УДК 552

CARBONATE MICROFACIES ANALYSIS AND MINERAL COMPOSITION OF THE MIDDLE-UPPER ORDOVICIAN SUCCESSION OF THE MOYERO RIVER SECTION, NE OF SIBERIAN PLATFORM

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Abstract *Lithological re-investigation of upper Volginian, Kirensko-Kudrinian, Chertovskian, Baksian and Dolborian regional stages (uppermost Darriwilian, Sandbian and lowermost Katian Global Stages) of Moyero River section results are presented. New data of clay minerals distribution in two outcrop sections have been obtained. Levels with kaolinite and smectite content as perspective stratigraphical markers have been allocated. Composition of heavy minerals in terminal part of Kirensko-Kudrinian deposits was studied. By the expected source of terrigenous material identified Anabar Land. The distribution of the carbonate ramp facies zones in the studied succession reflects development of marine transgression interrupted at the base of Kirensko-Kudrinian regional stage, at the middle of Kirensko-Kudrinaian regional stage (base of the Kudrinian substage) and at the base of the Chertovskian regional stage by regressive events.*

Keywords: *Ordovician, Siberian platform, clay minerals, heavy minerals, carbonate microfacies.*

Introduction

Ordovician outcrops along the Moyero River valley compose one of the most complete and best-exposed Ordovician sections on the entire Siberian Platform. The study of these sections was carried by different researchers starting from mid-20th century (Myagkova et al. 1963; Myagkova et al. 1977; Kanygin et al. 2007). However, the results of these investigations except field description of outcrops and fragmental biostratigraphical and paleontological data have not been published. In modern time, the Ordovician outcrops of the Moyero River valley were studied by paleomagnetic methods (Gallet, Pavlov 1996). As a result of this investigation, in the Ordovician was allocated the Moyero reversed superchron, corresponding to most part of Lower and Middle Ordovician (Pavlov, Gallet 2005; Cooper et al. 2012). In the year 2013, a special expedition was organized in order to re-investigate this key Ordovician section.

The Ordovician deposits are distributed in the midstream of Moyero River to the southwest of the Anabar shield (NE of Siberian Platform, Fig.1, A). Studied interval includes the upper Volginian, Kirensko-Kudrinian, Baksian and Dolborian regional stages (uppermost Darriwilian, Sandbian and lowermost Katian Global Stages). These deposits studied in two sections on the Moyerokan River right bank (location No 101A, uppermost Baksian and Dolborian regional stages, Fig. 1, C) and on the Moyero River left bank (location No 70, uppermost Volginian – Dolborian regional stages). Generally, the Volginian – Dolborian interval in Moyero River section has 111 meters thickness (Kanygin et al. 2007). The Volginian deposits are presented as an alternation of the light gray bioclastic and algal limestone and dark-gray and greenish-gray clays. The Kirensko-Kudrinian regional stage has a predominantly clayey composition (reddish, green and greenish-gray clays and argillites) with algal and bioclastic calcareous beds.

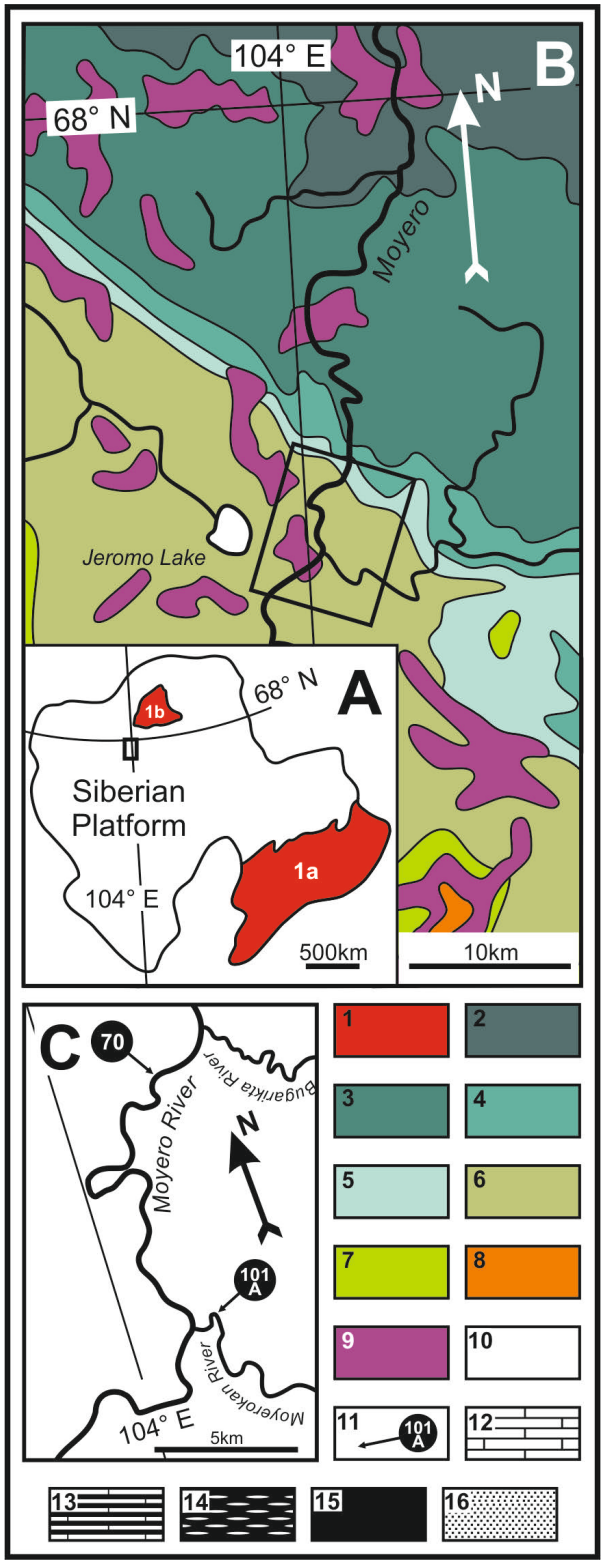

Fig. 1. A - Simplified geologic map of Siberian Platform and geographical position of Moyero River valley, 1 – basement uplifts: 1a – Aldan Shield, 1b – Anabar Shield; B – Simplified geologic map of Moyero River valley area, 2 – Upper Cambrian, 3 – Lower Ordovician, 4 – Middle Ordovician, 5 – Upper Ordovician, 6 – Lower Siilurian, 7 – Upper Silurian, 8 – Permian, 9 – Triassic trapps, 10 – Jeromo Lake; C – Schematic map of Moyero River midstream: 11 – number and position of studied locations (by Myagkova et al., 1977).

These deposits conformable overly the Volginian rocks. The Chertovskian, Baksian and Dolborian interval is composed as an alternation of dominantly gray and greenish-gray clays, nodular limestones and allochthonous bioclastic gradation-layered limestones.

Clay mineralogy

Semiquantitative mineral composition of the < 2 μm size clay fraction was analyzed using X-ray diffraction techniques. The clay mineral association includes illite, chlorite and mixed-layers minerals. At several levels contain an admixture of kaolinite and smectite. Illite (with admixture of mixed-layers minerals and chlorite) dominates (more than 50%) in Volginian – lower part of Baksian Regional Stage interval. The illite and chlorite content gradually decrease toward the upper part of the Baksian and Dolborian Regional Stage. On these levels, clays dominantly contain different mixed-layers with addition of illite. Smectite (less than 10%) is fixed in two levels in top of Baksian and Dolborian Regional Stages in section No 101A (left bank of Moyerokan River). Mineral assemblage also includes illite, Mg-chlorite and mixed-layers chlorite-smectite and illite-smectite minerals. Kaolinite is present in an amount less than 10% at several levels. It is upper part of Kirensko-Kudrinian, the top of Chertovskian and middle part of Baksian Regional Stages. All samples with content of kaolinite have admixture of silty or fine quartz grains.

Heavy minerals from kirensko-kudrinian terminal sandstones

The upper 3,5 meters of the Kirensko-Kudrinian regional stage are composed by alternation of fine-grained sandstones and clays. The boundaries of clay and sandstones beds have erosional character. Three samples from lower, middle and upper parts of sandstones were studied. For heavy minerals analysis we use < 0,1 mm fraction. The mineral composition of

the heavy fraction were examined by the light polarized microscope.

The colored and ore minerals were not studied. The sandstones have predominantly quartz composition and tiny grain size. The colorless heavy minerals association of sandstones from upper part of Kirensko-Kudrinian regional stage include tourmaline, titanite, staurolite, hornblende, kyanite and zircon (Fig. 2). The grains of heavy minerals have rounded and angular-rounded shape. The listed minerals include minerals with good and average degree of chemical resistance. The good resistant minerals are predominate. Their quantity increasing up the succession.

Microfacies analysis

About 150 thin sections were examined with a polarizing light microscope Carl Zeizz Axioscope 40. For carbonate microfacies analysis we use the model introduced by E. Flügel (Flügel 2004). The following facies zones of the carbonate ramp could be distinguished in the studied interval of the section:

1. The tidal deposits of the inner ramp are well developed in the Volginian and in the lower and middle parts of the Kirensko-Kudrinian regional stage. These rocks are represented by mudstone and bioclastic wackestone with admixture of algae and tiny quartz grains. In the lower part of Kirensko-Kudrinian regional stage these deposits overlay the facies of coastal sand shoals and banks. In the middle part, the tidal facies replaced by restricted marine facies.

2. The sand shoals and banks of the inner ramp include two microfacies: 1) oolitic grainstone with concentric ooids and bioclastic packstone with several predominant types of bioklasts. This microfacies could be found in the upper part of Volginian and the lower part of Kirensko-Kudrinian regional stages; 2) the fine grained quartz sandstones with phosphate grains comprise the upper part of the Kirensko-Kudrinian regional stage deposits.

3. Restricted-marine settings of the inner ramp are composed by the bioclastic packstone with numerous echinoderms and wackestone with ostracods. These facies developed locally and underlie the quartz sandstones of the sand bank in the upper part of the Kirensko-Kudrinian regional stage.

4. The open-marine deposits of the inner ramp (packstone and wackestone with various bioclasts) compose stratigraphic intervals of the Chertovskian and the lower part of the Baksian regional stages. These facies directly overly the quartz sandstones of the Kirensko-Kudrinian regional stage. The sharp boundary between these two contrasting facies is interpreted as a marine flooding surface and sequence boundary.

5. The sediments of the mid-ramp are represented by intercalation of non-bioturbated mudstones and highly bioturbated bioclastic wackestone with ostracods and trilobites as main components. These facies are typical for the lower part of the Baksian regional stage.

6. Carbonate rocks of the upper part of Baksian and Dolborian regional stages are composed predominantly by allochthonous wackestones and packstones less often floatstones and grainstones. The bioclasts are presented by echinoderms, bryozoan, trilobites, brachiopods, ostracods and calcareous algae. The bioclasts often are micritized. The lithotypes distribution of carbonate rocks in Dolborian regional stages were studied less detail. But, preliminary this interval may be interpreted by mid-ramp or upper part of outer ramp.

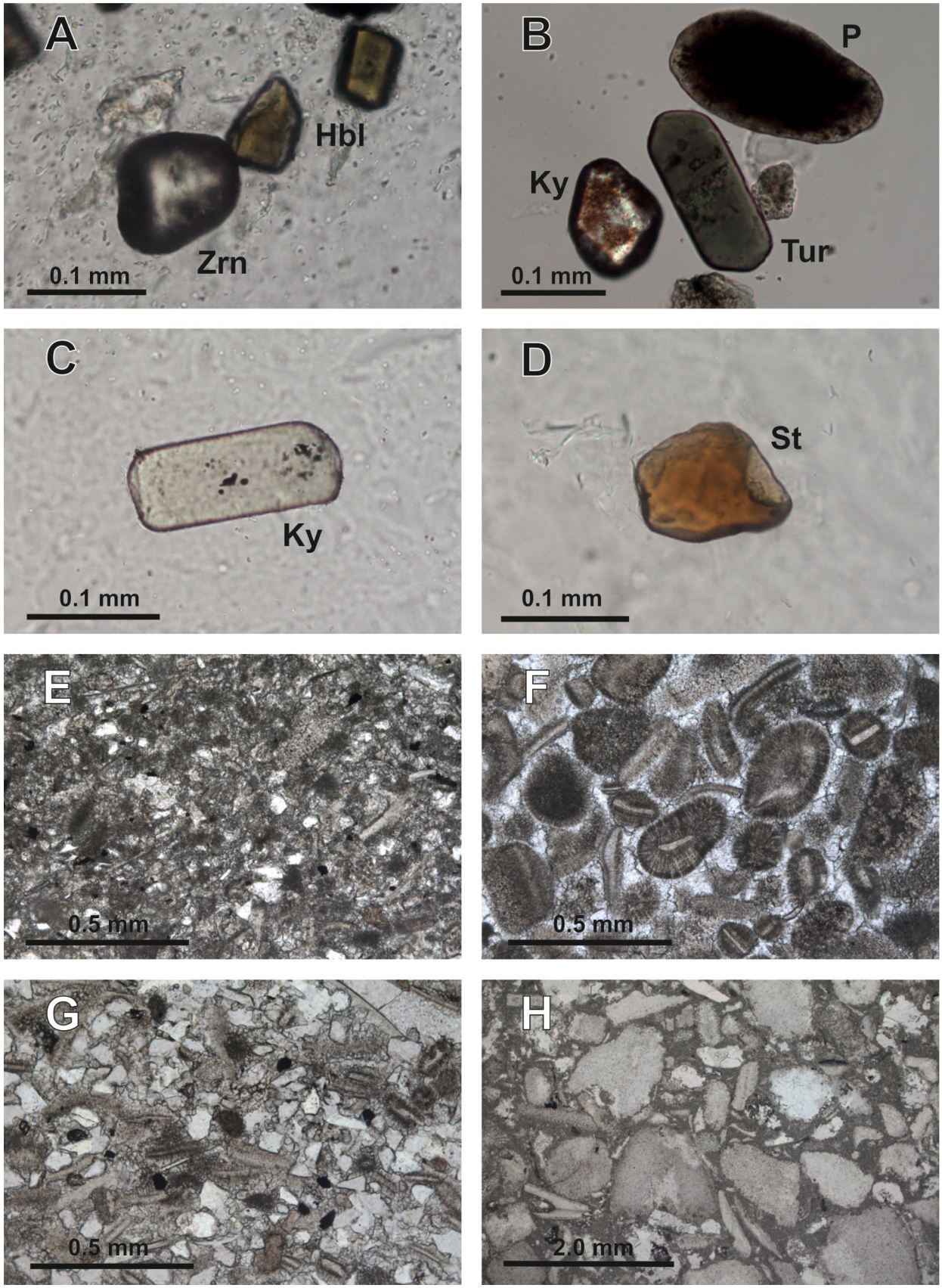

Fig. 2. Microphotographs of selected heavy minerals (A – D) and microfacies (E – H). A: Zrn – zircon, Hbl – hornblende, B: Ky – kyanite, Tur – tourmaline, P – authigenic phosphate grains, C: Ky – kyanite, D: St – staurolite, E - bioclastic wackestone with admixture of algae, lower part of Kirensko-Kudrinian regional stages, F – oolitic grainstone with concentric ooids, lower part of Kirensko-Kudrinian regional stages, G – bioclastic wackestone with ostracods and quartz grains, upper part of Kirensko-Kudrinian regional stages, H – allochthonous packstones with echinoderms.

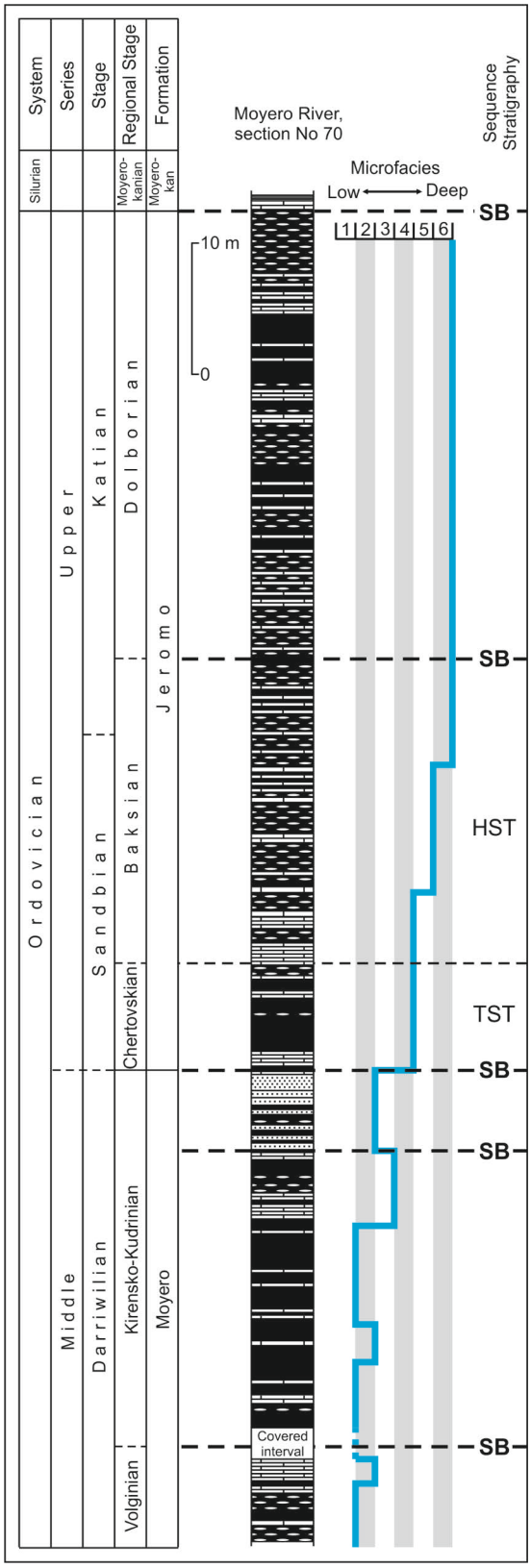

Fig. 3. Stratigraphic column and distribution of microfacies of the uppermost Darriwilian – lower Katian succession on the Moyero River left bank, section No 70 and distribution of microfacies. The position of boundaries of Global Stages modified by Kanygin et al. 2007, Cooper et al. 2012. Sequence stratigraphy by Dronov et al. 2009, Dronov et al., 2015. Legend see in Fig. 1: 12 – limestones, 13 – alternation of limestones and clays, 14 – nodular limestones, 15 – clays, 16 – sandstones.

Discussion and conclusions

The lithological investigation of the upper Volginian, Kirensko-Kudrinian, Baksian and Dolborian regional stages of Moyero River section has allowed to consider the levels with kaolinite and smectite content as perspective stratigraphical markers. The smectite and clorite-mixed-layers composition of clay fraction can be an evidence of volcanoclastic matter. The bentonite beds in the Upper Ordovician of Siberian Platform identified in southwest of the Platform in Podkamennaya Tunguska basin (Dronov et al. 2011; Huff et al. 2014).

The microfacies analysis of carbonate rocks displays the range of environments from tidal (in the lower part of succession) to upper part of outer ramp in the Dolborian regional stage. The general distribution of the carbonate ramp facies zones in the studied succession reflects development of marine transgression interrupted at the base of Kirensko-Kudrinian regional stage, at the middle of Kirensko-Kudrinaian regional stage (base of the Kudrinian substage) and at the base of the Chertovskian stage by regressive events (Fig. 3).

Acknowledgments

This is a contribution to the IGCP Project-591 “The Early to Middle Paleozoic Revolution”. Financial support provided from the Russian Foundation for Basic Research Grant № 13-05-00746.

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КАРБОНАТНЫЕ МИКРОФАЦИИ И МИНЕРАЛЬНЫЙ СОСТАВ СРЕДНЕ-ВЕРХНЕОРДОВИКСКИХ ОТЛОЖЕНИЙ РАЗРЕЗА Р. МОЙЕРО, СЕВЕРО-ВОСТОК СИБИРСКОЙ ПЛАТФОРМЫ

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Аннотация: *Представлены результаты литологического переизучения волгинского, киренско-кудринского, чертовского, баксанского и долборского горизонтов (верхняя часть даррывильского, сандбийский и низы катийского яруса) разреза среднего течения р. Мойеро. Получены новые данные по распределению глинистых минералов, выявлены уровни, обогащенные каолинитом и смектитом, которые представляются перспективными стратиграфическими маркерами. Изучен минеральный состав тяжелой фракции в терминальной части киренско-кудринского горизонта. В качестве предполагаемого источника сноса терригенного материала предложена Анабарская суша. Распределение микрофаций рампового типа в изученных разрезах указывают на трансгрессивный характер этих отложений. На фоне общей трансгрессивной обстановки установлены три уровня понижения уровня моря: в основании и средней части киренско-кудринского горизонта, а также на границе киренско-кудринского и чертовского горизонтов.*

Ключевые слова: *ордовик, Сибирская платформа, глинистые минералы, тяжелые минералы, карбонатные микрофации.*

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