Results of Pyrolytic Gas Chromatography of Domanik Facies from the Devonian–Carboniferous Boundary Deposits of the Kama–Kinel Trough System, Volga–Ural Petroleum Province

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The Devonian and Carboniferous successions of the Volga–Ural Petroleum Province contain several thousand discovered and potential oil accumulations. The Kama–Kinel Trough System (KKTS) rims the arching structures of the province and is filled with sediments of Late Devonian and Mississippian. Deposits of the axial and marginal zones of the troughs are represented by Domanik facies of Frasnian, Famennian, and Early Tournaisian age, which are traditionally regarded as source rocks and promising unconventional reservoirs.

This study reports pyrolytic gas chromatography data from cores of two boreholes: one penetrating the Devonian–Carboniferous boundary deposits in the axial zone of the trough, the other in its marginal zone.

Mean total organic carbon (TOC) values are 3.7% in the axial zone and 2.8% in the marginal zone, confirming the source rock character of these successions. Rock maturity, estimated from the temperature of maximum hydrocarbon yield (Tmax), ranges from 421 to 436 °C, corresponding to protocatagenesis—the early stage of organic matter (OM) transformation into kerogen and hydrocarbons. Thus, the OM should be considered immature and not yet at the stage of petroleum generation.

Hydrogen index (HI) values in rocks from the axial zone range from 260 to 820 mg HC/g TOC, indicating the presence of three kerogen types: type I, derived from algal and bacterial matter (highest oil-generating potential); type II, formed from marine phytoplankton (producing both oil and gas); and mixed type II/III, associated with input of higher plant material. In rocks from the marginal zone, kerogen of type II and mixed type II/III predominates, with HI ranging from 175 to 500 mg HC/g TOC.

It is significant that type I kerogen occurs only in the axial zone of the trough. In contrast, type II and II/III kerogen predominate in the marginal zone, reflecting a greater contribution of continental vegetation. The genetic potential (S1 + S2; mg HC/g rock) of rocks from both boreholes ranges from poor to excellent, which may be explained by differences in depositional and preservation conditions, as well as heterogeneity in the initial bioproductivity.

The data show that TOC, HI, S1, and S2 values are generally higher in the axial zone than in the marginal zone. This likely reflects deeper-water, more strongly anoxic conditions of sedimentation that favoured preservation of organic biomass. Conversely, the lower HI values in the marginal zone indicate a more prominent contribution of terrestrial organic matter transported from the hinterland. The results point to a marked facies differentiation of the source rocks, clearly expressed in pyrolytic parameters. This heterogeneity, within what appears to be a uniform source-rock interval, requires detailed study using biofacies and geochemical approaches. Sampling for pyrolytic analysis should be controlled by facies analysis to ensure reliable interpretation of the data.