A Common Water-Oil Contact—One of the Main Factors in Recognizing Exploitation Objectives

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In calculating reserves and planning efficient development of oil fields, it is very important to subdivide a thick productive unit into individual exploitation objectives. Practice has shown that improper subdivision of exploitation objectives has led to excess wells and thereby to a sharp drop in efficiency. Analysis of the development of large oil fields has shown that subdivision of exploitation objectives is often a complex task, the solution of which is not always unique. However, it cannot be assumed that many principles of subdivision of exploitation objectives are not true for both platform and geosynclinal objectives. The exploitation objective is that part of the productive section of an oil or gas field which on a basis of geological, technical, and economic conditions can be worked by a single net of wells. An exploitation objective may consist of a single stratum, several strata, or even an entire oil-bearing formation. Exploitation objectives should be distinguished without regard to whether they are worked by an independent net of wells or by overhauling of wells that produced from lower horizons. The present paper examines some of the principles of distinguishing exploitation objectives which, in our opinion, are very important and can be determined at the beginning of the study of a field by prospecting drilling.

Detailed study of the very large pools of the Russian platform has shown that at the margins of oil productivity of individual horizons, there are many zones of pinch-out of argillite members where the sandstones merge. See Fig. 1. The large number of such zones distributed over the entire oil pool governs the hydraulic connection between the oil strata and produces a single surface for the water-oil contact. During production an interrelationship is observed between all oil-bearing strata, and there is a flow of liquid from one stratum to the other depending on formation pressure.

A similar phenomenon was observed in the Tuymazy field (Bashkiria), where analysis of production established the presence of an overflow of oil and water from horizon DII into DIII through a zone of pinch-out of the argillite divider.

The communication between strata DIII and DIII is detected by comparing maps of the distribution of calculated formation pressure with maps of isobars constructed from observations. The comparison shows that the observed formation pressure in the region of wells on stratum DIII is higher than the calculated pressure, whereas in the region of wells on stratum DIII it is lower. In spite of the fact that the volume of injected water into stratum DIII is twice that of the oil extracted, the formation pressure has not changed for several years. See Fig. 2.

The presence of overflow is confirmed indirectly by the fact that the calculated value of the oil recovery for the flooded part of horizon DIII is very low (because of overflow of oil into horizon DIII) and is not in accord the possible recovery for a uniform permeable stratum.

Detailed correlation of electrical logs of numerous wells drilled during development has revealed the position of the majority of zones of pinch-out of the shale divider in various parts of the structure including its crest.

In the Romashkino field (Tataria) the Pashiy formation of the Devonian contains 4-5 productive strata, detailed study of which has shown that due to rapid lithologic change the dividers are not persistent areally and in most areas they pinch-out. On maps of lithologic change of the productive strata it is evident that each of them has many zones of “merging” with the higher and lower strata. The zones of pinch-out control the hydrodynamic connection between adjacent strata and the single surface of the water-oil contact. These strata are worked together as a single exploitation objective.

Such combining of productive strata with a single surface of water-oil contact, however, does not exclude the necessity of taking into account the physical properties of the reservoirs that constitute individual strata. This difference may result in injected water moving more rapidly along the more permeable strata, leaving the oil reserves contained in the less permeable strata. The result is a lower recovery for the horizon or for the exploitation objective as a whole. For even displacement of the water from all the oil-bearing strata and for attaining a maximum oil recovery, it is necessary to inject water into the productive strata selectively. Furthermore, because of the geological conditions of occurrence of the oil it is sometimes necessary to work combined strata successively—as, for example, when lower, very permeable strata after flooding may be a hindrance to recovery of oil from higher strata of the same exploitation objective.

In the Yarin field (Perm Region) the oil-bearing strata of the Tula and coal-bearing horizon of the Lower Carboniferous also have a single surface of water-oil contact. This circumstance is explained by the fact that, as electrical logs have shown, argillite dividers occurring between strata B1, B2, and B3 pinch-out, and the sandstones merge into a single thick stratum.