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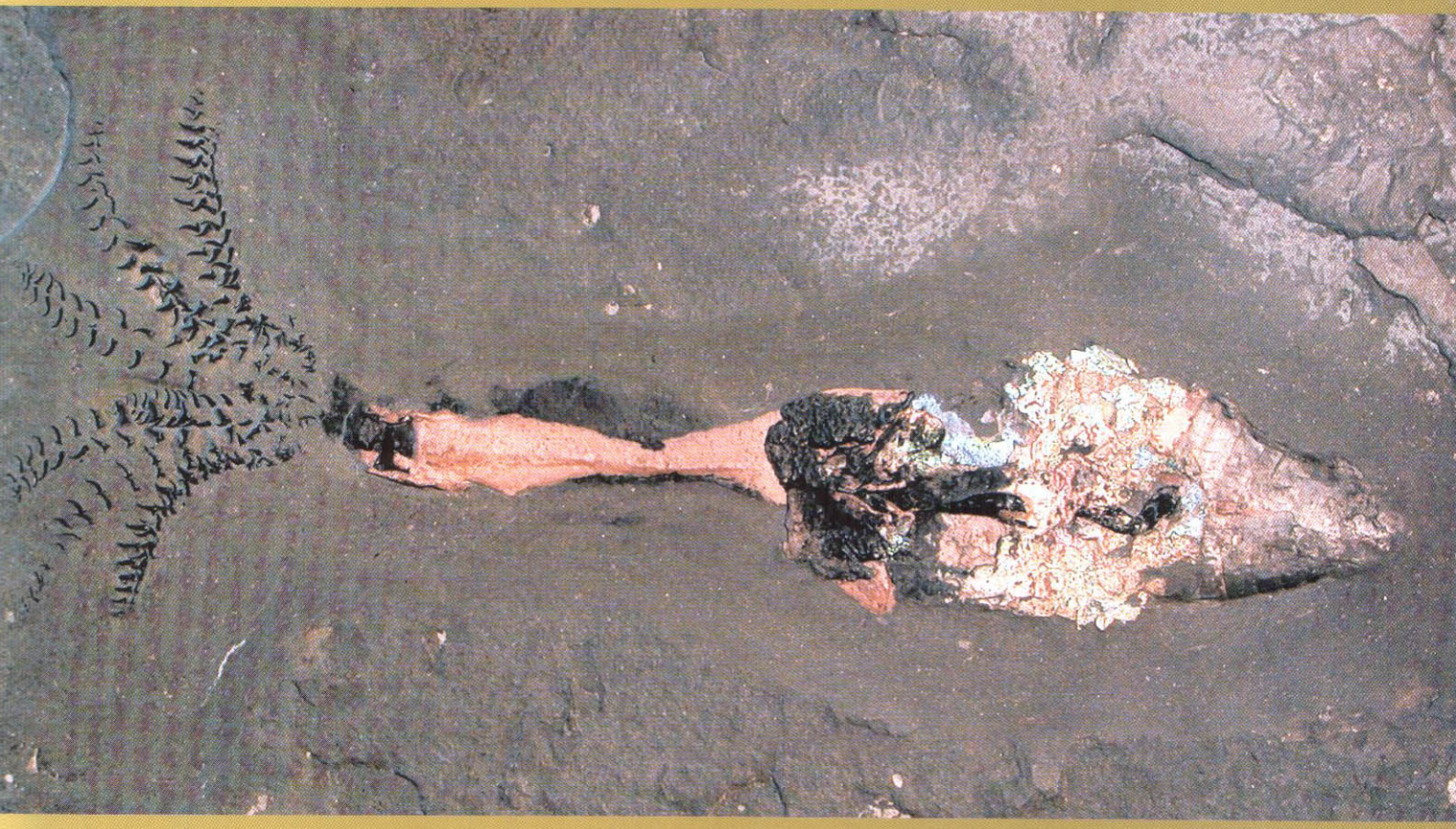

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New data on Middle Jurassic - Lower Cretaceous Belemnotheutidae of Russia. Their habit and possible mode of life

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ABSTRACT: Middle Jurassic – Lower Cretaceous Belemnoteuthidae of the Russia are reviewed for the first time. These coleoids are usually represented by phragmocone remains and cautiously assigned to genera *Acanthoteuthis* and *Volgobelus*. Their spatial distribution and range chart as a rule slightly differs, but sometimes both genera occur at the same level. On the basis of comparison with modern coleoids some conclusions concerning features of soft body morphology and ecology of Belemnoteuthidae were suggested.

Key words: Coleoid cephalopods, Belemnoteuthidae, Jurassic – Cretaceous, Russia, Palaeoecology.

Fossil coleoids of the family Belemnotheutidae represent one of the most mysterious groups of Mesozoic Cephalopoda. From one hand, they are similar with other representatives of the order Belemnitida in having well-developed phragmocone with ventral siphuncle, tongue-shaped tri-partied proostracum and peculiar hooks on the arms (Naef, 1922; Jeletzky, 1966, etc.). From the other hand, they lack the main distinctive feature of belemnoid shell, the rostrum. Conotheca of Belemnotheutidae is very thin, shell-like and usually lost in the course of fossilization, as well as fragile proostracum. Occurring much more rarely than belemnitids, Belemnotheutidae are usually represented by damaged phragmocones only. The later were generally ignored during field works by collectors who often misinterpreted them as isolated belemnoid phragmocones. Apparently it was the main reason why Belemnotheutidae remained a scarcely studied group until the latest time. Investigations of the recent years marked substantial progress in our knowledge on Belemnotheutidae (Donovan & Crane, 1992; Doyle & Shakides, 2004). However, the information on distribution and fauna of Belemnotheutidae in Russia is still fragmentary and is actually restricted by several brief mentions (Gustomesov, 1976; Kiselev et al., 2003, among others). The material collected by the authors provided some new data on distribution of belemnotheutids on the Russian platform. The aim of the present study is to describe fauna and distribution of Belemnotheutidae in Russia and to attempt to reconstruct some features of their soft body morphology and ecology basing on comparison with recent coleoids.

As the conotheca is often lost in belemnotheutid phragmocones the main problem in their study is to distinguish them from isolated belemnitid phragmocones. Recently, Doyle and Shakides (2004) showed that the apical angle in belemnotheutids is somewhat less than in belemnitids, though their ranges overlap partly. Our data proved that this criterion is quite unambiguous while comparing belemnotheutid and belemnitid phragmocones of similar size recorded from the same level.

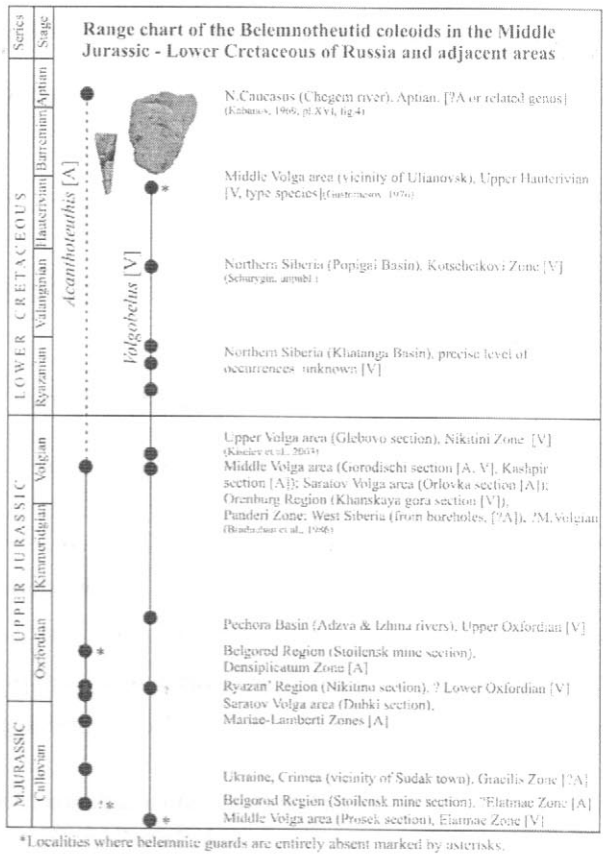

Fig.1. Distribution of the Middle Jurassic – Lower Cretaceous Belemnoteuthidae of Russia and adjacent areas in space and time.

The material collected by the authors as well as obtained from publications show that Belemnotheutidae are widely spread in the Callovian – Lower Cretaceous sediments of Russia and former USSR (Fig.). The fossils in authors' collection can be distinctly classified into three groups. The first group consisted of small (1-5 cm length; 2-3 cm width) crushed isolated phragmocones with characteristic low v-shaped ridges in the apical part on the dorsal side. These fossils were tentatively identified as *Acanthoteuthis* sp. The second group consisted of large (9-17 cm length; 7-10 cm width) uncrushed isolated phragmocones filled with sediments and lacking the dorsal ridges. These fossils were assigned to the genus *Volgobelus*. One specimen represented almost entire shell (only apical part was missing). It was 34 cm length; 10 cm width, and consisted of crushed phragmocone (18 cm length), tongue-shaped proostracum (16 cm length) and remains of the ink sac. This fossil combine some features of the 1st and 2nd groups and was tentatively identified as ? *Acanthoteuthis* sp. Geographic and stratigraphic distribution of *Acanthoteuthis* and *Volgobelus* in Russia is different. Within the studied area only in the Middle Volgian they occur together.

Comparison with living coleoids provides opportunity to reconstruct some features of soft body morphology and ecology of Belemnotheutidae. Dorsal v-shaped ridges in the apical part of conotheca – one of the most distinctive features of *Acanthoteuthis* – apparently represent a functional analogue to medial keel formed by the rachis in posterior part of the gladius in most recent squids. In squids this part of the gladius ensures articulation with the fins. Presence of similar keels in the shell of *Acanthoteuthis* indicates that in this form the fins apparently attached to dorso-lateral surface in apical part of conotheca. The bases of fins were separated, possibly merging apically. The fins were terminal, probably broad-oval or rhomboidal. Their length could slightly exceed the length of the ridges: 3/5ths of the length of the

phragmocone (Donovan & Crane, 1992). Considerable width and flat profile of proostracum in *Acanthoteuthis* indicates that it was not covered by the mantle muscles from the dorsal side. Most probably, the mantle attached to lateral edges (hyperbolar zones) of proostracum, as in recent *Vampyroteuthis*. Thickening of hyperbolar zones found in *Acanthoteuthis* as well as in other belemnite proostraca provide another prove for this hypothesis. Tongue-like proostracum of belemnoids, including *Acanthoteuthis*, lacks broadened vanes (lateral plates) that usually present in the gladii of recent squids providing place for the funnel retractors attachment (Bizikov, 1996; Bizikov & Arkhipkin, 1997). Absence of similar structures in belemnoid proostraca indicates that funnel retractors in Belemnitida attached either to the inner surface of thickened hyperbolar zones (like in recent Sepiidae) or to the inner side of the mantle wall, like in recent squids (Ommastrephidae and Chiroteuthidae). In the latter case there must be some strong funnel locking-apparatus of complex structure, or fusion of the funnel corners with the mantle. The presence of the ink sac in *Acanthoteuthis* indicates that this species inhabited upper layers of Mesozoic seas, apparently above 200 m. The arm length in *Acanthoteuthis* comprises about 40% of the total length (Donovan & Crane, 1992). It is considerably longer than in recent nektonic squids (Ommastrephidae, Loliginidae, Thysanoteuthidae) but very close to planktonic species (some Gonatidae, Mastigoteuthidae, Octopoteuthidae). The absence of rostrum in the shell of *Acanthoteuthis* signifies that living position of this animal was vertical head-down, like in recent *Spirula* and some planktonic squids, for example, *Mastigoteuthis*.

Taking into account all above-mentioned considerations it is possible to draw some conclusions on possible way of life of Belemnotheutidae. Apparently, these were middle- to large-sized planktonic forms inhabiting epipelagic (possibly upper meso-pelagic) horizons over shelf and slope of continental seas in Mesozoic era.

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