metacarpal, phalana, Altan Uu 2 MPC-D Sauropod 31 MPC-D Sauropod 32 Sacarun at at at a starta at a	
MPC-D Sauropod 12 Altan Uul 3 MPC-D Sauropod 13 MPC-D Sauropod 14 Partial skeleton (ribs, pelvis) Nemegt, North Sayr MPC-D Sauropod 15 Vertebra MPC-D Sauropod 16 Eroded tail Hermiin Tsav MPC-D Sauropod 16 Eroded tail Hermiin Tsav MPC-D Sauropod 17 MPC-D Sauropod 18 Altan Uul 2 MPC-D Sauropod 19 Eroded partial skeleton MPC-D Sauropod 20 15 articulated caudals MPC-D Sauropod 21 MPC-D Sauropod 23 Sacrum, pelvis MPC-D Sauropod 23 Sacrum, pelvis MPC-D Sauropod 24 Long bones MPC-D Sauropod 25 MPC-D Sauropod 25 MPC-D Sauropod 27 MPC-D Sauropod 27 MPC-D Sauropod 28 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 20 MPC-D Sauropod 21 MPC-D Sauropod 25 MPC-D Sauropod 26 MPC-D Sauropod 27 MPC-D Sauropod 28 MPC-D Sauropod 28 MPC-D Sauropod 28 MPC-D Sauropod 30 MPC-D Sauropod 30 MPC-D Sauropod 31 MPC-D Sauropod 31 MPC-D Sauropod 31 MPC-D Sauropod 31 MPC-D Sauropod 31 MPC-D Sauropod 30 MPC-D Sauropod 31 MPC-D Sauropod 30 MPC-D Sauropod 30 MPC-	
MPC-D Sauropol 13Nemegt, North SayrMPC-D Sauropol 14Partial skeleton (ribs, pelvis)Nemegt, East SayrMPC-D Sauropol 15VerebraNemegt, North SayrMPC-D Sauropol 16Eroded tailHermin TsavMPC-D Sauropol 17Hermin TsavMPC-D Sauropol 18Altan Uul 2MPC-D Sauropol 2015 articulated caudalsBugin TsavMPC-D Sauropol 21Eroded partial skeletonBugin TsavMPC-D Sauropol 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropol 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropol 24Long bonesAltan Uul 2MPC-D Sauropol 25Altan Uul 2MPC-D Sauropol 26Altan Uul 2MPC-D Sauropol 27Altan Uul 2MPC-D Sauropol 28Guriliin TsavMPC-D Sauropol 29Partial skeletonBugien TsavMPC-D Sauropol 29Partial skeletonMercin SayrMPC-D Sauropol 24Long bonesAltan Uul 2MPC-D Sauropol 25Guriliin TsavMercin SayrMPC-D Sauropol 26Guriliin TsavSayrMPC-D Sauropol 27Guriliin TsavSayrMPC-D Sauropol 30CaudalsBugeen TsavMPC-D Sauropol 31SaudalsBugeen TsavMPC-D Sauropol 31Tsagan KhushuuMPC-D PJC2012.070MPC-D Sauropol 31Tsagan KhushuuMPC-D Sauropol 31Tsagan KhushuuMuch Sauropol	
MPC-D Sauropod 14Partial skeleton (ribs, pelvis)Nemegt, East SayrMPC-D Sauropod 15VertebraNemegt, North SayrMPC-D Sauropod 16Eroded tailHermiin TsavMPC-D Sauropod 16Eroded tailHermiin TsavMPC-D Sauropod 18Altan Uul 2MPC-D Sauropod 19Eroded partial skeletonBugiin TsavMPC-D Sauropod 2015 articulated caudalsBugiin TsavMPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Jatan Uul 2Altan Uul 2MPC-D Sauropod 26Altan Uul 2Altan Uul 2MPC-D Sauropod 27Long bonesAltan Uul 2MPC-D Sauropod 28Guriliin TsavGuriliin TsavMPC-D Sauropod 28Guriliin TsavGuriliin TsavMPC-D Sauropod 29Partial skeleton, Cocipital condyle, alveoli, metacarpal, phala, altan Uul 2MPC-D Sauropod 28Guriliin TsavGuriliin TsavMPC-D Sauropod 29Partial skeleton, Cocipital condyle, alveoli, metacarpal, phala, altan Uul 2MPC-D Sauropod 31Tasagan KhushuuMPC-D Sauropod 31Tasagan Khushuu	
MPC-D Sauropod 15VertebraNemegt, North SayrMPC-D Sauropod 16Eroded tailHermin TsavMPC-D Sauropod 17Keroded tailHermin TsavMPC-D Sauropod 18Altan Uul 2MPC-D Sauropod 19Eroded partial skeletonBugin TsavMPC-D Sauropod 2015 articulated caudalsBugin TsavMPC-D Sauropod 21Partial skeleton, 25 caudalsBugin TsavMPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrum, pelvisAltan Uul 2MPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Guriliin TsavMPC-D Sauropod 28Guriliin TsavMPC-D Sauropod 29Partial skeletonGuriliin TsavMPC-D Sauropod 29Partial skeletonBugeen TsavMPC-D Sauropod 29Partial skeletonBugeen TsavMPC-D Sauropod 29Partial skeleton, 20 caudalsBugeen TsavMPC-D Sauropod 29Partial skeleton, 20 caudalsBugeen TsavMPC-D Sauropod 30CaudalsBugeen TsavMPC-D Sauropod 31Tsagan KhushuuTsagan KhushuuMPC-D PJC2012.070MPC-D Sauropod 32Pached skeleton; 00 ccipital condyle, alveoli, metacapal, halmal, altan Uul 2MPC-D PJC2012.070MPC-D Sauropod 32Mached skeleton; 00 ccipital condyle, alveoli, metacapal, halmal, altan Uul 2MPC-D PJC2012.070MPC-D Sauropod 32Mached skeleton; 00 ccipital condyle, alveoli, metacapal, halmal, altan Uul 2	
MPC-D Sauropol 16Eroded tailHermiin TsavMPC-D Sauropol 17Hermiin TsavMPC-D Sauropol 18Altan Uul 2MPC-D Sauropol 19Eroded partial skeletonBugiin TsavMPC-D Sauropol 2015 articulated caudalsBugiin TsavMPC-D Sauropol 21MPC-D Sauropol 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropol 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropol 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropol 24Long bonesAltan Uul 2MPC-D Sauropol 25Altan Uul 2MPC-D Sauropol 26Altan Uul 2MPC-D Sauropol 27Guriliin TsavMPC-D Sauropol 28Guriliin TsavMPC-D Sauropol 29Partial skeletonMPC-D Sauropol 30CaudalsMPC-D Sauropol 31Tagan KhushuuMPC-D PJC2012.070MPC-D Sauropol 32	
MPC-D Sauropod 17Hermin TsavMPC-D Sauropod 18Kiroled partial skeletonBugiin TsavMPC-D Sauropod 2015 articulated caudalsBugiin TsavMPC-D Sauropod 21Bugiin TsavBugiin TsavMPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Guriliin TsavMPC-D Sauropod 28Guriliin TsavMPC-D Sauropod 29Partial skeletonMPC-D Sauropod 29Partial skeletonMPC-D Sauropod 28Guriliin TsavMPC-D Sauropod 29Partial skeletonMPC-D Sauropod 29Partial skeletonMPC-D Sauropod 31Tsagan KhushuuMPC-D PJC2012.070MPC-D Sauropod 32	
MPC-D Sauropod 18Froded partial skeletonBugiin TsavMPC-D Sauropod 2015 articulated caudalsBugiin TsavMPC-D Sauropod 21Bugiin TsavBugiin TsavMPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Altan Uul 2MPC-D Sauropod 28Guriliin TsavMPC-D Sauropod 29Partial skeletonMPC-D Sauropod 31Tsagan KhushuuMPC-D PJC2012.070MPC-D Sauropod 32MPC-D PJC2012.070MPC-D Sauropod 32MPC-D Sauropod 32Poached skeleton; Occipital condyle, alveoli, metacarpal, phalan, aMPC-D PJC2012.070MPC-D Sauropod 32	
MPC-D Sauropod 20 15 articulated caudals Bugiin Tsav MPC-D Sauropod 21 Bugiin Tsav MPC-D Sauropod 22 Partial skeleton, 25 caudals Altan Uul 2 MPC-D Sauropod 23 Sacrum, pelvis Altan Uul 2 MPC-D Sauropod 24 Long bones Altan Uul 2 MPC-D Sauropod 25 Altan Uul 2 MPC-D Sauropod 26 MPC-D Sauropod 26 MPC-D Sauropod 27 MPC-D Sauropod 27 MPC-D Sauropod 28 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 30 MPC-D Sauropod 31 MPC-D Sauropod 32 MPC-D	
MPC-D Sauropod 21 MPC-D Sauropod 22 MPC-D Sauropod 22 MPC-D Sauropod 22 MPC-D Sauropod 23 MPC-D Sauropod 23 MPC-D Sauropod 24 MPC-D Sauropod 25 MPC-D Sauropod 25 MPC-D Sauropod 26 MPC-D Sauropod 27 MPC-D Sauropod 27 MPC-D Sauropod 28 MPC-D Sauropod 28 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 30 MPC-D Sauropod 30 MPC-D Sauropod 31 MPC-D Sauropod 32 MPC-D Sauropo	
MPC-D Sauropod 22Partial skeleton, 25 caudalsAltan Uul 2MPC-D Sauropod 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Guriliin TsavMPC-D Sauropod 28Guriliin TsavMPC-D Sauropod 29Partial skeletonMPC-D Sauropod 29CaudalsMPC-D Sauropod 30CaudalsMPC-D Sauropod 31Tsagan KhushuuMPC-D PJC2012.070MPC-D Sauropod 32MPC-D Sauropod 32Poached skeleton; Occipital condyle, alveoli, metacarpal, phalan, a gastralia	
MPC-D Sauropod 23Sacrum, pelvisNemegt, North SayrMPC-D Sauropod 24Long bonesAltan Uul 2MPC-D Sauropod 25Altan Uul 2MPC-D Sauropod 26Altan Uul 2MPC-D Sauropod 27Guriliin TsavMPC-D Sauropod 28Guriliin TsavMPC-D Sauropod 29Partial skeletonBugeen TsavMPC-D Sauropod 30CaudalsBugeen TsavMPC-D Sauropod 31Tsagan KhushuuMPC-D Suropod 32Poached skeleton; Occipital condyle, alveoli, metacarpal, phalan, aAltan Uul 2MPC-D Suropod 32SauratiaSauropod 30Altan Uul 2	
MPC-D Sauropod 24 Long bones Altan Uul 2 MPC-D Sauropod 25 Altan Uul 2 MPC-D Sauropod 26 Altan Uul 2 MPC-D Sauropod 26 Altan Uul 2 MPC-D Sauropod 27 Gurilin Tsav MPC-D Sauropod 28 Gurilin Tsav MPC-D Sauropod 29 Partial skeleton Caudals Bugeen Tsav MPC-D Sauropod 30 Caudals Bugeen Tsav MPC-D Sauropod 31 Tagan Khushuu MPC-D PJC2012.070 MPC-D Sauropod 32 Poached skeleton; Occipital condyle, alveoli, metacarpal, phalan, a Altan Uul 2 gastralia	
MPC-D Sauropod 25 Altan Uul 2 MPC-D Sauropod 26 Altan Uul 2 MPC-D Sauropod 27 Guriliin Tsav MPC-D Sauropod 28 Guriliin Tsav MPC-D Sauropod 29 Partial skeleton MPC-D Sauropod 30 Caudals Bugeen Tsav MPC-D Sauropod 31 Tagan Khushuu MPC-D PJC2012.070 MPC-D Sauropod 32 Poached skeleton; Occipital condyle, alveoli, metacarpal, phalanx Altan Uul 2 gastralia	
MPC-D Sauropod 26 Altan Uul 2 MPC-D Sauropod 27 Guriliin Tsav MPC-D Sauropod 28 Guriliin Tsav MPC-D Sauropod 29 Partial skeleton MPC-D Sauropod 30 Caudals Bugeen Tsav MPC-D Sauropod 31 Tsagan Khushuu MPC-D Sauropod 32 Poached skeleton; Occipital condyle, alveoli, metacarpal, phalanx, Altan Uul 2 gastralia	
MPC-D Sauropod 28 MPC-D Sauropod 28 MPC-D Sauropod 29 MPC-D Sauropod 29 MPC-D Sauropod 30 MPC-D Sauropod 31 MPC-D Sauropod 32 MPC-D Sauropo	
MPC-D Sauropod 29 Partial skeleton Bugeen Tsav MPC-D Sauropod 30 Caudals Bugeen Tsav MPC-D Sauropod 31 Tsagan Khushuu MPC-D Sauropod 32 Poached skeleton; Occipital condyle, alveoli, metacarpal, phalanx, Altan Uul 2 gastralia	
MPC-D Sauropod 30 MPC-D Sauropod 31 MPC-D Sauropod 32 MPC-D Saurop	
MPC-D Sauropod 31 Tsagan Khushuu MPC-D PJC2012.070 MPC-D Sauropod 32 Poached skeleton; Occipital condyle, alveoli, metacarpal, phalanx, Altan Uul 2 gastralia	
MPC-D PJC2012.070 MPC-D Sauropod 32 Poached skeleton; Occipital condyle, alveoli, metacarpal, phalanx, Altan Uul 2 gastralia	
gastralia	
MPC-D100F/015 MPC-D FS02_PJC2002_032Sauropod_footprints	
MPC-D FS06 Sauropod footprints Nemegt, Central Savr	
MPC-D FS23 Sauropod footprints Nemegt, Central Sayr	
MPC-D FS30 Sauropod footprints Nemegt, Central Sayr	
MPC-D FS40 Sauropod footprints Nemegt, East Sayr	
MPC-D FS43A Sauropod footprints Hermiin Tsav	
MPC-D KID005 Skin impression Ulaan Knushuu MPC-D KID010 Taeth	
MPC-D KID060 Forchell fragments Altan Uni 1	
MPC-D KID062 Tooth Altan Uul 1	
MPC-D KID076 Tooth Altan Uul 3	
MPC-D KID209 Tooth Hermiin Tsav	
MPC-D KID210 Tooth Hermiin Tsav	
MPC-D KID256 Tooth Hermin Tsav	
MPC-D KID284 100th Hermini 153V MPC D KID201 Unguile Namet North Sur	
MPC-D KID315 Tooth Hermin Tsay	
MPC-D KID316 Tooth Hermin Tsav	
MPC-D KID352 Tarsal Hermiin Tsav	
MPC-D KID387 Tooth Hermiin Tsav	
MPC-D KID405 Tooth Bugiin Tsav	
MPC-D KID425 Tooth Bugiin Tsav	
ארט איז	ne
MPC-D KID502 Caudal vertebrae Nemegt, South Monadhoch	13
MPC-D KID505 Tooth Altan Uul 2	
MPC-D KID535 Ungual Altan Uul 2	
MPC-D KID557 Phalanx Bugiin Tsav	
MPC-D KID599 Skin impression Nogon Tsav	
MPC-D KID6/4 Posterior caudals Khuree Tsav'	
איז	
(continued on next po	

Table 1 (continued)

Specimen #	Site #	Comment	Locality
MPC-D NEE Sauropod squamosal		Squamosal	Altan Uul 3
MPC-D PJC2000.019		Eggshell frags	Hermiin Tsav
MPC-D PJC2000.030		Caudal vertebrae	Nemegt, Central Sayr
MPC-D PJC2000.032		Ungual	Nemegt
MPC-D PJC2002.034		Phalanx	Nemegt
MPC-D PJC2003.001			Nemegt
MPC-D PJC2003.035		Skull or vertebral fragment	Nemegt
MPC-D PJC2005.018		2 unguals	Nemegt, North Sayr
MPC-D PJC2006.021		Caudal vertebra, tooth marked	Nemegt
MPC-D PJC2012.009		Skull fragment	Nemegt, North Sayr
MPC-D Hayashibara 060823 BgT-II BD		2006 report	Bugin Tsav II
MPC-D Hayashibara 060829 AU-IV TSI		Cervical vertebra, 2006 report	Altan Uul 4
MPC-D Hayashibara 080926 KmK KHB		Skull, 2008 report	Khamaryn Khural

interval of approximately 20 25 m in which the Nemegt Formation includes recurrent tongues of the Baruungoyot Formation (Eberth et al., 2009; Eberth, 2017, this volume; Fanti et al., 2012; Fanti et al., 2017, this volume) that crop out in the proximity of the quarry.

3. Systematic paleontology

DINOSAURIA Owen, 1842 SAUROPODA Marsh, 1878 MACRONARIA Wilson and Sereno, 1998 TITANOSAURIA Bonaparte and Coria, 1993 NEMEGTOSAURIDAE Upchurch, 1995 *NEMEGTOSAURIDAE* Nowinski, 1971

3.1. Type species

Nemegtosaurus mongoliensis Nowinski, 1971

3.2. Holotype

ZPal MgD I/9 (holotype), nearly complete skull and lower jaws lacking only parts of the narial region and palate, prearticular and articular (Nowinski, 1971; Wilson, 2005). In this paper, we augment the holotype with postcranial material that includes a caudal centrum, right femur, tibia, fibula, astragalus, and pedal ungual, all registered as MPC D100/413.

3.3. Referred specimens

MPC D100/402 (Maryańska, 2000) is a nearly complete skull with lower jaws that was found and collected in 1974 by B. Namsrai from the Nemegt locality at Khadat Tolgoi. Although it appears morphologically to be *Nemegtosaurus* (the preantorbital fenestra is lying in a conspicuous fossa, although only the anterior margin is preserved), the specimen has still not been properly studied or described.

3.4. Type locality and horizon

Central Sayr, Nemegt Locality (*sensu* Gradziński et al., 1969), 43°30′ 6.06''N, 101° 2′ 54.26''E. Nemegt Formation, lower tongues within the interfingering interval with the Baruungoyot Formation (see Eberth, 2017 this volume and Fanti et al., 2017 this volume).

3.5. Diagnosis (Wilson, 2005)

Autapomorphies of *Nemegtosaurus mongoliensis* include presence of a spur on the posterior edge of the squamosal and the preantorbital fenestra lying in a conspicuous fossa. Ambiguous autapomorphies are features that cannot be scored in *Quaesitosaurus* and other closely related taxa, such as the presence of an accessory fenestra (anterodorsal to the preantorbital fenestra), a jugal foramen, and a coronoid foramen.

4. Description

Only the bones recovered during the 2016 field season will be described in this paper. Although more of the specimen will be recovered



Fig. 1. A, Map of the Central Sayr area of the Nemegt locality (modified from Gradziński et al., 1969), showing the location of the *Nemegtosaurus* type quarry identified with number 6. B, detailed UAV-acquired map of the sayrs prospected to relocate the Polish Mongolian Paleontological Expedition quarry. C, composite orthophoto showing the location of the relocated *Nemegtosaurus* type quarry and other features discussed in this manuscript.



Fig. 2. A, panoramic view of the *Nemegtosaurus* type quarry (white star, facing south) showing the stratigraphic occurrence of the *in situ* elements within the Baruungoyot-Nemegt 'interfingering' interval. B, schematic stratigraphic column showing the interfingering tongues and the exact occurrence of the *Nemegtosaurus* type quarry. Abbreviations: Bg-I, Bg-II, interfingering tongues of the upper part of the Baruungoyot Formation; Nem-I, Nem-II, interfingering tongues of the lower part of the Nemegt Formation.

when funds become available, it is unlikely to be done until 2018. A caudal centrum, femur, tibia, fibula, astragalus, and pedal ungual were found at the site that produced the holotypic skull of *Nemegtosaurus mongoliensis* in 1965, and presumably belong to the same individual.

The centrum (Figs. 4, 5, 6) seems to be from either a sacral or proximal caudal vertebra. It is clearly opisthocoelous, which is the

feature for which the genus was named originally. Note that although the ventral edge of the intervertebral articulation seems to be deeply emarginated (Fig. 5F) on the midline, this is because the edge is damaged and has been restored conservatively (Fig. 6B). The centrum is wider (27 cm) than tall (19 cm), and relatively short (10 cm, excluding the ball), which are similar proportions to those of the sixth sacral



Fig. 3. A) Panoramic view of cliff face that contains the *Nemegtosaurus* quarry. Eroded bones and the Polish tin can were found on the *sayr* floor towards the right (1), *in situ* bones were found in the cliff (2) above the person on the left, and packing material (wood shavings) was found on the talus slope (3) next to the big rock with the packsack on top. B). Closer view of *Nemegtosaurus* quarry. Ends of femur (4) were found at the feet of the person with the white shirt to the left, while the shaft was recovered from the shelf at the feet of the person in a blue shirt. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)



Fig. 4. Opisthocoelous caudal centrum (MPC-D100/413) as found at the bottom of the talus slope.



Fig. 5. Opisthocoelous caudal centrum (MPC-D100/413) in dorsal (A), right lateral (B), anterior (C), left lateral (D), posterior (E) and ventral (F) views.

centrum of *Rapetosaurus* (Curry Rogers, 2009). The identification as an anterior caudal is more likely because the posterior width is only 82% of the anterior width of the centrum. The measurements are slightly smaller than the same ones in the anterior sacral and anterior caudal vertebrae of *Opisthocoelicaudia* (Borsuk Bialynicka, 1977, Tables 2, 3), in which the same dimensions are 28 cm, 24 cm and 12 cm in the first caudal vertebra. The dorsal surface, which is badly damaged, is marked on the left side by deep, anteroposteriorly oriented pits and ridges. However, it is impossible to tell if these were for contact with the unfused neural arch, or if they are just broken bone surfaces. If the neural arch had not fused by the time of death, this would suggest that the animal was not fully mature. Footprints from Nemegt suggest the presence in the area of sauropod individuals that were much larger than the holotypes of *Nemegtosaurus* and *Opisthocoelicaudia* (Nakajima et al., 2017, this volume), indicating that



Fig. 6. Restored anterior (A) and ventral (B) views of MPC-D100/413.



Fig. 7. Femora of *Nemegtosaurus* (MPC-D100/413) (A, B) and *Opisthocoelicaudia* (MPC-D100/404) (C) in anterior (A, C) and posterior (B) views. Abbreviation: 4th Tr, fourth trochanter.

MPC D100/413 is relatively small. Similar to *Opisthocoelicaudia* (Borsuk Bialynicka, 1977) but unlike *Rapetosaurus* (Curry Rogers, 2009), there is no evidence of lateral pneumatopores.

The right femur (Figs. 7A, B, 8) is 124 cm long, which is approximately 11% shorter than the length of the femur of the holotype (MPC D100/404) of *Opisthocoelicaudia*. The surfaces of both articular ends are strongly rugose (Fig. 8), which in other dinosaur taxa would suggest that this individual was approaching maturity. However, this does not appear to be the case in sauropods, which typically have weight bearing limb bones with rugose ends from young ages. Furthermore, the femur



Fig. 8. Distal end of right femur showing the rugose texture characteristic of the ends of the limb bones.

is almost 20% shorter than MPC D100/401 an isolated sauropod femur from the Nemegt Formation and as previously mentioned, footprints suggest that sauropods became much larger than known skeletal material (Nakajima et al., 2017 this volume; Stettner et al., 2017 this volume). The convex head of the femur is oriented dor somedially above the level of the greater trochanter, and the articula tion for the acetabulum is oriented dorsally as in other titanosaurs (Curry Rogers, 2009). Like the holotype of Opisthocoelicaudia and other titanosaurs (Curry Rogers, 2009), the shaft is flattened ante roposteriorly so that the transverse diameter is around 185% the anteroposterior diameter. A flange extends along the lateral surface of the proximal half of the femur. The shaft has a minimum circumference of 60 cm, compared with 68 cm in MPC D100/404 and 75 cm in MPC D100/401. The fourth trochanter is a low, 8 10 cm long ridge close to the middle of the bone on the posterior (flexor) surface. The centre of the trochanter is almost exactly midlength of the femur, whereas it is somewhat distal to midlength in the holotype of Opisthocoelicaudia skarzynskii (Borsuk Bialynicka, 1977). The medial (tibial) condyle of the distal end is a prominent, semicircular articulation that extends anteriorly and posteriorly well beyond the combined lateral and fibular condyle (Fig. 8).

Only the distal ends of the articulated right tibia and fibula (Fig. 9) can be seen at present, because their shafts and proximal ends are buried deep in a vertical sandstone cliff. The distal articular end of the tibia is deeply rugose, and measures 28.5 cm in width (compared with 29.8 cm in *Opisthocoelicaudia*; note that this was measured from the specimens and disagrees with the 20 cm width attributed to the distal end of the tibia by Borsuk Bialynicka, 1977), and a maximum of 14.5 cm in anteroposterior length.

The distal end of the fibula (Fig. 9C, D) is closely appressed to the anterolateral corner of the tibia and has a maximum anteromedial to posterolateral width of 15.5 cm (compared with 16 cm in MPC D100/404).

The right astragalus was found in articulation with the distal ends of the right tibia and fibula (Fig. 9A, B). Similar to *Opisthocoelicaudia* (Borsuk Bialynicka, 1977; Wilson, 2002) and other titanosaurs for which the lower leg is preserved (González Riga et al., 2016), there is no evidence that there were any other ossified tarsals. It covered most of the distal end of the fibula and about half of the tibia (Fig. 9B). The anteroventral surface is strongly curved and rugose, and it would have directly contacted the lateral metatarsals as in *Opisthocoelicaudia*. When it was initially removed, a thin, low ascending process with a triangular cross section was left between the distal ends of the tibia and fibula (Fig. 9C, D). The ascending process is comparable in size to that of *Opisthocoelicaudia* (Borsuk Bialynicka, 1977, her pl. XXIV, Fig. 2b), al though the body of the astragalus seems to have been positioned more laterally in *Nemegtosaurus*. This can of course be because of post



Fig. 9. A, B) distal view of *in situ*, articulated right tibia and astragalus (MPC-D100/413). C, D) same view but main body of the astragalus has been removed to expose the ascending process (ap) of the astragalus and the distal end of the fibula.

mortem taphonomic processes. However, it is unlikely to have shifted far because of the presence of the ascending process wedged between the tibia and fibula. The fact that the astragalus extends to the lateral edge of the distal end of the fibula clearly shows that there was no calcaneum. The astragalus is 15 cm wide and 12.7 cm ante roposteriorly, compared with 17 cm and 14 cm in the holotype of *Opisthocoelicaudia* (Borsuk Bialynicka, 1977).

A single ungual (Fig. 10G) was found downslope from the *in situ Nemegtosaurus* postcranial bones. Two other unguals (Fig. 10A F) were found together (but without any association with other sauropod bones) several kilometres away in Northern Sayr, but they clearly represent another titanosaurid individual. They are subequal in size, which is one of the characters used to diagnose *Opisthocoelicaudia* (Wilson, 2002). All are mediolaterally compressed, although the outer surface is inclined dorsomedially in relation to the roughly horizontal ventral surface. They are nearly identical with pedal unguals recovered with the holotype of *Opisthocoelicaudia* (Borsuk Bialynicka, 1977), as well as several described by Madzia and Borsuk Bialynicka (2014).



Fig. 10. Pedal unguals of *cf. Nemegtosaurus* in lateral (A, F, G), medial (C, E) and proximal (B, D) views. A-F, MPC-D PJC2005.18. G) MPC-D100/413.

5. Discussion

Although they are less common than those of theropods and hadrosaurs, sauropod remains such as isolated teeth, postcranial elements and footprints are now known from multiple localities in the Nemegt Formation, including Altan Uul II, III and IV, Hermiin Tsav II, Nemegt, Tsagaan Khushuu, and Ulaan Khushuu (Table 1).

At the time of writing, eight sites within the Nemegt locality preserve sauropod remains (one in the Western Sayr, two in the Central Sayr, five in the Northern Sayr), and more than six sauropod footprint sites have been identified. An additional 24 sauropod sites have been found at other Nemegt Formation localities. The stratigraphic range of these localities (including the holotypes of *Nemegtosaurus mongoliensis* and *Opisthocoelicaudia skarzynskii*, a partial skeleton discovered in 2002, and the vast majority of tracks) is from the Baruungoyot Nemegt transition to the lower 80 m of the Nemegt Formation (Table 1). As such, this study provides evidence that *Nemegtosaurus* can be added to the list of taxa that co existed at the time of deposition of the Bar uungoyot Nemegt transition, including *Avimimus, Ingenia, Nemegtomaia*, and *Tarchia* (Fanti et al., 2012).

Although more than 70 titanosaur genera are known, less than one

quarter of these are known from cranial remains and only four are known from complete skulls (*Nemegtosaurus, Rapetosaurus, Sarmientosaurus, Tapuiasaurus*). Very few titanosaurs are known from complete vertebral columns, and associations between cranial and postcranial remains are rare. As a consequence, the interrelationships of the group remain poorly resolved, although recent efforts have begun to improve this situation (*e.g.*, Díez Díaz et al., 2016; Gorscak and O'Connor, 2016). Nevertheless, lack of morphological overlap between closely related titanosaur taxa, such as is the case with *Nemegtosaurus* and *Opisthocoelicaudia*, remains a difficult issue to resolve (Wilson et al., 2016).

Borsuk Bialvnicka (1977) argued for the generic separation of Nemegtosaurus and Opisthocoelicaudia on the grounds that there is high generic diversity of sauropods within single formations in other parts of the world. Although this may be the case in certain taxa within certain formations (e.g., Morrison, Tendaguru), it does not appear to characterize the Nemegt Formation. In spite of its diversity of dinosaurs, there are relatively few species within any of the families represented by large animals, which suggests a stressed environment, probably with a relatively restricted geographic area. There are no ceratopsids in the Nemegt Formation, and there could be as few as one species of hadrosaurid (Saurolophus angustirostris, which may be the senior synonym of Barsboldia sicinskii). Much of the diversity of large herbivores is composed of large herbivorous theropods like Deinocheirus and Ther izinosaurus. Compare this with the Dinosaur Park Formation (Currie and Koppelhus, 2005), which has high species diversity of large herbivorous animals such as ankylosaurids, ceratopsids, hadrosaurids and nodosaurids. Thus, there is clearly something fundamentally different between the ecosystems of the Dinosaur Park and Nemegt formations.

Where previously there was no morphological overlap between *Nemegtosaurus mongoliensis* and *Opisthocoelicaudia skarzynskii*, now there are several overlapping postcranial bones that can be compared. Our preliminary results were not able to identify significant differences in size or morphology between these two individuals. Significantly, one of the few characters originally used to diagnose *Opisthocoelicaudia* is the presence of opisthocoelus vertebrae, which is now also known in *Nemegtosaurus*. This has been considered an autapomorphic character for *Opisthocoelicaudia* (Wilson, 2002), which clearly shows that *Nemegtosaurus* and *Opisthocoelicaudia* are closely related, perhaps as sister taxa. Both *Nemegtosaurus mongoliensis* and *Opisthocoelicaudia skarzynskii* lack a calcaneum, but this feature is present in other titanosaurs (González Riga et al., 2016).

This is also the case with isolated teeth and postcranial remains from the same formation (Table 1), which do not appear to differ significantly from one another. This led Madzia and Borsuk Bialynicka (2014) to speculate that *Opisthocoelicaudia skarzynskii* is a junior synonym of *Nemegtosaurus mongoliensis*. This leads us to suspect that there is no more than a single sauropod species in the Nemegt Formation. Additional support for this hypothesis comes from the spatiotemporal distribution of these sauropod fossils, which are concentrated close to the interface between the Baruungoyot and Nemegt Formations, and probably represent a single ecosystem spanning a limited time period.

A pair of unguals (Fig. 10A D) found about two kilometres from the *Nemegtosaurus mongoliensis* holotype locality are subequal in size. These are morphologically similar to the ungual found in the *Nemegtosaurus* quarry, but are also similar to other titanosaur unguals. However, *Opisthocoelicaudia* is distinct from other titanosaurs in that the second pedal ungual is not significantly different in size from the first. If the pair of claws are identified as *Opisthocoelicaudia* on the basis of their relative size, then they show that this genus is found in geographically the same area (at the same general level stratigraphically) as *Ne megtosaurus*. The sauropod footprints (Currie et al., 2003; Nakajima et al., 2017 this volume; Stettner et al., 2017 this volume) from the Nemegt locality also suggest that the claws on the first and second digits were equally well developed. This character can be used to support the idea that either the sauropod at Nemegt is *Opisthocoelicaudia*, or that

Nemegtosaurus also shares this character, or that the two animals are synonymous.

6. Conclusions

Relocation of the quarries of the holotypes of *Nemegtosaurus mon* goliensis and Opisthocoelicaudia skarzynskii has led to the discovery of additional bones of *Nemegtosaurus* that allow for the first time direct morphological comparison between the two species. Currently, these include one caudal centrum, a femur, the distal ends of the tibia and fibula (both of which are still *in situ* in the field), an astragalus, and a pedal ungual. Each of these bones is very similar to corresponding elements in *Opisthocoelicaudia skarzynskii*. The opisthocoelous caudal centrum is diagnostic of *Opisthocoelicaudia*, and its shared presence in *Nemegtosaurus* suggests the two taxa are closely related, possibly even synonymous. However, caution leads us to wait until more of the holotypic skeleton of *Nemegtosaurus mongoliensis* is excavated sometime in the foreseeable future.

Acknowledgments

Relocation of the Polish Mongolian Paleontological Expedition quarries has only been possible because of the maps that were produced by R. Gradziński, T. Jerzykiewicz, and various people who assisted them. The Opisthocoelicaudia quarry was relocated in 2009 after R. Gradziński provided detailed notes, photographs and sketches to PJC. The Nemegtosaurus holotype quarry was not rediscovered until after Gradziński had passed away, but finding a means to confirm its discovery would not have been possible without the help of his son (Dr. M. Gradziński) and W. Skarzynski who searched through photographs and film footage, and old field notes for anything that might be useful. We are extremely grateful for their help and support. Additional data on Rapetosaurus vertebrae were provided by K. Curry Rogers, and her willingness to share unpublished information is appreciated. Appreciation is also extended to Editor in Chief Prof. T. Algeo and two anonymous reviewers. Fieldwork for this project was funded by the National Geographic Society/Waitts Grant Program (grant #W434 16), by the Sistema Museale di Ateneo, University of Bologna, and by an NSERC (grant #2016 04674) grant to the first author.

References

- Borsuk-Bialynicka, M., 1977. A new camarasaurid sauropod Opisthocoelicaudia skarzynskii, gen. n., sp. n. from the Upper Cretaceous of Mongolia. Palaeontol. Pol. 37, 1–64.
- Currie, P.J., 2016. Dinosaurs of the Gobi: following in the footsteps of the Polish-Mongolian Expeditions. Palaeontol. Pol. 67, 83–100.
- Currie, P.J., Koppelhus, E.B., 2005. Dinosaur Provincial Park, a Spectacular Ancient Ecosystem Revealed. Indiana University Press, Bloomington, Indiana, pp. 648.
- Currie, P.J., Badamgarav, D., Koppelhus, E.B., 2003. The first Late Cretaceous footprints from the Nemegt locality in the Gobi of Mongolia. Ichnos 10, 1–13. http://dx.doi. org/10.1080/10420940390235071.
- Curry Rogers, K., 2009. The postcranial osteology of Rapetosaurus krausei (Sauropoda: Titanosauria) from the Late Cretaceous of Madagascar. J. Vertebr. Paleontol. 29,

1046-1086

- Díez Díaz, V., Mocho, P., Páramo, A., Escaso, F., Marcos-Fernández, F., Sanz, J.L., Ortega, F., 2016. A new titanosaur (Dinosauria, Sauropoda) from the Upper Cretaceous of Lo Hueco (Cuenca, Spain). Cretac. Res. 68, 49–60.
- Eberth, D.A., 2017. Stratigraphy and paleoenvironmental evolution of the dinosaur-rich Baruungoyot-Nemegt succession (Upper Cretaceous), Nemegt Basin, southern Mongolia. Palaeogeogr. Palaeoclimatol. Palaeoecol. XX-XX (this volume).
- Eberth, D.A., Badamgarav, D., Currie, P.J., 2009. The Baruungoyot-Nemegt transition (Upper Cretaceous) at the Nemegt type area, Nemegt Basin, south central Mongolia. J. Paleontol. Soc. Korea 25 (1), 1–15.
- Fanti, F., Currie, P.J., Badamgarav, D., 2012. New specimens of *Nemegtomaia* from the Baruungoyot and Nemegt formations (Late Cretaceous) of Mongolia. PLoS ONE 7 (2),
- e31330. http://dx.doi.org/10.1371/journal.pone.0031330. Fanti, F., Cantelli, L., Angelicola, L., 2017. High-resolution maps of Khulsand and Nemegt localities (Nemegt Basin, southern Mongolia): stratigraphic implications.
- Palaeogeogr. Palaeoclimatol. Palaeoecol. XX-XX (this volume). Gimenez, O., 1992. Estudio preliminar del miembro anterior de los sauropodos titanosauridos. Ameghiniana 30, 154 (Abstract).

González Riga, B.J., Lamanna, M.C., Ortiz David, L.D., Calvo, J.O., Coria, J.P., 2016. A gigantic new dinosaur from Argentina and the evolution of the sauropod hind foot. Sci. Rep. 6, 19165. http://dx.doi.org/10.1038/srep19165.

- Gorscak, E., O'Connor, P.M., 2016. Time-calibrated models support congruency between Cretaceous continental rifting and titanosaurian evolutionary history. Biol. Lett. 12, 20151047.
- Gradziński, R., 1970. Sedimentation of dinosaur-bearing Upper Cretaceous deposits of the Nemegt Basin, Gobi Desert. Palaeontol. Pol. 21, 147–229.
- Gradziński, R., Kazmierczak, J., Lefeld, J., 1969. Geographical and geological data from the Polish-Mongolian Palaeontological Expedition. In: Palaeonto Gradziński Logia Polonica. 19. pp. 33–80.
- Kielan-Jaworowska, Z., 1969. Hunting for Dinosaurs. MIT Press, Cambridge, MA (177 pp. [Translated from the Polish]).
- Kielan-Jaworowska, Z., Dovchin, N., 1968–1969. Narrative of the Polish–Mongolian palaeontological expeditions 1963–1965. Palaeontol. Pol. 19, 7–30.
- Kurzanov, S.M., Bannikov, A.F., 1983. A new sauropod from the Upper Cretaceous of Mongolia. Palaeontol. J. 2, 91–97.
- Madzia, D., Borsuk-Bialynicka, M., 2014. New sauropod material from the Nemegt Formation supports the conspecificity of *Opisthocoelicaudia skarzynskii* and *Nemegtosaurus mongoliensis* (Sauropoda, Titanosauria). J. Vertebr. Paleontol. 2014, 173–174 (Program And Abstracts).
- Maryańska, T., 2000. Sauropods from Mongolia and the former Soviet Union. In: Benton, M.J., Shishkin, M.A., Unwin, D.M., Kurochkin, E.N. (Eds.), The Age of Dinosaurs in Russia and Mongolia. Cambridge University Press, Cambridge, pp. 456–461.
- Nakajima, J., Kobayashi, Y., Chinzorig, Tlk, Tanaka, T., Takasaki, R., Tsogtbaatar, K., Currie, P.J., 2017. Dinosaur tracks at the Nemegt locality: paleobiological and paleoenvironmental implications. Palaeogeogr. Palaeoclimatol. Palaeoecol. XX-XX (this volume).
- Nowinski, A., 1971. Nemegtosaurus mongoliensis n. gen., n. sp., (Sauropoda) from the uppermost Cretaceous of Mongolia. Palaeontol. Pol. 25, 57–81.
- Salgado, L., Calvo, J.O., 1992. Cranial osteology of Amargasaurus cazaui Salgado and Bonaparte (Sauropoda, Dicraeosauridae) from the Neocomian of Argentina. Ameghiniana 29, 337–346.
- Salgado, L., Calvo, J.O., 1997. Evolution of titanosaurid sauropods. II: the cranial evidence. Ameghiniana 34, 33–48.
- Stettner, B., Persons IV, W.S., Currie, P.J., 2017. A giant sauropod footprint from the Nemegt Formation (Upper Cretaceous) of Mongolia. Palaeogeogr. Palaeoclimatol. Palaeoecol. XX-XX (this volume).
- Wilson, J.A., 2002. Sauropod dinosaur phylogeny: critique and cladistic analysis. Zool. J. Linnean Soc. 136, 217–276.
- Wilson, J.A., 2005. Redescription of the Mongolian sauropod Nemegtosaurus mongoliensis Nowinski (Dinosauria: Saurischia) and comments on Late Cretaceous sauropod diversity. J. Syst. Palaeontol. 3, 283–318.
- Wilson, J.A., Sereno, P.C., 1998. Early Evolution and Higher-level Phylogeny of Sauropod Dinosaurs. 5. Society of Vertebrate Paleontology Memoir, pp. 1–68 (Supplement to the Journal of Vertebrate Paleontology 18).
- Wilson, J.A., Pol, D., Carvalho, A.B., Zaher, H., 2016. The skull of the titanosaur Tapuiasaurus macedoi (Dinosauria: Sauropoda), a basal titanosaur from the Lower Cretaceous of Brazil. Zool. J. Linnean Soc. 178 (3), 611–662.