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A Unique Burial Site of Early Cretaceous Vertebrates in Western Siberia (the Shestakovo 3 Locality, Kemerovo Province, Russia)

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The Shestakovo locality (Shestakovo, Chebula region, Kemerovo oblast, Fig. 1) is known for rich occurrences of Early Cretaceous continental fauna [1–3]. A fragment of a skeleton of the *Psittacosaurus* was first found in 1953 [4]. Since 1995, the locality has been studied by specialists of several research organizations, including the Borissiak Paleontological Institute of the Russian Academy of Sciences [5, 6].

Vertebrate remains in Shestakovo are found in the deposits of the Ilek Formation [7]. Modern data allow this locality to be dated as Barremian [8]. The locality includes three sites, referred to as Shestakovo-1 (Shestakovo Bluff on the Kiya River), Shestakovo-2, and Shestakovo-3. Shestakovo-3 located about 3 km east of the village of Shestakovo, 2 km northeast of the Shestakovo Bluff and represents a roadcut outcrop. Two skeletons of dinosaurs of the genus *Psittacosaurus*, assigned to the new species *P. sibiricus* Voronkevich et Averianov, 2000, were found in Shestakovo-3 in 1997 [9]. Shestakovo-3 is one of two dinosaur localities in Russia where skeletons are preserved complete and with the bones in situ, in their anatomical positions (the first such locality is the Late Cretaceous Kundur in the Far East).

In the summer of 2014, a team from the Paleontological Institute (PIN) and the Kemerovo Regional Museum of Natural History (KRMNH) resumed excavations at the Shestakovo-3 site. These works resulted in the discovery of a new bone-bearing lens with a mass burial of skeletons.

The uniqueness of this bone-bearing lens is in the state of preservation and abundance of the complete skeletons of *Psittacosaurus*. Three monoliths and plas-

ter jackets with bone fragments, the preparation of which is not yet finished, were collected in Shestakovo-3. Skeletons and fragments of skeletons of 12 individuals of *Psittacosaurus* of various ages were provisionally identified in the monoliths.

The Shestakovo-3 site visited in 2014 is located on the southeastern slope of a hill called Krutoshishka by the Shestakovo local people. The coordinates of the excavation site are the following: western margin, 55°52'33" N, 87°59'57" E; eastern margin, 55°52'35" N, 87°59'57" E.

The horizon with the bone-bearing lens is stratigraphically higher than the analogous layers, on a more western part of the Shestakovo-3 site [7, 10]. Stratigraphically, this interval of the locality is essentially different from the beds of the adjacent parts of the Shestakovo-3 section. The Site section demonstrate the following layers, from bottom to top.

Layer 1. Alternation of brownish red and greenish gray dense clay. The top of the section yielded skulls and fragments of skeletons of the *Tagarosuchus kulemzini* Efimov, 1999. At a level of 0.3 m from the top of the member, there is a bone-bearing lens with *Psittacosaurus* skeletons about 0.5 m thick. The lens is underlain by bluish gray siltstone 0.6 m thick. The siltstones are underlain by an alternation of brownish red compact and greenish gray clay. The total thickness is 2.7 m.

Layer 2. Brownish red compact clay. Thickness, 1 m.

Layer 3. Weathered redeposited eluvium topping the Cretaceous beds. Thickness, 0.35 m.

Layer 4. Humus soil (recent). Thickness, 0.7 m.

Three monoliths were collected from Layer 1 to retain the in situ preservation of the *Psittacosaurus* skeletons (Fig. 2). *Monolith 1*, collected in the southernmost part of the bone-bearing lens, is currently being prepared. Provisionally, it contains a large fragment of a skeleton without a skull (Fig. 2J) and a separate large skull of a different individual, the postcra-

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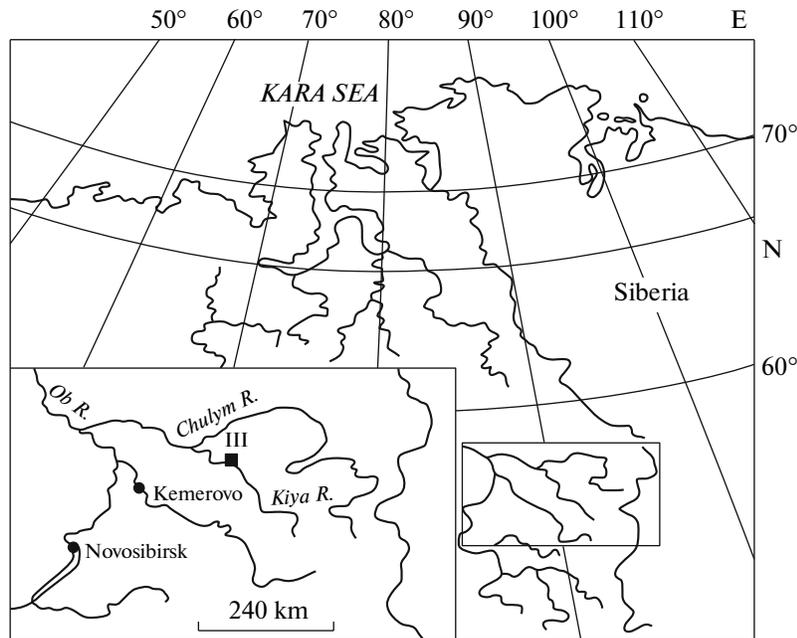


Fig. 1. Geographical position of the Early Cretaceous vertebrate locality Shestakovo 3, Chebula District, Kemerovo oblast (marked as III).

nial skeleton of which is in *monolith 2* (Fig. 2I). *Monolith 2* (208 × 110 × 80 cm) contained an almost complete skeleton of an adult individual (Fig. 2I). The bones include a skull with a mandible, hyoid bones (two ear bones were collected separately), four cervical vertebrae, the last eight thoracic vertebrae, six sacral vertebrae and 26 caudal vertebrae, 10 ribs, a pelvis, fragments of a right forelimb (a humerus bone anatomically joined with the proximal ends of the ulna and radius), right femur, and bones of the left hind limb. The skull of this skeleton with the first two cervical vertebrae is in *monolith 1* (Fig. 2I). In addition, *monolith 2* contained fragments of an adult skeleton (Fig. 2A, with seven caudal vertebrae, several ribs, part of the pelvis and the long bones of the fore limbs, the bones of the left and right posterior limbs) and a sub-adult skull incomplete at the base (Fig. 2g).

Monolith 3 (212 × 100 × 80 cm) contained remains of adult and juvenile *Psittacosaurus* skeletons. An almost complete adult skeleton (Fig. 2D) includes a distorted skull with a mandible, a spine with 47 vertebrae, including 17 pre-sacral vertebrae (the spine is displaced and not all vertebrae are exposed, being overlain by other bones), six sacral and 24 caudal vertebrae (centers are missing in the first three caudal vertebrae), rib fragments, left scapula, coracoid, left sternum, some pelvic bones, left humerus, and bones of the posterior right limb. In addition, *monolith 3* contained fragments of skeletons of another two adults and one juvenile. The first specimen includes skull fragments, two cervical, 10 thoracic, and 12 caudal vertebrae, bones of posterior limbs, and of pelvis

(Fig. 2B). The second specimen includes a complete undistorted skull with a mandible, and hyoid bones, a pectoral arch (right coracoid, right sternum, and scapula), and right forelimb (Fig. 2C). Fragments of a juvenile skeleton include a scapula, a humerus, a coracoid, rib fragments, hind limbs and pelvic bones (Fig. 2h).

Other specimens collected separately from the monoliths in the lateral parts of the bone-bearing lens (Figs. 2e, 2f), included two incomplete skulls, one skull with a mandible and hyoid bones (both ear bones were extracted), and the first four cervical vertebrae (Fig. 2K), over a thousand variously preserved bones and bone fragments of an adult *Psittacosaurus*; an incomplete juvenile skull (length ~57 mm), and also incomplete hind limb and postcranial fragments of the same individual (Fig. 2I).

The studied part of the lens is 1 m wide and about 4.5 m long. The uniform composition of the bone-bearing layer suggests that it was formed in one sedimentological cycle. The nature of bone distortion and preservation of the anatomical articulation of the skeletons suggest that the lens contains members of the same *Psittacosaurus* herd, including specimens of various individual ages and sizes (body length ranges from 35 cm to 3 m). The good state of preservation of the skeletons shows that they were not transported over a long distance.

Laterally consistent beds of siltstone and clay in this locality suggest a large low-energy basin. The lens with mass burial of *Psittacosaurus* skeletons was apparently formed as a result of a short-term catastrophic

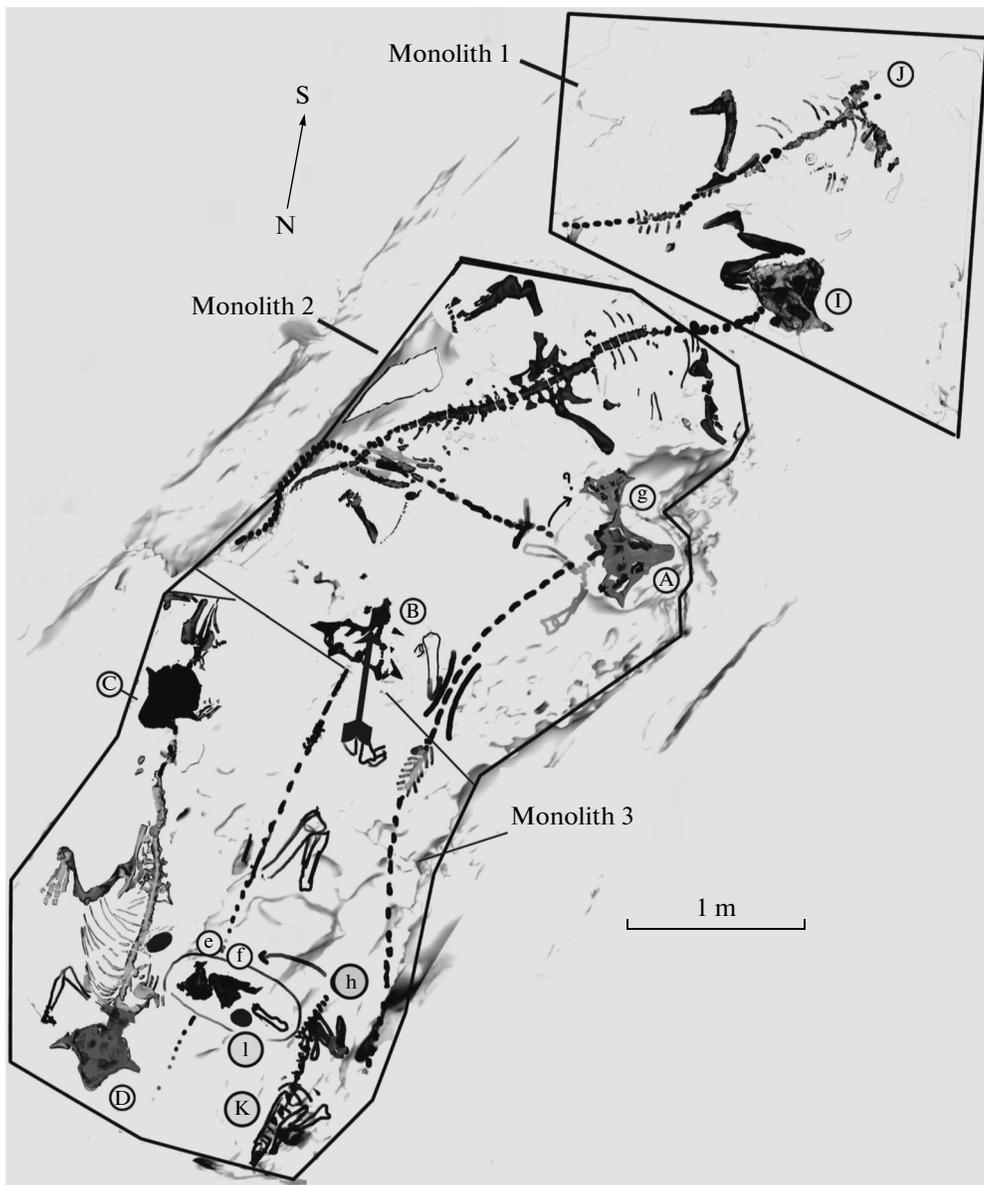


Fig. 2. A three-dimensional block reconstruction of the position of *Psittacosaurus* skeletons in the bone bearing lens. Letters and figures in circles (A–J) mark skeletons of different individuals; capital letters mark adults, lower case letter mark juveniles and subadults, broken lines show the borders of the monoliths.

event, such as flooding. It can be suggested that the animals were washed in by a temporary, not very strong flow. The presence of a considerable number of young individuals apparently suggests complex mode of group behavior, possibly including caring for the offspring.

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