# Prospects for Cretaceous vertebrate exploration in Kazakhstan

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**Abstract.** The brief summary of the previous activity on the study of Mesozoic fossils in Kazakhstan shows high potential of known localities to reveal new and unique fossils. Mangystau, Kyzylorda (Lower Syr-Darya uplift), and Turgay Depression regions may provide good data on the change of fossil vertebrate assemblages around the K-T boundary due to the extinction of non-avian Dinosaurian fauna and the rise of mammals.

**Key words**: vertebrate paleontology, K-T boundary, future study

## Introduction

Kazakhstan boasts numerous prospective Cretaceous (circa 120 million years ago to 65 million years ago) fossil sites, most of which remain unexplored (Fig. 1).


**Fig. 1.** The map of Kazakhstan and the Shakh-Shakh Locality, shown as dark square.

Hence, this report; our goal is to highlight the known Cretaceous vertebrate sites across Kazakhstan, especially the ones we have experience of, in the hope that this will stimulate further research and exploration. The region of Central Asia is important because it provides a little studied, but very important, link between Europe to the west and China and Mongolia to the east. Vertebrates of this age are, of course, well known from Europe and southern-eastern Asia.

A number of known Upper Cretaceous continental stratigraphic units across Kazakhstan have produced vertebrate fossil remains. The best known and most extensively sampled is the Bostobe Formation, widely exposed over hundreds of kilometers northeast of the Aral Sea (Fig. 2) (Averianov et al., 2015, 2016).


**Fig. 2.** Map of known vertebrate localities in southern Kazakhstan (region of Kyzylorda) (from Averianov et al. 2015, 2016). 1. Tyulkili; 2. Shakh-Shakh; 3. Buroinak; 4. Akkurgan; 5. Baibishe; 6. Egizkara.

As noted by Averianov et al. (2015): "The first vertebrate fossils known from the Bostobe Formation, including turtles, crocodyliforms, and dinosaurs, were collected from the Shakh Shakh locality in 1956 by K.V. Nikiforova and N.A. Konstantinova. In 1957, a team from the Paleontological Institute of the Soviet Academy of Sciences, Moscow, under the direction of A.K. Rozhdestvensky, conducted extensive excavations at Shakh Shakh (Rozhdestvensky, 1964). Between 1961 and 1964, a team from the Institute of Zoology in Almaty led by T.N. Nurumov further explored the Shakh Shakh area (Nurumov, 1964). In 1977, P.V. Shilin discovered the Akkurgan locality north of Shakh Shakh (Shilin and Suslov, 1982) while L. A. Nesov (1995, 1997) discovered several new vertebrate localities (including Buroinak, Baibishe, and Egizkara) within the Bostobe Formation and the first vertebrate occurrences (Tyulkili) from the underlying Zhirkindek Formation in 1980 and 1982. Additional vertebrate fossils, including some microvertebrate specimens, were collected at Shakh Shakh by a Kazakh-American expedition in 1995 (Kordikova et al., 2001) and, later, we worked in this area between 2003 and 2007 (Dyke and Malakhov, 2004; Malakhov et al., 2009). In 2012, additional specimens were collected by an expedition from the Zoological Institute of the Russian Academy of Sciences, Saint Petersburg. In 2007 and 2012, a large-scale screen- washing effort was undertaken at the Shakh Shakh and Tyulkili localities that produced numerous microvertebrate fossils, including mammals (Averianov et al., 2014, 2016). In this report we summarize the known vertebrate assemblages of the Zhirkindek and Bostobe formations and describe some of our more recent finds." A comprehensive review of sites and fauna across this area was provided by Averianov et al. (2015, 2016). Our long term goal is to document vertebrate faunas across the Cretaceous-Paleogene (K-P) boundary in Kazakhstan.

## Background

The transition between vertebrate faunas of the Cretaceous and Paleogene periods in geological time are marked by the K-P boundary (e.g., Benton, 1997, 2001; Gradstein et al., 2004; Schulte et al., 2010; Chiarenza et al., 2020), one of the largest extinction events in Earth's history, 65 million years ago.

Likely caused by climate change associated with the impact of a giant asteroid, more than 40 percent of family-level diversity met its demise at this extinction, including all lineages of dinosaurs (apart from birds), marine sauropterygian reptiles, turtles and fish (Wolfe & Russell, 2001). The K-P extinction allowed 'faunal turnover' and is important to our understanding of the evolutionary dynamics of vertebrate lineages (Milner, 1998; Benton, 2001; Dyke, 2001). It has been suggested that the K-P extinction opened up a range of ecological niches to less diverse groups of taxa, not available during the Cretaceous: the evolutionary diversification of birds and mammals, for example, really began in earnest in the earliest Paleogene (Benton, 1997; Dyke, 2001).

The effects and aftermath of this major evolutionary transition have been well-studied in many regions of the world, particularly Europe and North America (reflecting obvious geological and palaeontological interest units and the history of fossil collecting). This is the state-of-the-art in our field. Moving away from North America and Western Europe, our palaeobiological team seeks a new direction: we aim to unravel fauna changes across this boundary in a much understudied region of the world -- Middle Asia -- an area considered critical for the exchange of taxa between Asia and Europe in the late Cretaceous and Paleogene (see Benton, 1997), but has never been explored in a systematic manner. We have assembled an international team of vertebrate palaeontologists, geologists and palaeobiological statisticians to document the K-P vertebrate faunal transition in the Republic of Kazakhstan. The main aim of our collaborative research project is to document the fossil vertebrate faunas preserved at three field sites (already identified) that span a range of sedimentary environments across Kazahkstan. The effects of the Cretaceous-Paleogene (K-P) boundary extinction event on vertebrate faunas in Middle Asia has never been documented, but is critically important because of linkages and faunal exchange between much better studied and understood Asian and European assemblages.

In the terminal Cretaceous, the end of the 'Age of Dinosaurs', Middle Asia (including the vast territories of the Republic of Kazakhstan) was located on the northern part of the tectonically active Turan Plate (Dyke & Malakhov, 2004). At this time, 70-65 mya, the Turan Plate is known to have formed a land connection linking and allowing exchange of taxa between the vertebrate faunas of Europe and Asia; movement along this plate margin created the so-called Lower Syr-Darya Uplift, a series of sedimentary basins in southern Kazakhstan (see below). Documenting end-Cretaceous faunas from this critical part of the world will allow us to statistically address the degree of actual faunal exchange for the first time. The palaeontology of Kazakhstan, the largest current member of the Commonwealth of Independent States (CIS), remains almost completely unexplored and undocumented. Very few field studies or geological surveys have ever been undertaken in the regions of this country that document the transition between the Cretaceous and the Paleogene, across the K-P faunal extinction horizon.

The primary scientific objective of our work is to understand the effects of the K-P extinction on vertebrate faunal assemblages in Kazakhstan and, in a more wider context, faunal evolution across this region (Fig. 3).

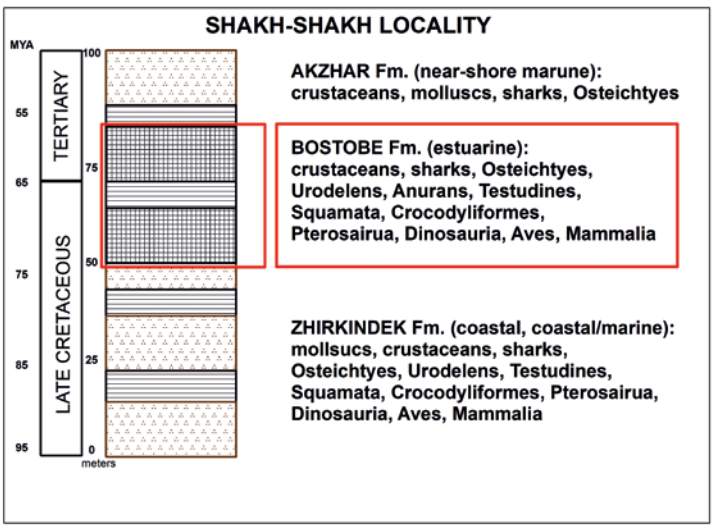


**Fig. 3.** Simplified stratigraphy of sections in the region of Kyzylorda, Kazakhstan.

## Prospectus

To address questions of vertebrate faunal exchange across the K-P boundary in Kazakhstan we have already identified and researched three broad field areas that we will investigate. All three of these areas have been studied superficially in the past (by us and in historical studies) and are known to preserve sediments that document the terminal Cretaceous extinction event and contain the fossil remains of vertebrates in abundance. Survey work completed in field seasons 2003-2005 has allowed us to locate (but not yet record in context or excavate) fossil remains preserved both in situ (i.e., partial and complete articulated skeletons of dinosaurs and other vertebrates have been entered into our ongoing GPS database), and in abundance on sedimentary surfaces (i.e., microsites comprising scattered teeth, bone and scutes, etc). We will sample, describe, database and correlate the faunas preserved in the sediments in these three regions, namely:

(1) The Mangystau region (marginal marine, low floodplain and freshwater sediments of western Kazakhstan).

(2) The region of the Lower Syr-Darya Uplift (alternating freshwater, marine floodplain and fully terrestrial sediments; southern Kazakhstan).

(3) Sediments of the former Turgay Strait (deep-water marine sediments of Northern Kazakhstan, extending into western Russia).

Through investigation of these sites by use of standard and state-of-the-art palaeobiological and geological methods forms the basis of our studies over the 30 month duration of this project. Sediments in the three regions we have selected document a suite of palaeoenvironments (i.e. ranging deep-water marine through terrestrial) and lithological conditions as well as spanning almost the entire geography of Kazakhstan.

To achieve the primary scientific objective of our project (outlined above) we will work within two themes. Aims of future work will be to:

(1) Document late-Cretaceous and early Paleogene fossil vertebrate faunas, on land and in the sea, within three broad palaeoenvironments across the territories of Kazakhstan (Mangystau, Syr-Darya and Turgay). This objective will be accomplished initially by extensive field-expeditions to the regions in question, followed by detailed descriptive palaeontology combined with an extensive data base of Kazakh fossil vertebrate records;

(2) Collect and use geological data to reconstruct geographic and climatic changes across the K-P transition in Kazakhstan in particular and Central Asia in general. This objective will be accomplished by detailed geological field observations as well as subsequent use of GIS methods and mapping of regions studied.

In addition, our data compilation combined with palaeobiogeographic information will allow us to test, for the first time, the widely stated hypothesis that Central Asia formed a 'land-bridge' for the late Cretaceous movement of vertebrates between Europe and Asia.

## References

Averianov A., Archibald J., Skutschas P., Dyke G. 2014. New mammal remains from the Late Cretaceous Bostobe Formation (Northeast Aral Sea Region, Kazakhstan). *Palaeoworld*. 23. 10.1016/j.palwor.2014.10.009.

Averianov A., Dyke G., Danilov I., Skutschas P. 2015. The paleoenvironments of azhdarchid pterosaurs localities in the Late Cretaceous of Kazakhstan. *ZooKeys*. 483: 59-80. 10.3897/zookeys.483.9058.

Averianov A., Danilov. I., Skutschas P., Kuzmin, I., Sues, H-D., Dyke, G. 2016. The late Cretaceous vertebrate assemblages of western Kazakhstan. In: Khosla, A. and Lucas, S.G. (Eds) *Cretaceous Period: Biotic Diversity and Biogeography*. New Mexico Museum of Natural History and Science 71. pp. 5-18.

Benton M.J. 1997. *Vertebrate Palaeontology*. Chapman and Hall, 452 pp.

Benton M.J. 2001. Biodiversity through time. In: Briggs, D.E.G. and Crowther, P.R. (Eds) *Palaeobiology.* Blackwell Publishing. Vol.II. pp. 211-219.

Chiarenzaa, A.A., Farnsworth, A., Mannion, P.D., Lunt, D.C., Valdes, P.J., Morgan, J.V., Allison, P.A. 2020. Asteroid impact, not volcanism, caused the end-Cretaceous dinosaur extinction. *PNAS* 117: 17084-17093

Dyke G.J. 2001. The evolution of birds in the early Tertiary: systematics and patterns of diversification. *Geological Journal, 36: 305-315.*

Dyke G.J., Malakhov D.V. 2004. Abundance and taphonomy of dinosaur teeth and other vertebrate remains from the Bostobynskaya Formation, Northeastern Aral Sea region, Republic of Kazakhstan. *Cretaceous Research*, *25(5): 669-674.*

Gradstein F.M., Ogg J. 2004. *A Geologic Time Scale*. Cambridge University Press, 589 pp.

Kordikova E.G., Polly P.D., Alifanov V.A., Rocek Z., Gunnel, G.F., Averianov A.O., 2001. Small vertebrates from the late Cretaceous and early Tertiary of the northeastern Aral Sea region, Kazakhstan. *Journal of Vertebrate Paleontology. 75: 390–400.*

Malakhov D.V., Dyke G.J. 2003. New finds of Upper Cretaceous vertebrates in North-Eastern Aral [Novye nakhodki verkhnemelovykh pozvonochnykh v Severo-Vostochnom Priaral'e]. *Selevinia*. 2003:66-73. [In Russian].

Malakhov D. V. Dyke G. J. King Ch. 2009. Remote Sensing Applied to Paleontology: Exploration of Upper Cretaceous Sediments in Kazakhstan for Potential Fossil Sites. *Palaeontologia Electronica*. 12(2): 10p; http://palaeo-electronica.org/2009_2/164/index.html

Milner A .C. 1998. Timing and causes of vertebrate extinctions across the Cretaceous-Tertiary boundary. In: McCall, G. J., Grady, M., Hutchison, R. and Rotherby, D. (Eds) *Meteorites: flux with time and impact effects*. A Geological Society, London, Special Publications, 140: 223-233.

Nessov L.A., 1995. Dinosaurs of Northern Eurasia: New Data about Assemblages, Ecology and Paleobiogeography. St Petersburg, 156 p. [in Russian].

Nessov L.A. 1997. *Cretaceous Nonmarine Vertebrates of Northern Eurasia*. St Petersburg, 218 pp. [in Russian].

Nurumov T.N., 1964. On findings of dinosaur remains in Kazakhstan. In: Terentiev, P.V. (Ed.) *Questions of Herpetology*. Leningrad, pp. 49-50. [in Russian].

Rozhdestvensky A.K., 1964. New data on the localities of dinosaurs on the territory of Kazakhstan and Middle Asia. *Nauchnye Trudy Tashkentskogo Gosudarstvennogo Universiteta imeni V.I. Lenina*. Ser. Geol., 234:227-241 [in Russian].

Schulte P., et al. 2010. The Chicxulub asteroid impact and mass extinction at the Cretaceous-Paleogene boundary. *Science* 327: 1214-1218.

Shilin P.V., Suslov Y.V. 1982. Hadrosaur from northeastern Aral Sea region. *Paleontologicheskii Zhurnal,* 1:131-135 [in Russian].

Wolfe J.A. Russell D.A. 2001. Impact of K-T boundary events on terrestrial life In: Briggs, D.E.G. and Crowther, P.R. (Eds) *Palaeobiology*. Blackwell Publishing. Vol.II., pp. 232-233.

## Қазақстандағы бор омыртқалыларын зерттеу перспективалары

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**Тұжырым**. Қазақстанның мезозой фаунасының зерттелуіне келтірілген шолу қазба фаунасының жаңа, бірегей үлгілерін анықтау үшін белгілі жерлердің жоғары әлеуетін көрсетеді. Маңғыстау, Қызылорда облысы (төменгісырдария көтерілімі), Торғай депрессиясы бор-палеоген шекарасындағы жер үсті және теңіз омыртқалылары қауымдастықтарының құрамындағы өзгерістер, яғни динозаврлар фаунасының жойылу дәуірі және сүтқоректілер фаунасының қалыптасуы туралы мәліметтерге қатысты өте перспективалы.

**Кілт сөздер**: омыртқалылар палеонтологиясы, бор мен палеоген шекарасы, зерттеу перспективалары

# Перспективы изучения меловых позвоночных в Казахстане

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**Аннотация.** Приведенный обзор изученности мезозойской фауны Кзахастана демонстрирует высокий потенциал известных местонахождений для выявления новых, уникальных образцов ископаемой фауны. Мангыстау, Кызылординская область (нижнесырдарьинское поднятие), Тургайская низменность очень перспективны в отношении данных по изменениям в составе сообществ наземных и морских позвоночных на границе мел-палеоген, т.е. эпохи вымирания динозавровой фауны и становления фауны млекопитающих.

**Ключевые слова:** палеонтология позвоночных, граница мела и палеогена, перспективы изучения