SEARCH FOR THE SOURCE ROCKS IN THE TURIJA OIL FIELD REGION (SE PANNONIAN BASIN, SERBIA)

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In the last two decades, the Turija oil field (Serbia) has attracted attention through oil discoveries in new wells. A total of 119 wells have been drilled in this field, of which 72 are active in oil production. The source rocks of the Turija oil are still unknown. In this study, potential lower Miocene (Ottnangian-Karpatian) to upper Miocene (Pannonian) source rocks from some boreholes near the Turija oil field were investigated to determine the origin, depositional environment, hydrocarbon potential and maturity of organic matter (OM). The Rock-Eval method, biomarker and carbon isotope analyses were used.

The majority of the lower Miocene samples contain kerogen Type II. Distributions of *n*-alkanes and regular C_{27}-C_{29} αα(R) steranes indicate a mixed aquatic-terrestrial origin of OM in samples from the two studied boreholes TUS 2 and TUI 1. This is further supported by the Gammacerane Index (GI=10 x gammacerane/ (gammacerane+C_{30} αβ hopane)) ranged from 0.89 to 1.05 and the Oleanane Index (OI=10 x oleanane/(oleanane+C_{30} αβ hopane)), which varied between 0.40 and 0.55. The slight negative $\delta^{13}C$ slope with an increased *n*-alkane chain length (Fig. 1) was observed for oils from fluvio-deltaic and freshwater transitional environments (Murray et al., 1994), while the relative flat $\delta^{13}C$ profile of *n*-alkanes between C_{24} and C_{30} implies marine incursion. The ratios of pristane to phytane (Pr/Ph) and C_{35} αβ/C_{34} αβ hopane indicate transitional to oxic depositional environment.
The majority of the middle Miocene (Badenian) samples contains kerogen Type II and II/III, with few exceptions with kerogen Type I or III. The distributions of the *n*-alkanes with a maximum at C_{17} or C_{27} and the distributions of C_{27}-C_{29} αα(R) steranes in samples from the borehole TU 2 indicate a mixed aquatic-terrestrial origin. The GI is slightly lower ($\approx$ 0.8), while the OI (0.5-0.6) shows similar values to the lower Miocene samples. The slight negative $\delta^{13}C$ slope with increasing *n*-alkane carbon number (Fig. 1) suggests a marine influenced deltaic environment, consistent with Hydrogen Index (HI) ranging from 163 to 300 mg hydrocarbons (HC)/g TOC. The Pr/Ph and the C_{35} αβ/C_{34} αβ hopane ratio imply deposition of OM under oxic conditions. Samples from the borehole TUS 2 have similar biomarker characteristics with samples from the borehole TU 2, with a somewhat greater impact of aquatic OM, in accordance with higher HI (294-429 mg HC/g TOC). However, $\delta^{13}C$ profiles of *n*-alkanes indicate difference between TUS 2 and TU 2 samples. The ^{13}C depletion of *n*-alkanes in TUS 2 samples (Fig. 1) may be indicative for reduced salinity and/or enhanced microbial activity. Samples from the borehole TU 4 showed different biomarker patterns, compared to the other Badenian samples. They are characterized by *n*-alkane maxima at C_{23} and C_{21}, apparent prevalence of C_{28} homologues in the distribution of C_{27}-C_{29} αα(R) steranes, high GI > 2.6 and lower OI ($\leq$ 0.25). Furthermore, the $\delta^{13}C$ profile of *n*-alkanes is quite different from the other samples, showing significant ^{13}C depletion and V-shape. Similar V-shaped patterns, associated with elevated C_{28} steranes were observed in

samples from the lower Oligocene Tard Clay Formation (Hungary; Körmös et al., 2021). The results obtained suggest a predominance of aquatic OM (phytoplankton) with a significant bacterial contribution and some influence of land plant vegetation, consistent with an HI in range 339-440 mg HC/g TOC. The samples from borehole TUS 7 are also significantly different from the other Badenian rocks. They are characterized by a notable prevalence of short chain *n*-alkanes with a maximum at C_{18}, Carbon Preference Index (CPI < 0.9), relatively high amount of squalane in the TIC of saturated fraction, Pr/Ph < 0.7, GI in the range of 0.85 to 2.88, and dominance of C_{35} over C_{34} αβ hopane. This indicates a notable prevalence of aquatic OM, low terrigenous input (OI ≤ 0.25), and deposition under reducing conditions. These results coincide with high HI values (524-646 mg HC/g TOC) and a flat $\delta^{13}C$ profile of *n*-alkanes from C_{18} to C_{24} (Fig. 1).
The upper Miocene (Pannonian) samples from all studied boreholes have similar biomarker compositions. They are characterized by the predominance of short chain *n*-alkanes with a maximum at C_{17}, uniform or C_{28} enhanced distributions of C_{27}-C_{29} αα(R) steranes, high GI (> 2), OI < 0.3, C_{35} αβ/C_{34} αβ hopane > 1, implying the predominance of aquatic OM deposited under reducing conditions. The results are consistent with high and relatively uniform HI values (415-666 mg HC/g TOC). The V-shape of $\delta^{13}C$ profile of *n*-alkanes (Fig. 1) can be attributed to bacterial activity.

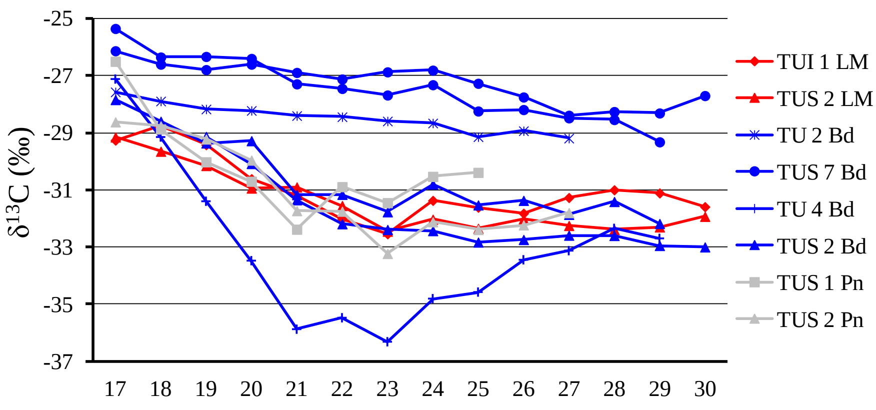

Figure 1 *Carbon isotopic compositions of individual n-alkanes in representative samples (LM – lower Miocene; Bd – Badenian; Pn – Pannonian).*

The majority of studied samples show a good oil generation potential (TOC > 1%, (S_1+S_2) > 5 mg HC/g rock; HI > 300 mg HC/g TOC; S_2/S_3 >10). The measured vitrinite reflectance, Rock-Eval T_{max}, and hopane, sterane and phenanthrene maturity ratios indicate that the OM of the Pannonian and Badenian samples from borehole TUS 7 is immature; the OM of the Badenian samples from boreholes TUS 2 and TU 4 and OM of the lower Miocene samples from borehole TUI 1 is at a very early stage of oil window maturity; while the lower Miocene samples from borehole TUS 2 and the Badenian samples from borehole TU 2 reached peak oil window maturity. The large heterogeneity (facies and maturity) of the Badenian samples is consistent with remarkable environmental changes caused by the uplift of the Alps and Carpathians in the middle to late Badenian.

References

Körmös, S, Sachsenhofer, R.F., Bechtel, A., Radovics, B.G., Milota, K., Schubert, F., 2021. Mar. Pet. Geol. 127, 104955.

Murray, A.P., Summons, R.E., Boreham, C.J., Dowling, L.M., 1994. Org. Geochem. 22, 521–542.