

# SEVERAL METHODS TO INCREASE PRODUCTION FROM CARBONATE RESERVOIRS, DEVELOPED BY MEANS OF HORIZONTAL TECHNOLOGY

R.Kh. Akhmadullin

Oil and Gas Production Department Prikamneft Tatneft PJSC, Elabuga, Russia

E-mail: ahmadullinrh@tatneft.ru

**Abstract.** Market conditions during the economic crisis require the provision of high efficiency of capital investments at all stages of production in two main areas: increasing the flow rate of new wells, recovering production from highly-drained and inactive stock of wells, and reducing drilling and well site construction costs. The task is solved by improving the existing development systems, broadly implementing the already proven methods of increasing oil recovery, including the use of horizontal technology that provides more complete production of inter-well space and massive geological and technical measures to restore production from inactive and highly watered wells. Among the latter, there is little costly technology to restore oil production in open wells with a horizontal end, which operate carbonate reservoirs of the Lower and Middle Carboniferous deposits in the Republic of Tatarstan. The essence of the technology is to lower the suspension of the pump directly to the horizontal part of the well, if possible, to the lowest hypsometric mark of its trajectory in the oil-saturated part of the operational object. At the same time, the oil production rate increases, the watering of the well production decreases, its service life is extended, the design levels of production are maintained, the most complete production of oil reserves is achieved and the ultimate oil recovery factor is increased. Taking into account the positive results of the application of the technology, it is proposed to extend it to all fields of Tatarstan, where the carbonate reservoirs with wells with horizontal end are operated.

**Keywords:** geological structure, development object, pumping equipment, increase in production capabilities, well with horizontal end

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High efficiency of producing oil reserves from weak permeable carbonate reservoirs is carried out in two main directions: increasing the flow rate of new wells and recovering production from inactive and highly watered well stocks, reducing drilling and well development costs. In both cases, the development of oil reserves has proved to be effective through the introduction of modern technologies and methods for developing hydrocarbon fields using horizontal technology (HT). Moreover, the use of HT reduces the number of project vertical wells, while not decreasing, but increasing the coverage of produced oil reserves due to the spatial drainage of reservoirs, which means raising the oil recovery factor and saving on infrastructure. An important point is to increase the period of effective operation of wells with a horizontal end.

The Republic of Tatarstan, which has more than half a century of development of oil fields, plays a significant role in the total oil production of the country as a whole. All the fields of the republic are complex: multi-object and multi-deposit. By now, the share of oil production from low-productive carbonate reservoirs is steadily growing

against the background of outstripping development of highly productive reservoirs. The problem of increasing reservoir recovery and maintaining a steady extraction rate at the fields of Oil and Gas Production Department Prikamneft of Tatneft PJSC is very relevant. The territory of the fields belongs to the Tatarstan oil-bearing region and is confined to the northern slope of the South Tatar arch and the southern slope of the North Tatar arch.

On the example of Kadyrovsky, Bastryksky and Kontuzlinsky fields, developed with the use of HT, the dependencies have been established of the production capabilities by wells with horizontal end and hypsometric position of the pumping equipment in the well: above the productive formation and directly in the interval of the productive formation. In the fields under consideration, deposits in the carbonate reservoirs of the Tournaisian and Bashkirian are being developed using wells with horizontal end. Moreover, it should be noted that the Tournaisian deposits at the Kadyrovsky and Bastryksky fields are damaged by erosion incisions, they have a predominantly massive type of structure (Figure 1).

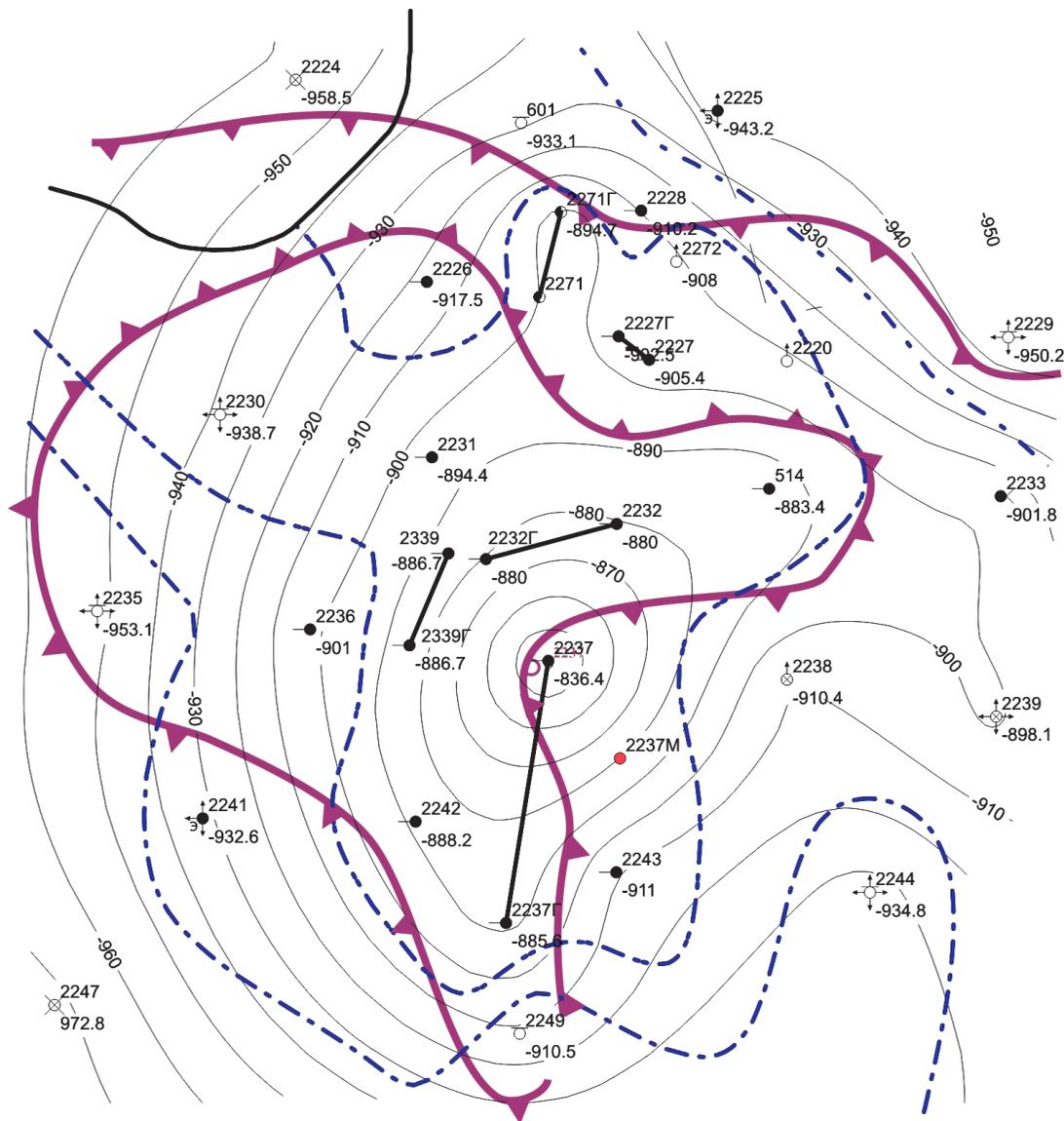


Figure 1. Fragment of the structural map along the top of the Tournaisian deposits at the Middle Bagryazhsky section of the Kadyrovsky field (area of wells Nos. 2271g, 2339g, 2227g)

Values of reservoir properties, determined by logging, on the Tournaisian deposits amounted to an average porosity of 10.2%, and a permeability of  $4\text{-}157 \times 10^{-3} \mu\text{m}^2$ . According to V.N. Dakhnov the reservoir refers to low-and medium-sized, weakly permeable reservoirs.

For a number of wells with horizontal end, for which oil production decreased by more than 60% from the initial, as well as for low-rate wells with horizontal end, an attempt was made to resuscitate and increase oil production by lowering pumping equipment into the conventional horizontal part of the well, into the interval of production formation.

The analysis results of technological indicators state about the significant advantage of producing reserves from carbonate reservoirs by means of open wellbores with a horizontal end, with the suspension of the pump placed in the conditional horizontal part of the well trajectory to the lowest hypsometric level (Figure 2).

As follows from the analysis (the graph of the technological indicators), the initial oil production for well No. 2271g was 10 tons per day with water cut 5.7%. The production rate fell according to the drop of the current reservoir pressure in the extraction zone. The section of sediments is highly inhomogeneous and the net to gross sand ration on the average on the Tournaisian deposits is 0.59 unit fractions, the ratio of permeable intervals is 4.7 units; on the Bashkirian carbonate sediments – the net to gross sand ration on the average is 0.344 unit fractions, and the ratio of permeable intervals is – 13.9 units. With such dismemberment, the reservoir pressure in the extraction zone is practically not restored even if there is injection of a displacing agent. In the latter case, water breaks into production wells are observed along the fractures.

Due to the low production rate of the well, the geological service of the Oil and Gas Production Department decided to apply technology of moving

the pump suspension in the conventionally horizontal part of the well to the maximum possible depth with logging – control of the position in the porous permeable interlayers, because the site is disturbed by the Early Visean erosion incision and has a high heterogeneity both in area, and the section (Figure 2).

On 05.2015 the suspension of the pump was lowered to the conventionally horizontal part of the well at a

depth of 1172.1 m, which corresponds to an absolute mark of minus 905.1 meters, to the uppermost permeable pack of 8 meters thick (Figure 2). As a result of the measure conducted, the oil production rate doubled (Table 1, Figure 3).

Reservoir properties of the Bashkirian layer are slightly different from the characteristics of the Tournaisian rocks: they have a higher capacity (up

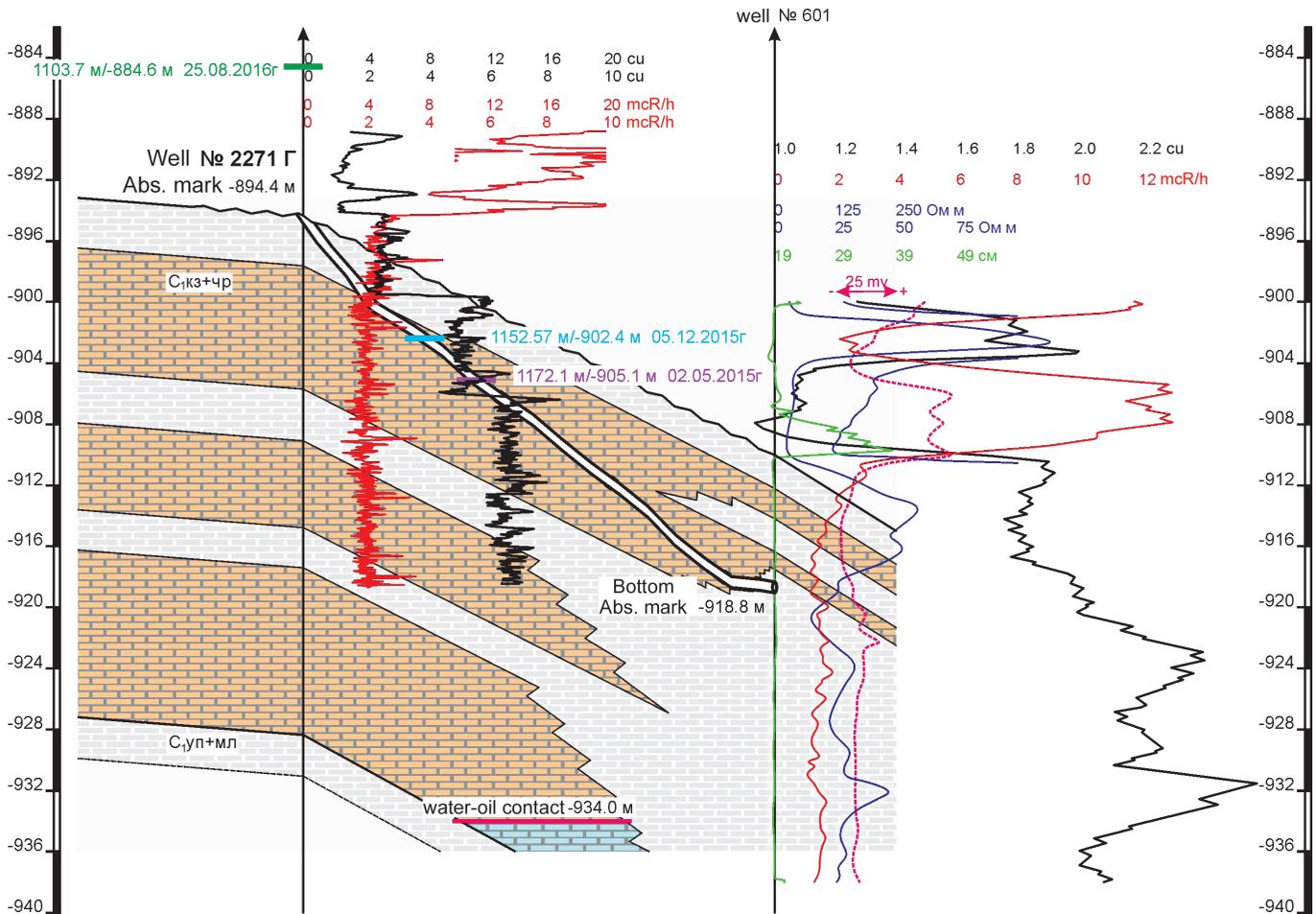


Figure 2. Fragment of the profile of the Tournaisian deposits in the Middle Bagryazhsky section of the Kadyrovsky field in the area of well with horizontal end No. 2271g

№ №	№№ well	Stage	Operating indicators of well depending on the position of pumping equipment in the well with horizontal end							
			initial		before lowering into the HW		after lowering into the HW		on 01.01.17 after pre-lift	
			Qo, t/day	%w	Qo, t/day	%w	Qo, t/day	%w	Qo, t/day	%w
1	1555	Tournaisian	9,6	76,5	5,8	36	13,25	8,3	8	19,5
2	1627Г	Tournaisian	7,8	13,1	6,32	12,3	6,86	2	3,2	6,8
3	1714Г	Bashkirian	3,2	12,5	1,81	4	6,37	3	2,484	2,32
4	1719Г	Bashkirian	1,1	5,4	1,3	3	5,18	10	2,708	3,37
5	1723Г	Bashkirian	2,6	4,8	3,89	4	5,22	3,3	3,148	3,36
6	2271Г	Tournaisian	10	5,3	2,7	11	5,35	9	1,527	7,12
7	2339Г	Tournaisian	3,6	3,3	2,09	5,3	3,41	4,2	5,475	4,02
8	2227Г	Tournaisian	2,6	25,3	0,57	11	2,85	6	1,036	4,6
9	2237Г	Tournaisian	7,6	3,9	3,9	7,2	7,2	4	3,078	25,7

Table 1. Dependence of oil production rate from the position of pumping equipment in the well with horizontal end

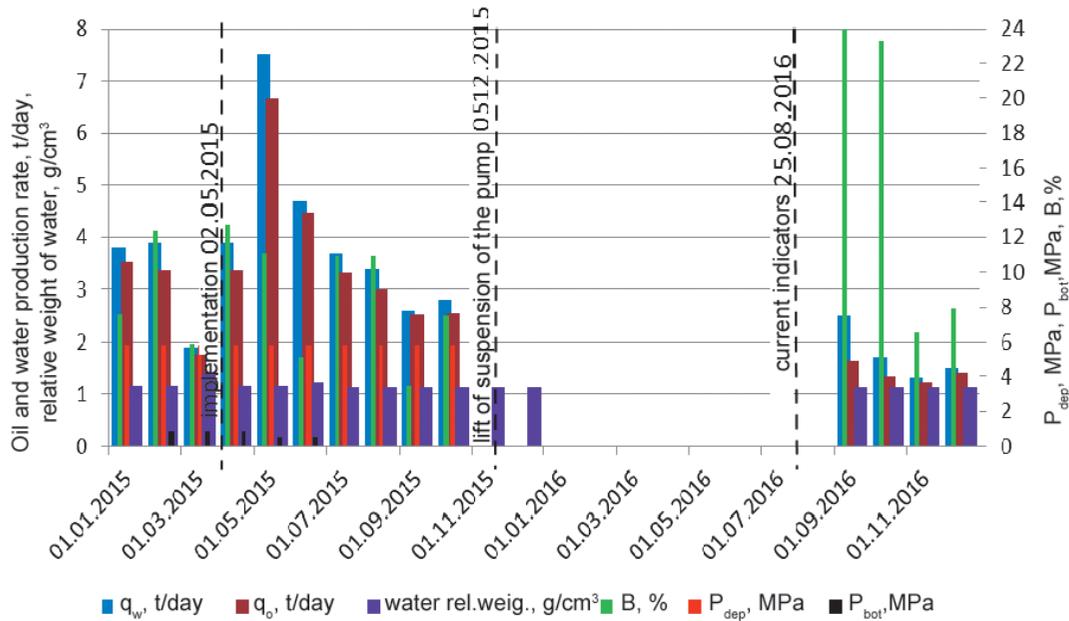


Figure 3. Technological performance of the well with horizontal end No. 2271g on the Tournaisian deposits of the Kadyrovsky field from the beginning of operation

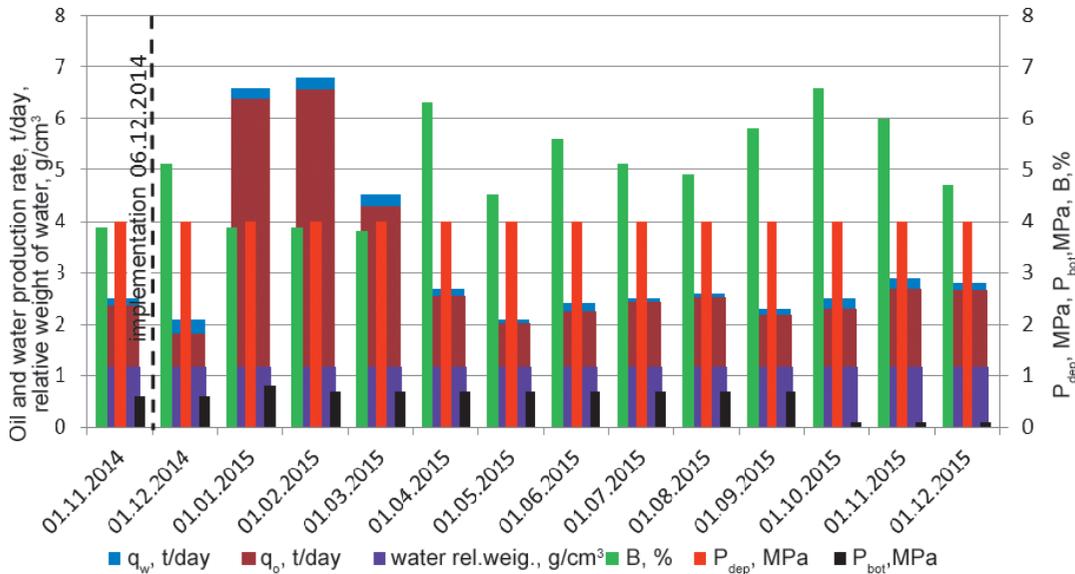


Figure 4. Technological performance of the well with horizontal end No. 1714g on the Bashkirian deposits of the Kontuzlinsky field from the beginning of operation

to 22%) and higher permeability (up to  $300 \mu\text{m}^2 \times 10 \mu\text{m}^*$ ) due to a more dense fracturing (up to 500 un./p.m) and cavernosity, which is increased down the section. But the dismemberment of the Bashkirian-Serpukhovian carbonate complex is higher.

The same picture is noted for all wells on which the technology was tested, including the wells with horizontal end, which operate the Bashkirian carbonate reservoir (Table 1, Figure 4).

Thus, for resuscitation of oil production in the wells with horizontal end and with open trunks that exploits carbonate reservoirs of the Lower and Middle Carboniferous in the territory of the Republic of Tatarstan, the author proposes new low-cost

technology. The essence of the technology is to lower the suspension of the pump directly to the productive formation into the conventionally horizontal part of the well, where the zenith angle is 74-88°, to the lowest hypsometric mark of its trajectory in the oil-saturated part of the operational object. At such angles, the known brands of rod pumps are practically not working. Replacing them with upgraded 2SPNL-45/19 and 2SP45/24 makes it possible to operate pumping equipment in a horizontal trunk or in trunks with large zenith angles (over 60°), keep production levels, extend the life of the well with horizontal end, produce the most complete production of oil reserves and increase the final oil recovery factor.

The additional oil production from the geological and technical measures conducted for these wells as of 01.01.2017 amounted to 6507 tons of oil for the average life of the wells with the downhole pumping equipment in the horizontal part of the reservoir – 20 months.

### **About the Author**

*Rustam Kh. Ahmadullin* – Head of the Technological Department for Oil and Gas Field Development, Oil and Gas Production Department Prikamneft Tatneft PJSC  
32 Neftyanikov Ave, Elabuga, 423603, Russia

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