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Magneto- and carbon-isotope stratigraphy of the Lower–Middle Bathonian in the Sokur section (*Saratov, Central Russia*): implications for global correlation

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Abstract

The discovery of Tethyan and Boreal fossils in Bathonian deposits of the Sokur section in the vicinity of Saratov (Central Russia) reopened the possibility of direct correlation of the Bathonian sections in different paleobiogeographic provinces, which require further integrated studies involving both paleontological (based on different groups of fauna) and physicochemical (paleomagnetic and isotope-geochemical) methods. Stable carbon isotope data for belemnite (Cylindroteuthididae) rostra from the Sokur section show that the Subboreal Oraniceras besnosovi Zone and Boreal Arcticoceras harlandi Subzone are correlated with the Zigzag Zone of the standard scale, whereas the Boreal A. ishmae Subzone can be correlated completely or, even partly, with the Tenuiplicatus Zone. We identified equivalents of chrons of the geomagnetic polarity time scale (GPTS): e-Bath N, m-Bath R, and lt-Bath N, corresponding to the Lower–Middle Bathonian and, possibly, lowermost Upper Bathonian.

Keywords: Bathonian; magnetostratigraphy; chemostratigraphy; Boreal–Tethyan correlation; paleotemperature; Russian Plate

Introduction

The Boreal–Tethyan correlation of the Bathonian successions is one of the most complex problems of Mesozoic biostratigraphy. The standard chronostratigraphy of the Bathonian is based on the ammonite zonal successions of NW European taxa such as Parkinsoniidae, Perisphinctidae, Morphoceratidae, Oppeliidae, Tulitidae, etc. In a large part of the Lower Bathonian and Middle Bathonian Substages, this scale works well for the Sub-Mediterranean and Mediterranean sections (Callomon, 2003; Fernández-López, 2001; Fernández-López et al., 2009). The zonal scales of Boreal Bathonian deposits, which are widespread over vast areas, were based on the succession of taxa belonging to the subfamily Arctocephalitinae (family Cardioceratidae) and therefore were only provisionally correlated with the standard scale.

The discovery of ammonites of the Peri-Tethyan family Parkinsoniidae and Boreal Cardioceratidae in the East European Sokur section in the vicinity of Saratov (Fig. 1) reopened the possibility of direct Boreal to Tethyan correlation in the Lower Bathonian (Mitta and Seltzer, 2002). Subsequent detailed studies of this section allowed recognition of the Boreal ammonite zones and related "Boreal Bathonian" zones and beds based on bivalves, foraminifers, and belemnites. These data changed our understanding of the correlation of the Boreal zonal standard with Subboreal and Tethyan scales for the Bajocian–Bathonian boundary interval (Mitta et al., 2004, 2014). The integrated biostratigraphy revealed systematically older successions (based on different faunal groups) of Boreal biostratigraphic units than previously reported. This evidence needs to be corroborated by independent physicochemical methods.

The results of reconnaissance paleomagnetic studies of the Sokur section were presented in the previous papers (Molostovskii, 2005; Pimenov et al., 2006). The first data (Molostovskii, 2005) revealed that this section has a single, long

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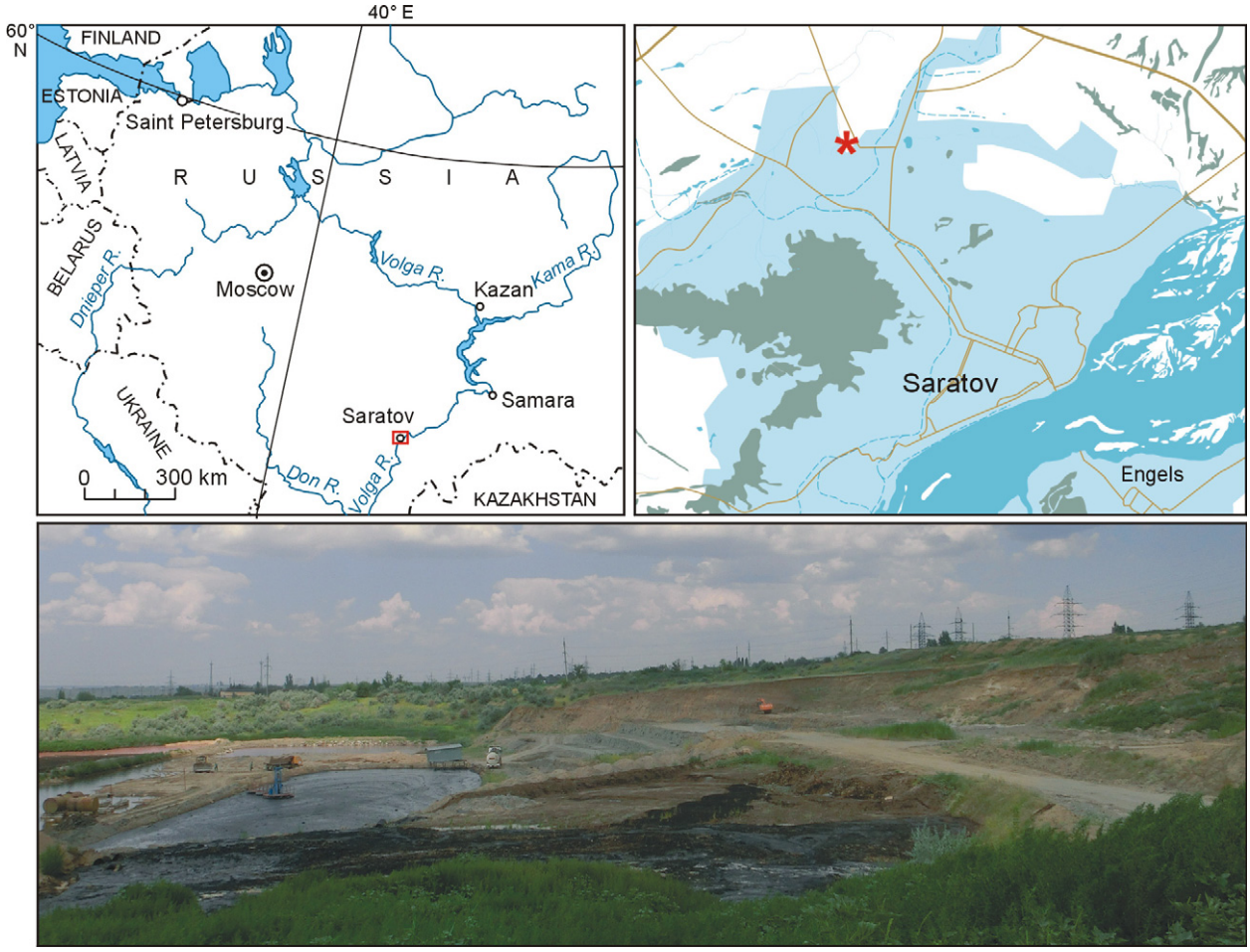

Fig. 1. The location of the Sokur section and view of the quarry (Photo 2013 by O.S. Urman).

reversed polarity zone (R), with three normal polarity intervals (N) (Pimenov et al., 2006), each of which has been confirmed in 1–2 sample levels, rendering statistically unambiguous identification of magnetic polarity zone difficult. Additional excavations in the quarry exposed a continuous geological sequence of layers and demonstrated that a large part of the target section was missed during sampling.

Interregional correlation, considering a complex polarity zonation of the Bajocian–Bathonian (Ogg et al., 2012), needs the largest possible subset of the stratigraphically most detailed polarity data, with high sampling density, reasonable biostratigraphy, and bed-by-bed description supported by other types of analyses. No isotope and geochemical data have been reported for the Sokur section and other Bathonian sections of Central Russia. In 2013, we undertook a comprehensive investigation of the Sokur section, which included a geological description, sampling for faunal, paleomagnetic, and stable isotope ($\delta^{18}O$, $\delta^{13}C$) analyses. Preliminary results were presented at the VI All-Russia Meeting "The Jurassic System of Russia: Problems of Stratigraphy and Paleogeography" (Manikin et al., 2015; Shurygin et al., 2015).

Characterization of the Sokur section

The Sokur section is exposed in a former quarry in the northwestern suburb of Saratov (51°36′47.03″ N, 45°56′27.30″ E) that was abandoned with backfilling in 2015 (Fig. 1). The section exposed at the quarry includes 16.5 m of Bathonian strata. The lower part consisting mostly of clays (8.5 m thick) deposited in a moderately deep-water setting (middle sublittoral zone) contains abundant and taxonomically diverse fossils of Early Bathonian age (ammonites, belemnites, bivalves, gastropods, reptilian teeth and vertebra, crinoid columns, and microfossils). The upper part of the section comprises a barren siltstone stratum (8.0 m thick) deposited in a shallow-water setting (Mitta et al., 2014) (Fig. 2).

The paleogeographic maps for the Middle Jurassic (Rees et al., 2000) show that the Saratov region was located between 45° and 50° N paleolatitudes during Bathonian time. Recent studies (Mitta et al., 2014) show that the Late Bajocian marine transgression over the Russian Plate resulted in the mixing of Boreal and Tethyan water masses, because the taxonomic composition of fossil assemblages from the Sokur section points to the existence of a seaway connecting cooler northern