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Spatial heterogeneity of the Early–Middle Toarcian (Jurassic) ammonite diversity and basin geometry in the Northwestern Caucasus (southwestern Russia; northern Neo-Tethys)

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ABSTRACT

Paleontological and geological information from the Northwestern Caucasus, a large region in southwestern Russia, allows to evaluate the spatial heterogeneity of the Early–Middle Toarcian ammonite diversity and its possible controls. The total number of ammonite species and genera is calculated for four time slices, which correspond to the *Dactylioceras semicelatum*, *Harpoceras falciferum*, *Hildoceras bifrons*, and *Haugia variabilis* zones, in each of the ten areas distinguished within the study region. These areas differ by the ammonite diversity, which indicates heterogeneity. The latter persisted through the entire Early–Middle Toarcian. This heterogeneity was relatively low in the beginning of the Toarcian, when the total regional diversity of ammonites was minimal. Long- and short-term landward shoreline shifts facilitated spatial distribution of ammonites and increase in their taxa number. Shallow-marine paleoenvironments tended to sustain a higher diversity than those deep-marine, and, therefore, changes in the basin depth were also responsible for the observed spatial heterogeneity of the ammonite diversity. Interestingly, a more or less similar diversity dynamics is established in the areas of the Northwestern Caucasus. The distribution of ammonites in the study region indicates that these invertebrates migrated there from the open sea(s) stretched along the northern margin of the Neo-Tethys Ocean. Results of the present analysis also imply that the mass extinction might have been responsible for the low diversity of ammonites (observed in the entire region and its particular areas) in the beginning of the Toarcian.

1. Introduction

Ammonites reacted to paleoenvironmental changes in a different and, sometimes, peculiar way (Lehmann, 1981). For instance, some studies confirmed the importance of sea-level control on their diversity dynamics (Sandoval et al., 2001a,b; Ruban, 2007; Zaton, 2011), whereas the other results revealed more complicated relationships between the latter and transgressions/regressions (Ruban, 2010, 2012). When regional ammonite diversity is investigated, one can hypothesize that its dynamics could differ spatially depending on specific paleoenvironmental history of different parts of the study region. To consider such a possibility is especially important in the case of large sedimentary basins evolved under the strong control of tectonic activity. This makes an analysis of spatial heterogeneity of the ammonite diversity and its possible links to basin changes always urgent.

The Greater Caucasus Basin, which is a large tectonic domain stretching between the Black Sea and the Caspian Sea, is an appropriate object to prove or to disprove the above-mentioned ideas. On the one hand, ammonites are common fossils in the Jurassic deposits there, and the information on them has been well compiled by Okuneva et al. (1992), Rostovtsev et al. (1992), and Ruban (2012). On the other hand, the Jurassic history of this basin has been reconstructed with a certain precision (Jasamanov, 1978; Panov et al., 1996; Ruban, 2007, 2012). Of course, the Greater Caucasus Basin with stratigraphic sections of great thickness, inter-bedded marine and continental facies, numerous hiatuses, etc. (Rostovtsev et al., 1992; Ruban, 2007, 2012) does not meet adequate conditions for the "ideal" diversity analysis of organisms such as the paleocologically specific organisms as ammonites (Lehmann, 1981). However, the majority of Jurassic basins in the world are similarly not "ideal". If so, they should not escape our attention.

The present paper aims at the Early–Middle Toarcian ammonites reported from the northwestern part of the Greater Caucasus Basin, i.e., the Northwestern Caucasus (Fig. 1). Two main objectives are 1) evaluating the ammonite diversity in different parts of this region in order to conclude about its spatial heterogeneity and 2) tracing possible links between the diversity dynamics and the changes in basin geometry. The latter is understood here provisionally as shoreline shifts (transgressions and regressions) and changes in the basin depth. The present study differs from those attempted earlier by Ruban (2007, 2012) by data and methods, and it pays the main attention to the spatial dimension of the diversity dynamics.

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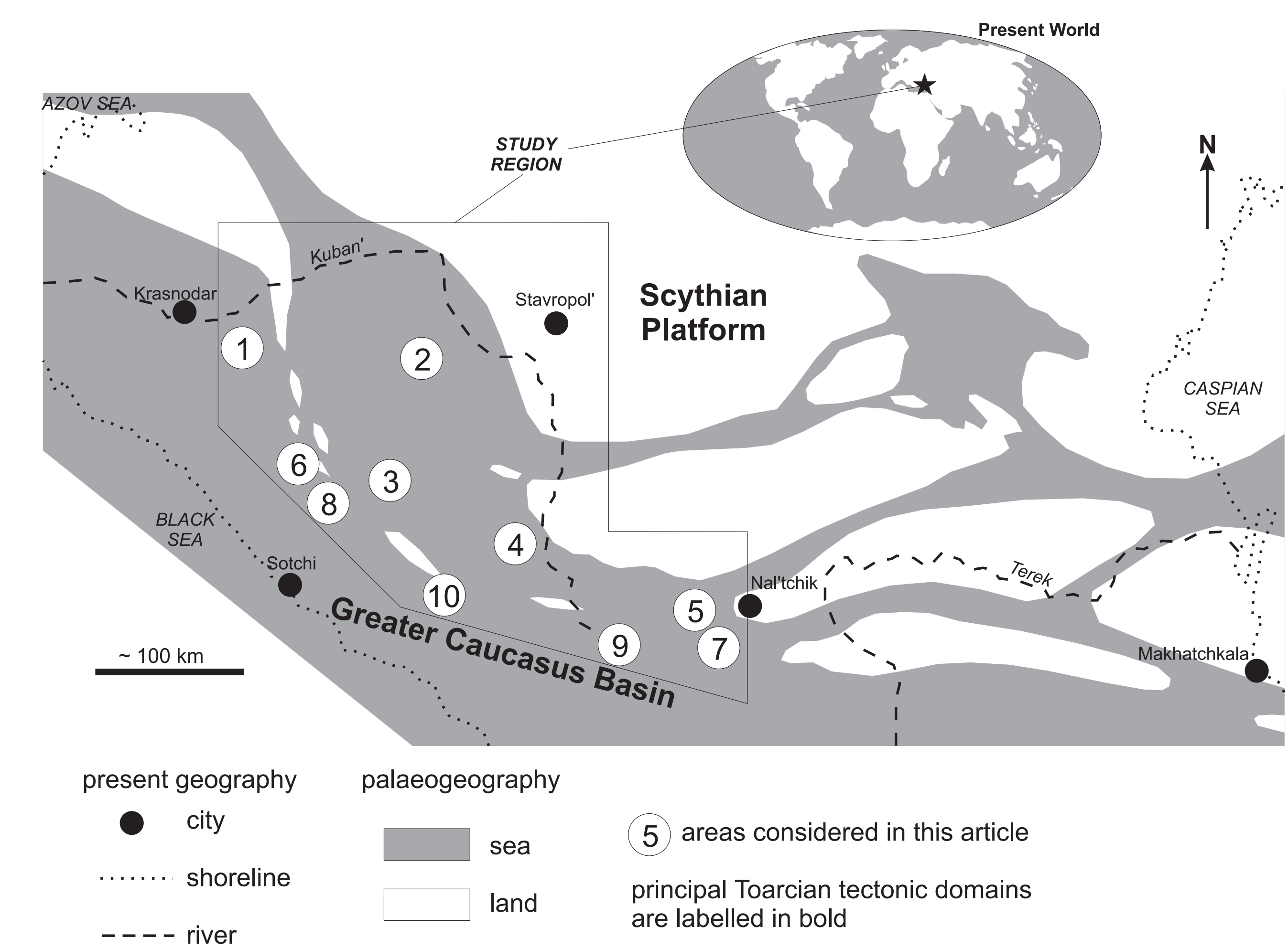

Fig. 1. Geographic and paleogeographic location of the study region. Generalized Toarcian paleogeographic reconstruction is modified from Panov et al. (1996). The nomenclature of the areas of the Northwestern Caucasus follows (with certain modifications) Rostovtsev et al. (1992) and Ruban (2007). Areas: 1 — Western Kuban', 2 — Eastern Kuban', 3 — Western Laba-Malka, 4 — Central Laba-Malka, 5 — Eastern Laba-Malka, 6 — Western Pshekish-Tyrnyauz, 7 — Eastern Pshekish-Tyrnyauz, 8 — Northern Arkhyz-Guzeripl', 9 — Eastern Arkhyz-Guzeripl', and 10 — Southern Arkhyz-Guzeripl'.

2. Geological setting

The Northwestern Caucasus includes the western edge of the Greater Caucasus fold-and-thrust belt and its foreland (Fig. 1). The principal structural elements of this region were formed in the Mesozoic and the Cenozoic, when the large back-arc Greater Caucasus Basin evolved along the margin of the Scythian Platform; further tectonic compression led to the growth of the present-day mountain chain in the late Cenozoic (Milanovskij and Khain, 1963; Lordkipanidze et al., 1984; Gamkrelidze, 1986; Saintot and Angelier, 2002; Ershov et al., 2003; Kazmin and Tikhonova, 2006; Ruban, 2006; Saintot et al., 2006; Tawadros et al., 2006; Adamia et al., 2011a,b; Marinin and Saintot, 2012; Nikishin et al., 2012). According to the classification of Merle (2011), this basin was a subduction-related rift in the Early Jurassic. The classification of sedimentary basins proposed by Ingersoll (2012) allows to assign it probably to the category of "nascent ocean basins and continental margins". In the Early Jurassic, the Greater Caucasus Basin evolved on the northern margin of the Neo-Tethys Ocean that underwent permanent re-organization (Stampfli and Borel, 2002; Golonka, 2004; Kazmin and Tikhonova, 2006; Seton et al., 2012).

The Lower–Middle Toarcian deposits are distributed widely in the Greater Caucasus Basin (Krymgol'ts, 1972; Prosorovskaya, 1979; Rostovtsev et al., 1992; Panov et al., 1996; Ruban, 2007, 2012). Particularly, they occur in all ten areas of the Northwestern Caucasus (Fig. 2). Lithologically, they are chiefly siliciclastic (both coarse and fine). Their total thickness varies from ~50 m to ~800 m (Rostovtsev et al., 1992). Their age is established with ammonites, foraminifers, brachiopods, and other invertebrates (Antonova and Pintchuk, 1991; Rostovtsev et al., 1992; Prosorovskaya, 1993; Ruban, 2003; Ruban and Tyszka, 2005; Ruban, 2006; Topchishvili and Lominadze, 2007; Ruban, 2012). The ammonite zonation forms a "core" of the regional biostratigraphical framework, and the regional zones (Rostovtsev et al., 1992) are brought in correspondence with those standard (Ogg et al., 2008; see also Cariou and Hantzpergue, 1997) (Fig. 2).

The Lower–Middle Toarcian deposits exposed on the territory of the modern Northwestern Caucasus were accumulated in a transgressing marine basin with gentle northern slope "attached" to the Scythian Platform (i.e., southernmost part of Baltica) and steep southern slope "attached" to the Northern Transcaucasian Arc (Jasamanov, 1978; Ruban, 2006, 2012). When it reached the maximal size, the western part of this basin looked like a large embayment (Fig. 1) connected by straits with the neighboring water masses (Panov et al., 1996). The seawater was warm, and it had normal salinity (Jasamanov, 1978). The basin was populated by diverse invertebrates (Rostovtsev et al., 1992; Ruban, 2007), and it belonged paleobiogeographically to the Tethyan Subrealm, although it remained also close to the Boreal Subrealm (Westermann, 2000).

3. Material and methods

This study is based on data compiled from a number of available sources bearing the information on the occurrence of ammonite