BIOGEOCHEMISTRY OF UPPER JURASSIC AND LOWER CRETACEOUS DEPOSITS OF THE ANABAR BAY (LAPTEV SEA)

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The Late Jurassic evolution of the Boreal and Arctic basins is reflected in the widespread deposition of organic-rich black shales. The one of the well-known geological section is located on the left bank of the Anabar Bay of the Laptev Sea. The section is exposed in coastal cliffs and consists mainly of silty clay deposits with abundant macro- and microfossils. Paleontological analyses of ammonites, foraminifers, ostracods, dinocysts, spores and pollen revealed the Upper Oxfordian to Lower Valanginian age for the investigated succession. The aim of this study was to extend our knowledge about the evolution of the depositional environment based on geochemical parameters of samples, including total organic carbon (TOC), Rock-Evel pyrolysis data, molecular (biomarkers) composition of extractable organic matter (EOM), carbon isotopic composition etc. Three biogeochemical horizons – "Lower" (Upper Oxfordian – Kimmeridgian), "Middle" (Volgian-Boreal Berriasian) and "Upper" (Lower Valanginian) – were distinguished based on biomarker and microfossil parameters.

Bulk geochemical parameters. The TOC contents in Upper Jurasic and Lower Cretaceous deposits vary from 0.31-5.82 wt%. Generally, higher TOC contents are measured in the "Middle" horizon as compared to the "Lower" and "Upper" horizons. The low T_{max} values (420-441°C) indicate the immature organic matter (OM) in all samples. All samples contained a suite of *n*-alkanes from C_{13} to C_{35}, but components with carbon number above C_{33} were only trace constituents. C_{21}- C_{31} *n*-alkanes are the most abundant peaking at C_{29}, in the context of a strong odd predominance. Alkenes were not detected. All the samples contained small amounts of steranes dominated by 20R isomers. The carbon isotopic composition ($\delta^{13}C$) of EOM for all samples fall within the ranges between -30.5 and - 23.7**⁰/₀₀.** The extracts of samples from the Volgian-Berriasian age have relatively light isotopic composition of carbon. The shift towards isotopically heavier $\delta^{13}C$ values in the "Lower" and "Upper" horizons could be explained by the increased contributions of terrigenous OM.

"Lower horizon" (Upper Oxfordian – Kimmeridgian).
Low T_{max} values (420-436°C) indicate the immature OM in all samples from the horizon, while low HI values (12-21 mg HI/TOC) in the horizon indicate a relative high contribution of land plants. Hopane distributions showed a dominance of those with the biological 17β,21β-stereochemistry, as expected for an immature shale, with low amounts of 17β,21α-hopanes (moretanes) and 17α,21β- hopanes. Hopenes are absent. Benzohopanes and retene (biomarker of *coniferous*) were identified in the aromatic factions.

"Middle horizon" (Volgian-Berriasian). The highest TOC contents (5,82%) are measured in the Upper Volgian unit. The T_{max} values (422-441°C) also indicate the immature OM. The HI values (154-298 mg HI/TOC) in the Volgian-Berriasian stages indicate a relative higher contribution of marine organic matter. A high abundance of C_{19}-C_{20} isoprenoid alkanes is consistent with high algal productivity in the overlying water column. The amounts of the Pr/n-C_{17} ratios vary from 3,19 to 6,66 in the Upper Volgian unit and decrease to 0,83-4,95 in the Berriassian. Steranes were found to be components in relatively minor amounts. Abundant diasterenes and 4-methyldiasterenes, (m/z 257 and m/z 271) reflecting significant conversion of the original lipid composition by way of clay-catalysed diagenesis (Volkman et al., 2015). In the diasterene series $C_{29} > C_{27} > C_{28}$, whereas in the 4- methyldiasterene series $C_{28} > C_{30} > C_{29}$ the total amounts of diasterenes and 4-methyldiasterenes were very similar. Hopane distributions (m/z 191) also showed a dominance of "biological" isomers. Two hopenes (m/z 191) were also abundant and assigned as C_{29} and C_{30} neohop-13(18)-enes, which occurred together with hop-17(21)-enes (m/z 367). These hopanoids were probably origin from the lipids of methanotrophic bacteria. A series of methylated chromans (MTTCs) occurs in high (m/z 149->414) and low (m/z 135->400, m/z 121->386) amounts in the aromatic fraction. A good positive relationship exists between Pr/n-C_{17} or Ph/n-C_{18} ratios and MTTCs contents (r^2=0,77 and 0,78), suggesting that MTTCs values depends from algal productivity. OM accumulation during this period occurred at normal salinity (by the MTTCs index). The origin of MTTCs is still under discussion (Sinninghe Damste et al., 1987; Li et al.,1995).

"Upper horizon" (Lower Valanginian).

The lowest TOC contents (0,34-1,01 wt%) were obtained from the samples of Valanginian clays. Low HI values (16-42 mg HI/TOC) is very similar to those for the "Lower" horizon. The "Upper" horizon demonstrated the absence of diasterenes, 4-methyldiasterenes, chromanes MTTCs and hopenes. Among polycyclic biomarkers, only hopanes and tricycloalkanes were detected. Benzohopanes and retene were also identified in the aromatic fraction.

High primary bioproductivity resulted in the stratified water column and the accumulation of OM-rich (of algal and microbial origin) sediment in the "Middle" biogeochemical horizon. Laminated clays of this horizon are considered as oil prone sediments with good HC potential, but their organic matter is thermally immature. All these data do not compromise the optimistic assessment of the petroleum potential prospects for Jurassic-Cretaceous sediments submerged on the continental shelf of the Laptev sea.

References

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