Zonality in the Distribution of Oil and Gas Pools of Fields of the Botuobinsk Region in Relation to Conditions of their Formation

A. Z. Zakharyan

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The Botuobinsk region is located in the south part of the Siberian platform and tectonically is the northeast nose of the Nepa-Botuobinsk regional high at the junction of three large depressions - the Tunguska regional low on the north, the Vilyuy basin on the east, and the Cis-Patom foredeep on the south. The gas-oil zones and fields are shown in Fig. 1.

The sedimentary section on the regional high consists of 1.5-2.5 km of Vendian-Cambrian sediments. Thicknesses are greater in the depressions, up to 4-6 km in the Cis-Patom foredeep.

The vendian sediments include two complexes, separated by a regional unconformity: clastic and carbonate.

The thickness of the elastic complex increases from northwest to southeast from 10-20 m to 200-500 m. At its base are sandstones of the Vilyuchan and Talakh horizons. The first of these is present only in the Vilyuchan zone, where it is up to 100 m thick; porosity is 8-12%, and average permeability is 0.05-0.07 m km$^2$. The Talakh horizon is more widespread but contains too much clay and is essentially impermeable. In its most favorable zones the porosity is 10-12%, and permeability is 0.03-0.04 m km$^2$. The upper part of the clastic complex consists of argillites, in which sandstone lenses are present.

The Botuobinsk horizon, which was deposited after a break in deposition, is the top of the clastic complex. It is a sandstone body 5-30 m thick with dimensions of 120 by 70 km located on the southeast flank of the Nepa-Botuobinsk regional high. This horizon has good reservoir properties: porosity 14-18%, average permeability 0.15-0.2 m km$^2$.

The carbonate complex is 200-400 m thick and is a seal.

The Cambrian sediments consist of rhythmically alternating carbonate and halogen-carbonate beds. Permeable beds are present in the carbonates, particularly in the Osin and Yuryakh horizons at the base of the Cambrian. See Fig. 2. Porosity of the carbonates is as much as 12–16%, and permeability 0.02–0.03 m km$^2$. Effective thickness is 5–15 m.

The composition of the oil as well as that of the gas is practically the same along the entire section, indicating that the pools in the carbonates formed due to vertical migration. The content of condensate is practically the same in both the gas-condensate and gas-oil pools (about 50 cm$^3$/m$^3$). The oil belongs to the aromatic-naphthenic-methane class, containing 15–20% tar and asphalt, whereas the condensate consists of hydrocarbons of only the methane class. This indicates the absence of any genetic relationship between the oil and the condensate, and this is confirmed by the presence of pure gas-condensate pools.

There is a definite regularity in the distribution of the oil and gas pools along the section. Gas-oil pools occur in the Botuobinsk horizon and higher. Only gas-condensate pools have been found below this level in the Vendian sediments. There is a parallel zonation in the distribution of allochthonous chloroform-soluble bitumens. For example, their maximum content is in the Botuobinsk horizon (0.4%), average in the Kharystan and Khamakin (0.1%), and least in the Vilyuchan (0.01). In the Vilyuchan the content of oxidized iron (magnetite, hematite) exceed by 4 times the content of authigenic pyrite, and in the Talakh 2.5 times. These sandstones are red in some places. In the Botuobinsk the pyrite content is 25 times that of the iron oxides. Since oil bitumens reduce iron, the predominance of iron oxides along with the low content of chloroform-soluble bitumens in the Vilyuchan horizon indicates that this horizon was never oil-bearing.

The Vendian sediments of the study area never reached the oil window; consequently, the oil-gas kitchen was to the south in the Cis-Patom foredeep where these sediments subsided to depths of 3–3.5 km. The oil and gas migrated a great distance laterally. Under such conditions the oil sought out the best reservoirs, which were in the Botuobinsk horizon. Therefore, the oil pools were...