

GEOCHEMISTRY OF THE EARLY-MATURE ORGANIC MATTER OF MIDDLE-UPPER JURASSIC DEPOSITS ON THE PERIPHERY OF THE WEST SIBERIAN BASIN

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The obtained result including Rock-Eval Pyrolysis data and biomarker distribution of source-rock extracts (alkanes, terpanes and steranes) based on 26 samples of mudstones and silty mudstones from Upper Jurassic deposits (14 samples, 1860-1993 m) and from Middle Jurassic deposits (12 samples, 2059-2323 m) have been used to describe the depositional environment and to assess thermal maturity of Middle-Upper Jurassic deposits from Medvezhiya-316 well (Western Siberia).

These results show that total organic carbon (TOC) values range between 0.7 and 2.5 wt.% throughout the Jurassic section and reach 10.2 wt.% in one sample from a depth of 2292 m. The hydrogen index (HI) is mostly below 100 mg HC/g TOC, while in two Middle Jurassic samples it is equal 228 and 332 mg HC/g TOC. The organic matter (OM) of Middle-Upper Jurassic source rocks is derived from terrigenous higher plants with the presence of aquatic organic matter. Most of samples are characterized by the predominance of C₂₉ steranes over C₂₇ and C₂₈ (C₂₉/C₂₇=1.7-6.5) and high values of I_{Tc}=2Σ(C₁₉₋₂₀)/Σ(C₂₃₋₂₆) tricyclic terpanes ratio (1.4-5.2). The bitumens from the depth interval of 1872-1927 m contain higher concentrations of C₂₇ steranes (C₂₉/C₂₇=0.9-1.5) and have low values of I_{Tc} (I_{Tc}=0.9-1.4). n-Alkanes distribution in the extracts are characterized by the dominance of lower molecular weight homologue members (C₁₇ and C₁₈) indicating algal organic matter and/or higher odd n-alkane homologues (C₂₃-C₂₉), which evidences that terrestrial organic matter was also contributed.

Assessment of the redox conditions during the Jurassic source rocks deposition was based on the interpretation of organic geochemical parameters. The pristane/phytane ratio values ranged widely from 0.8 to 5.4 indicating variable redox conditions during the Jurassic. The low C₃₅/C₃₄ homohopanes ratio equal 0.20-0.62 bears the evidence of oxic deposition of the precursor organic material. C₃₀ 17α-diahopane were also identified in all samples, which is in agreement with the availability of oxygen in the environment [1].

The determination of the OM maturity showed that all the analyzed samples are thermally early mature. The vitrinite reflectance values are between 0.53 and 0.63 % Ro and Tmax 429-440 °C. Carbon preference index (CPI) calculated for C₂₄-C₃₄ is 1.16-2.20. All of the investigated samples have 20S/(20S+20R) and ββ/(ββ+αα) C₂₉ sterane ratios ranging from 0.12 to 0.40 and 0.19 to 0.56, respectively, both being less than equilibriums. Among the C₂₇ hopanes are dominated by the Tm with the traces of Ts (Ts/Tm<0.16). The distribution of extended C₃₁-C₃₅ homohopanes is characterized by a strong predominance of the C₃₁(22S+22R) homologues and significant excess of the less stable R epimer which is characteristic of the immature OM. C₃₁αβ S and R epimers concentrations become equal at a depth of 2176 m, and S>R at 2220 m. In the studied sediments occurring deeper than 2292 m, C₃₁-C₃₅ homohopanes 22S epimer is predominated by 22R epimer.

Distribution patterns of steranes and terpenes showed the presence of thermodynamically less stable isomers. Hopane distributions are characterized by the occurrence of immature hopanes with biological 17β,21β-stereochemistry and rearranged unsaturated C₂₇, C₂₉, C₃₀ hopenes

having a double bond at 13(18) and C₂₉-C₃₁ hopenes with double bond at 17(21). On the m/z 191, C₂₇ ββ-hopane is more abundant, while C₂₉-C₃₂ compounds are present in a smaller amount. With increasing thermal maturity, ββ-hopanes concentrations tend to decrease, and C₂₇ hopane is observed only in trace concentration in the sample from a depth of 2323 m. Hopenes determined as C₂₇, C₂₉ and C₃₀ neohop-13(18)-enes and C₂₉-C₃₁ hop-17(21)-enes were identified in low amounts. These peaks were detected by comparing the m/z 191 chromatograms with the published elution orders of various possible hopene isomers and mass spectral data [2; 3; 4]. Hop-17(21)-enes were found only in Upper Jurassic deposits, but traces of neohop-13(18)-enes are persistent in the samples with the level of maturity up to Ro 0.64 %. The significant amounts of diacholest-13(17)-enes (diasterenes) and 4-methyldiacholest-13(17)-enes (4-methyldiasterenes) contained in bitumens were measured using m/z 257 and 271, respectively.

For ten samples, unusual C₂₈ 28,30-bisnorhopane has been identified in high concentration. The presence of a suite of C₂₇-C₃₀ 25-norhopanes (10-desmethylhopanes) together with the C₂₈ 28,30-bisnorhopane were revealed in six non-biodegraded source-rock extracts. The appearance of C₂₈ 28,30-bisnorhopane is usually attributed to the existence of specific bacteria in early stages of the OM transformation. Typically, the origin of 25-norhopanes is associated with the processes of biodegradation. The discovery of 25-norhopanes in indigenous bitumens with no signs of biodegradation requires further study. The origin of these compounds is uncertain and there are several hypotheses [1].

Based on these results, it can be concluded that early-mature organic matter in sediments from Medvezhiya-316 well, located on the periphery of the West Siberian basin, contains significant amount of TOC with low Rock-Eval HI that have mixed origin due to terrestrial and algae biomass deposited under suboxic to oxic environment. Well preserved hopanes and steranes with biological structure and measured Ro values show that thermodynamically unstable biomarkers can maintain their primary biological structure for a long time.

References

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