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## Materiały konferencyjne

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# THE MAIN ORGANIC MATTER RICH SHALE SEQUENCES IN THE UPPER JURASSIC AND LOWER CRETACEOUS OF THE RUSSIAN PLATFORM: SEDIMENTOLOGY, GEOCHEMISTRY AND PALEOENVIRONMENTAL MODELS

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Stratigraphical, lithological and geochemical study of the Upper Jurassic and Lower Cretaceous deposits of the Russian Plate (Gavrilov *et al.* 2002; 2008; Shchepetova 2009) has allowed to distinguish two levels of intensive organic matter (OM) enrichment - the Middle Volgian (Panderi Zone) and the Lower Aptian (Volgensis Zone) (fig. 1a, 1b). Both were assumed as regional manifestation of specific conditions, which were spread on the global scale. The second half of the Late Jurassic was characterized by the accumulation of high-carbonaceous (frequently, oil-generating) sediments in different regions of the Northern Hemisphere (West Europe, Barents Sea, West Siberia, and others). The Early Aptian episode on the Russian Plate has been referred to *Deshayesites volgensis* (Mikhailova and Baraboshkin, 2001) = *Deshayesites forbesi* ammonite zone (Casey, 1961) and this provides a good correlation with global OAE-1a («Selly level»).

The pyrolytic and microscopic studies demonstrate the prevalence of marine OM in the Volgian (kerogen of types I and II, $C_{org}$ content up to 20-35%) and in the Aptian (kerogen of type II, $C_{org}$ up to 4-9,6 %) carbonaceous shales. Both kerogens are dominated by the amorphous OM (up to 90–99%) corresponding to colloalginite (according to terminology in Ginsburg 1991). Colloalginite has different tints of yellow, orange and brown colors. It is concentrated in the clayey matrix as thin laminae or flattened lenses (from 0.0*n* to *n* mm long) arranged parallel to bedding surfaces. Carbonaceous shales of both intervals are enriched with a same range of chemical elements which could be divided into two groups with regard to their concentrations: 1) Mo, S, Se exceed those of an average shale (Turekian & Wedepohl 1961; Wedepohl 1991) in 10 times or more; 2) V, Ag, Cu, P, Ni, Co, Zn - in 2-5 times above.

The Middle-Volgian and Lower Aptian OM-rich shale sequences were formed in paleobasins with the different types of sedimentation. During Middle-Late Jurassic (from Callovian to Volgian) terrigenous marine sedimentation took place, while in the mid Cretaceous time (from the Late Hauterivian to the Aptian) it was replaced by exclusively terrigenous one. The structure of MiddleVolgian and Lower Aptian OM-rich shale sequences is different (fig. 2a, 2b). In the Volgian basin organic carbon accumulation was impulsive, resulting in a shale-bearing sequence with a well-defined cyclic structure. Elementary cycles (to 1 m in thickness) demonstrate contrast distribution of $C_{org}$ and $CaCO_3$. In the Aptian basin OM was accumulated more regularly and that resulted in the formation of relatively monotonous "bituminous" horizon.

Based on the complex of sedimentological, biotical and geochemical parameters it is assumed that: a) a stable anoxia existed in the central part of the Early Aptian basin when OM-rich sediments were accumulated; b) anoxic environments existed in numerous extensive depressions in the Middle Volgian basin, where carbonaceous sediments were accumulated, but anoxia were unstable and often interrupted by short- and long-term periods (to first tens of thousands of years), when normally aerated conditions prevailed.

Both OM-rich shale sequences were accumulated in shallow epicontinental seaways (no more than 100-200 m in deep), in the course of frequent sea level fluctuations. The high OM concentration in both cases was determined by a sharp increase of the organic-walled plankton productivity. These, in turn, were caused by increased influx of nutrients from the onshore landscapes into basins during rapid and powerful transgressions, preceded by a brief regressive episode. It is supposed (Gavrilov 1994; Gavrilov *et al.* 2002, 2008 ) that such regressions were accompanied by rapid formation of lacustrine–boggy onshore landscapes on released from seawater territories, previously flattened and smoothed by marine erosion and sedimentation. These specific short-living ("ephemeral") landscapes were favorable for the accumulation of both dissolved forms of OM and compounds of biophile elements, such as P, N, Fe, and others. Correspondingly, sea level fluctuations (in particular, rises) even of low-amplitude resulted in the flooding of spacious lowlands covered by such landscapes and, as consequence, to the rapid increase of bioproductivity and accumulation of OM-rich sediments.

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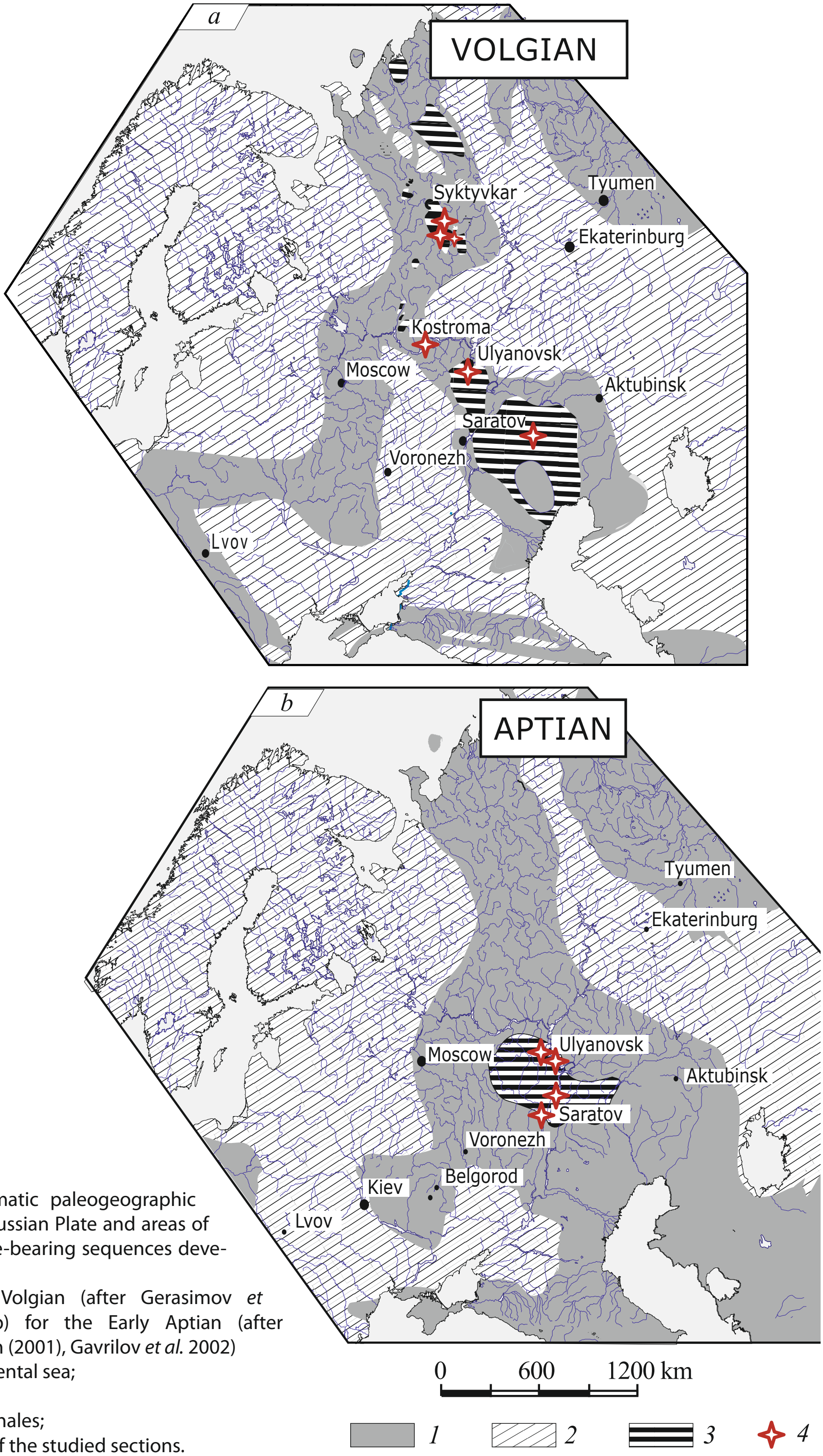


**Fig 1.** Schematic paleogeographic map of the Russian Plate and areas of OM-rich shale-bearing sequences development:
(a) for the Volgian (after Gerasimov *et al*. 1962); (b) for the Early Aptian (after E.Baraboshkin (2001), Gavrilov *et al.* 2002)
1 – epicontinental sea;
2 – land;
3 – OM-rich shales;
4 – location of the studied sections.

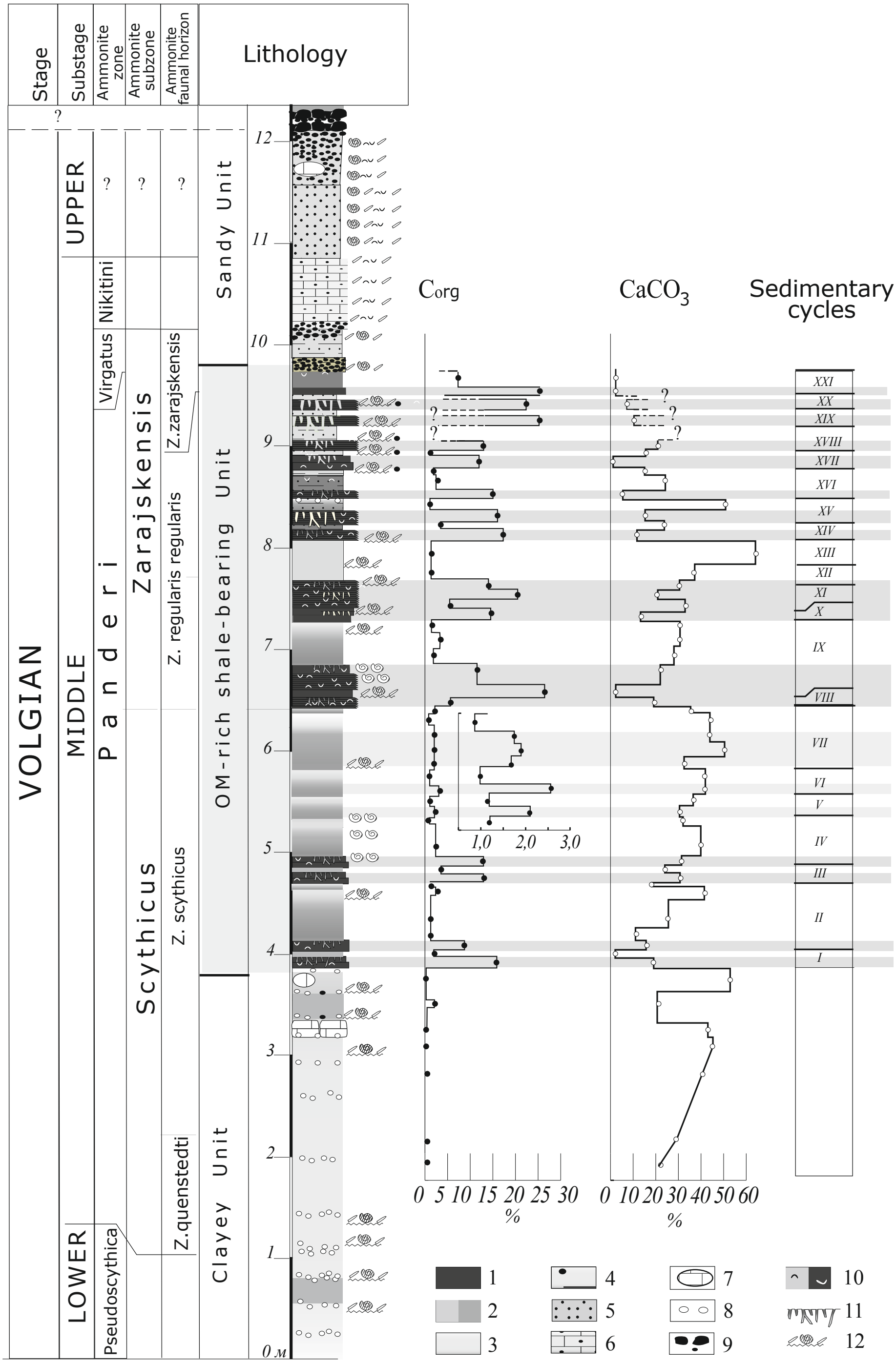


**Fig 2.** Stratigraphy, lithology and distribution of $C_{org}$, $CaCO_3$ in the Gorodishi section (near Ul'yanovsk) of the Middle Volgian (Panderi Zone) OM-rich sequence: 1 – oil shale; 2 –calcareous clay; 3 – clayey limestone; 4 – silty and sandy clay; 5 – sand; 6 – sandstone; 7 – calcareous concretions 8 – phosphate concretions; 9 – phosphoritic nodules and pebbles; 10 – fossils; 11 – "softground" with burrow systems; 12 – erosion and sediment condensation surfaces, rich in pyritized ammonites and belemnites.

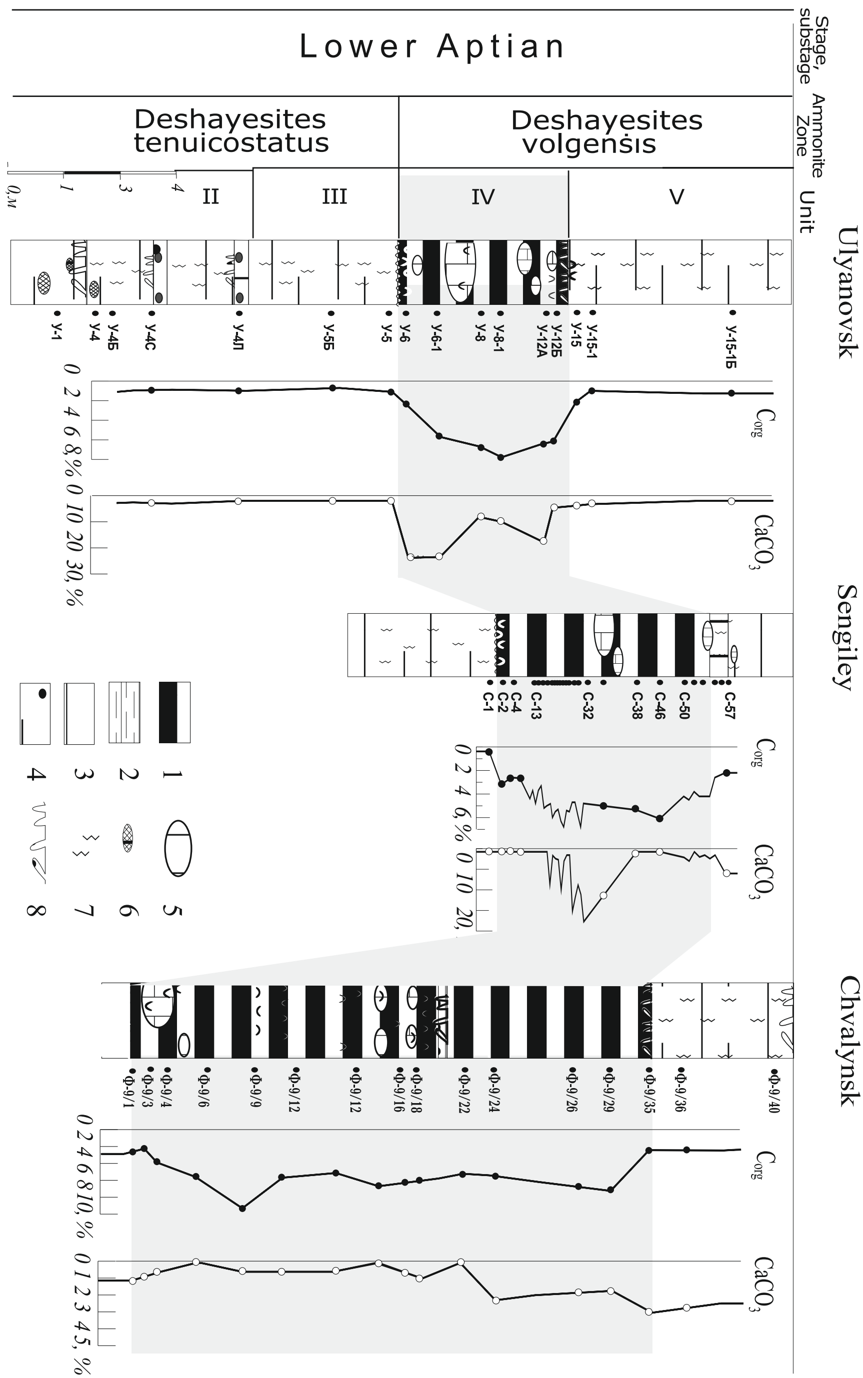


**Fig 3.** Stratigraphy, lithology and distribution of $C_{org}$, $CaCO_3$ in the series of sections of Lower Aptian OM-rich (“Bituminous”) Shale:
1 – “bituminous” shale; 2 – clay; 3 – silty clay; 4 – sandy clay; 5 – calcareous concretions; 6 – pyritic concretions; 7 – bioturbation; 8 – burrow system.

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