

THE EFFECT OF BIODEGRADATION ON THE CARBON ISOTOPIC COMPOSITION OF FLUIDS IN LODOCHNOYE FIELD (RUSSIA)

Maxim A. Veklich¹, Ivan V. Goncharov^{1,2}, Vadim V. Samoilenko¹, Pavel V. Trushkov¹,
Alexandra V. Zherdeva¹, Nikolay V. Oblasov¹, Svetlana V. Fadeeva^{1,2}

¹ TomskNIPIneft, Russia.

² National Research Tomsk Polytechnic University, Russia

The effect of biodegradation on fluid composition has previously been repeatedly described in the literature (Peters K.E. et al., 2005; Wenger L.M. et al., 2002). The impact of microorganisms is reflected on the molecular and isotopic composition of oil and gas.

The Lodochnoye oil & gas field is located in the north-east of Western Siberia and is one of the Vankor group of fields (Vankor, Suzunskoe, Lodochnoye, Tagulskoe). This is a multi-layered field. The main production potential is associated with the Yakovlevskaya (Yak), Nizhnekhetskaya (Nkh) and Sukhodudinskaya (Sd) reservoirs of the Lower Cretaceous in the depth interval of 1800-2900 m. Low reservoir temperatures (from 30-35° C (Yak layer) to 65° C (Nkh layer) determine the active flow of microbial processes.

All analyzed gas samples were very dry - the dryness coefficient varies in the range of 0.98-0.99. A high iso / n-C4 ratio (2.5-16.5) along with a low proportion of C2 + is typical for biodegradable fluids. The results of isotopic studies confirmed this.

It is well known that propane and n-butane are among the first to be microbially affected (Wenger L.M. et al., 2002; Peters K.E. et al., 2005; Wan-Chun Wang et al., 2005). In the analyzed gas samples of the Lodochnoye field, the carbon isotope composition of propane varying from -21 to + 3 ‰ VPDB. The heavy carbon isotopic composition of propane is detected in gas samples from Malohetskaya formation (Mkh VIII layer) and Yakovlevskaya formation (Yak IV layer). The carbon isotopic composition of methane from $\delta^{13}\text{C} - 49.3$ to -44.0 ‰ VPDB is also quite typically for biodegraded and secondary microbial gases (Milkov A.V., 2018)

Earlier, we (Goncharov I.V. et al., 2013) suggested that the $\delta^{13}\text{C}$ value of propane could be positive values with a deep degree of biodegradation.

Oils and condensates from Yakovlevskaya formation (Yak III, Yak IV, Yak VI layers) and Sukhodudinskaya formation (Sd III, Sd III-I, Sd III-II, Sd IV layers) have heavy degree of biodegradation - the range of 4 to 6 on the scale Peters et al (2005). That is determined by the absence of n-alkanes, methyl - and dimethylnaphthalenes, methylphenanthrenes.

Oils have carbon isotopic composition more heavy in the upper layers (from $\delta^{13}\text{C} - 31.4$ (Nkh layer) to -30.0 ‰ (Yak layers). This according of such factors reservoir as rock properties (porosity, permeability), low reservoir temperature, formation water salinity.

However, in the Vankor oil field, which is a neighbor of the Lodochnoye field, in the strata of the Yak and the vYak, even in the biodegradation of oil of the corresponding degree 7 (Peters et al., 2005), the carbon isotopic composition of propane varying in the range -16...- 10 ‰. Among the published literature data on the study of biodegraded and secondary microbial gases of Western Siberia, we also failed to detect propane and butane with such an abnormally heavy isotopic composition.

Thus, the gas of the Yak and Mkh layers of the Lodochnoye field is to some extent unique.

It is noteworthy that with heavy carbon isotope composition of propane, carbon isotopic composition of n-butane is slightly changed. As a rule, the change in the carbon isotope composition of propane and n-butane proceeds more or less in parallel.

The relatively small range of $\delta^{13}\text{C}$ C_2H_6 values (-26.5... -24.0) suggests that all these gases have a common source. However, $\delta^{13}\text{C}$ CH_4 and $\delta^{13}\text{C}$ C_3H_8 was changed in consequence of biodegradation.

If we focus on the values of $\delta^{13}\text{C}$ C_2H_6 and assume that this component was not affected by biodegradation, then the source gas (which was subjected to microbial exposure) has very high thermal maturity. According to the James diagram (James A.T., 1984), the analyzed gases can correspond to $R_o \sim 1.6$ -1.8).

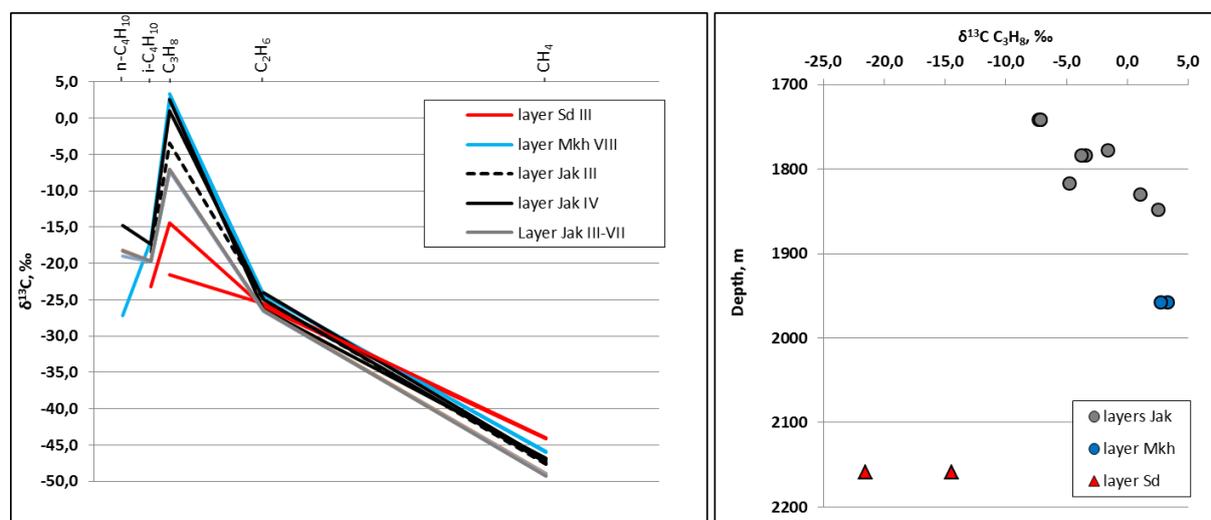


Figure 1- Carbon isotopic composition ($\delta^{13}\text{C}$) of gas from the Lodochnoye field

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