On the So-Called Transition Zone in the Determination of the Water-Oil Contact

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The separation of the oil-bearing part of a stratum from the water-bearing, that is, the determination of the position of the water-oil contact, is very important in calculating oil reserves and developing oil pools. Exact knowledge of the position of the water-oil contact makes it possible to plan well spacing correctly and subsequently to observe the rate of vertical migration of the water-oil contact. It also affords the possibility of determining the volume of injected parts of the stratum, of establishing the value of the coefficient of oil recovery during development of an oil pool, and of very accurate estimates of the current oil reserves.

Study of the spatial distribution of the water-oil contact can contribute in a considerable degree to solution of the problem of the isolation or hydrodynamic connection of individual exploitation objectives by the analysis of thick oil-bearing suites before the beginning of their development.

However, in view of the lack of cores and imperfection of methods of interpreting geophysical investigations, it is difficult to determine the true position of the water-oil contact. In this connection the practice has arisen of using the rather vague and indefinite term “transition zone”, meaning the part of the stratum lying between “purely” oil-bearing and “purely” water-bearing rocks.

It must be noted that in the entire history of geologic study of the oil pools of the Baku, Grozny, and Kuban-Azov regions, the position of the water-oil contact was determined very clearly and was based mainly on core investigation data obtained by continuous sampling. After the introduction of well logging, comparison of the results of electrical logging with core analysis data contributed to accurate interpretation of the data; therefore, the subsequent change over to geophysical logging methods did not affect the accuracy of determination of the water-oil contact.

A completely different situation existed in the Volga-Ural oil district, where the oil pools, conforming to gently dipping strata, are underlain by water within a considerable area, and the zone situated between the inner and the outer oil-bearing limits cannot be studied adequately by cores.

Under these circumstances the water-oil contact could be determined only on geophysical logging data.

In recent years a number of works have been published devoted to the problem of determining the water-oil contact. It is interesting to note that not one of the authors fails to designate a transition zone, reaching rather impressive thicknesses (4-6 m). Thus, a group of investigators (A. Sh. Galyavich, I. L. Dvorkin, N. Yu. Lepeshinskii, V. S. Dorofeyev) in estimating the water- and oil-bearing capabilities of strata by means of neutron gamma logging give an example of a water-oil contact (Figure 1a) in which the transition zone is 5.5 m thick. Similar widths of the transition zone were distinguished by V. N. Dakhnov, A. I. Khelov, and O. A. Barsukov in interpreting data for separating the oil- and water-saturated strata in well 1314 of the Tuymazy field (Figure 1b). Some logging geophysical organizations also often resort to the aid of the transition zone.

In this connection it must be noted that although an error of 1 m, permissible in locating the water-oil contact in steeply dipping strata, alters the estimate of oil reserves but little, a similar error considerably affects the oil reserves in deposits of the platform type. Meanwhile, not one of the authors points out how to deal with a huge “transition” zone, how to take it into account, or, conversely, how to eliminate it in calculating oil reserves. At the same time the sampling of wells gives substantially different results: in one case they obtain pure oil from the transition zone, in another oil with water, and in a third only water. The different results from test wells drilled at different intervals in the very same “transition” zone are evidence that interpretation of the physical nature of the transition zone based only on geophysical data is subjective and imperfect. By virtue of this, in some cases the transition zone belongs to the oil pool, in others to the water-bearing part of the stratum.

It cannot be doubted that rocks of the water-bearing part of a stratum directly adjacent to an oil pool might contain a small amount of oil and therefore be characterized by relatively higher resistivity against the general background of water-bearing rocks. However, this oil occurs in the water-bearing part of the stratum in a bound state. In view of its small amount it cannot be forced out of the rock spaces and therefore should not be considered part of the oil pool. Furthermore, in a given oil pool, especially one of platform type, the water content also fluctuates. The large part of the area of an oil pool in contact with the underlying water governs the penetration of water into the oil pool. In this connection it must be supposed that the water content in the section of an