GEOCHEMICAL ASSESSMENT OF UNCONVENTIONAL SHALE-OIL RESOURCE SYSTEM OF BAZHENOV FORMATION IN WEST SIBERIA BASIN

S. Mozhegova

All Russian Research Geological Oil Institute, Russia

Bazhenov suite of the Volgian – Early Berriasian age in the West Siberia basin is among the most studied oil shale formations in Russia. The clay-silica rocks of this suite enriched in organic matter (OM) have been deposited in a vast epicontinental sea basin in its most deeply immersed part where the downwarping was undercompensated with sediment accumulation. The area occupied by the high-bituminous shale deposits of the Bazhenov suite and its facial analog (the Lower Tutleim subsuite) is about 1 million sq.km. Thickness of the Bazhenov shales varies from 10 to 60 m.

The Bazhenov highly bituminous shales contain OM of the sapropelic type (the II type). The weighted average concentration of total organic carbon (TOC) in the Bazhenov suite is 5-7% or higher almost all over the area of the suite occurrence. In some places the TOC concentration exceeds 10%. Regional regularities in the present-day distribution of OM (TOC) in the Bazhenov shales are mainly controlled by catagenesis. Lateral variations of the TOC initial concentration in the Bazhenov shales are insignificant, the average ranging from 10 to15%.

Most straightforward picture of distribution of the OM different forms (including oil) in the suite sections can be derived from results of the Rock-Eval analysis of shale samples.

Study of cores from more than 80 wells drilled in the central regions of the West Siberia basin has shown that in the majority of studied sections the intervals most enriched in OM (TOC exceeding 10-15%) are found mainly in the upper or middle parts of the Bazhenov suite. Its lower part is, as a rule, impoverished in OM (TOC), their concentration not exceeding 5%. Predominantly carbonate or silica-carbonate interlayers with poor content of OM are also traced in the suite middle section.

Abnormally high content of free HC (S1) relative to the TOC content, known as indication of the rock oil saturation (Jarvie, 2012), in the Bazhenov shale sections is observed in intervals composed of rocks with relatively low TOC content. The interlayers highly enriched in OM (where present-day concentration of TOC exceeds 10%) usually do not contain para-autochthonous oil.

The established relation between the rock oil saturation and its TOC content permits to identify potentially oil-saturated intervals within a shale section based on well logging data in the absence of core. The intervals contacting with interlayers highly enriched in TOC should be considered as the most promising ones.

The Rock-Eval derived concentrations of free HC in OM of oil-saturated intervals attain maximum values at Tmax = 440-445 °C and with further progress of catagenesis remain almost stable or even decline. Perhaps, this decline is caused by escape of free HC from the core samples in the process of core lifting from depth, its storage, transportation and handling

for analysis. Such HC losses need to be accounted for at quantitative assessment of oil potential of the Bazhenov shales.

For estimation of the core HC loss we propose to use comparative quantitative analysis of hydrocarbon composition of extracts from rocks versus extracts from oils related to same localities with equal levels of the OM thermal maturity. The investigations thus performed have shown that, as expected, the major losses associate with low-molecular HC – C_6 – C_{14}. Hydrocarbons C_{15+} are practically do not escape. The results obtained show that as much as 10-25% of HC escape from cores taken in zones of a moderate thermal maturity, the loss attaining 30-45% for cores taken in zones of high thermal maturity.

In the quantitative assessment of the Bazhenov shales oil potential based on the Rock-Eval data the measured amounts of free HC (S1) should be corrected by using a multiplying factor to account for the core HC losses. Value of this factor varies with the degree of catagenesis of OM and depends on the fluid properties. For instance, by our estimates the value of this correction factor equals to 1.1-1.3 and 1.4-1.8 in zones of moderate and high catagenesis, respectively.

The observed regularities in distribution of oil saturation values over the section and their dependence on catagenesis can be used for regional forecast of oil-and-gas potential of the Bazhenov suite. Thus, in high catagenesis zones (such as those in the Salym Arch) the share of free hydrocarbons in the OM of the Bazhenov shales is much higher than in zones of lower catagenesis. And it is in the Salym Arch that maximum oil flow rates were registered for the Bazhenov shales.

References

1. Jarvie, D. M., 2012. Shale resource systems for oil and gas: Part 2 — Shale-oil resource systems, In: J. A. Breyer (Ed.), Shale reservoirs — Giant resources for the 21st century. AAPG Memoir 97, pp. 89 – 119.