Watercut YLIQ plot

One if the Watercut Diagnostics plots with water cut (Y_w) along y-axis and inverse liquid rate $1/q_L$ along x-axis (see **Fig. 1** – **Fig. 3**).

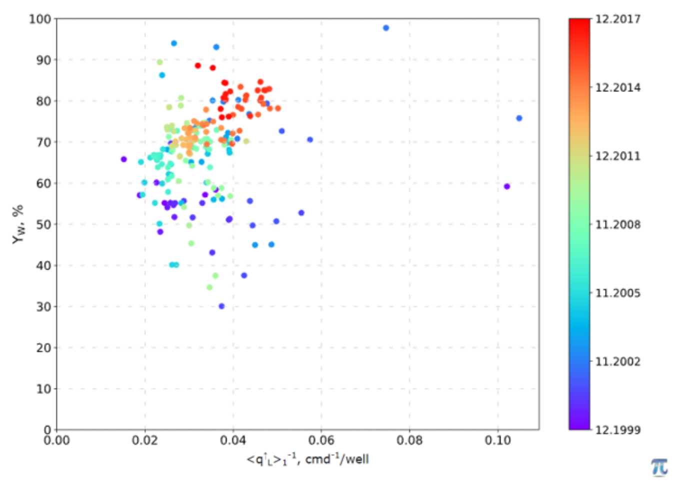

Fig. 1 – Good Water

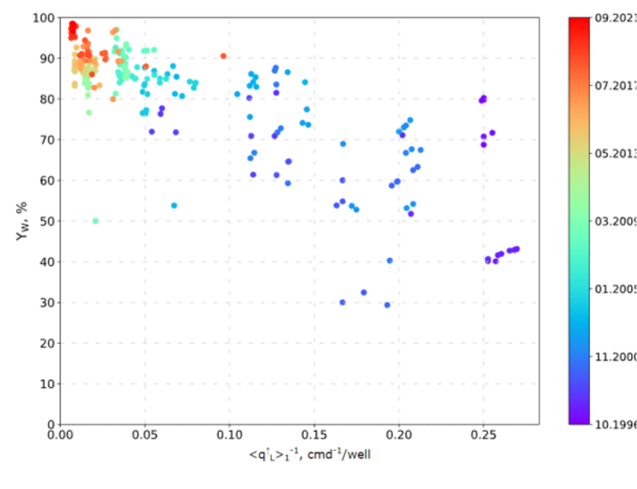

Fig. 2 – Bad Water with low pressure

The absence of correlation between Y_w and liquid rate suggest that either produced water is all good or it may have bad water production from the reservoir with the same formation pressure as oil pay: $P_{\text{bad water}} = P_{\text{oil pay}}$ (see **Fig. 1**).

In practice, it is very rare occasion that bad water has the same formation pressure as the oil pay: $P_{\text{bad water}} = P_{\text{oil pay}}$ and usually the absence of correlation between Y_w and liquid rate indicates that all produced water is good.

The negative correlation between Y_w and inverse liquid rate $1/q_L$ suggests that produced water contains bad water with lower formation pressure than that of oil pay: $P_{\text{bad water}} < P_{\text{oil pay}}$ (see **Fig. 2**).

The positive correlation between Y_w and inverse liquid rate $1/q_L$ suggests that produced water contains bad water with higher formation pressure than that of oil pay: $P_{\text{bad water}} > P_{\text{oil pay}}$ (see **Fig. 3**).

There is no clear regulation on what value of correlation is enough to discriminate between the cases on **Fig. 1** – **Fig. 3**.

This is usually done by an eye pick or artificial intelligence and stands as a part of the complex Watercut Diagnostics.

Some people see that growing Y_w with increasing of liquid rate for low-pressure bad water is counter-intuitive but in reality this is a solid fact which can be easily verified mathematically and/or tested in practise.

The YLIQ analysis is not always applicable as sometimes well produces at constant rate and correlation with watercut can not be assessed.

But even when historical rates were varying the YLIQ analysis does not provide the unique answer on whether produced water contains bad water.

Nevertheless, in many practical cases YLIQ analysis is very helpful as additional argument (and sometimes as the key argument) in assessing if produced water contains bad water.

The mathematical model of the thief water production from aquifer is based on the following equation:

(1) $Y_W = a + b \cdot q_L^{-1}$	(2) $a = \dfrac{J_{1W} + J_{2W}}{J_{1O} + J_{1W} + J_{2W}}$	(3) $b = \dfrac{J_{1O} \cdot J_{2W}}{J_{1O} + J_{1W} + J_{2W}} \cdot (p_2^* - p_1^*)$

where

		q_W	water production rate	q_L	liquid production rate
p_1^*	formation pressure in petroleum reservoir	J_{1W}	water productivity index of petroleum reservoir	J_{1O}	oil productivity index of petroleum reservoir
p_2^*	formation pressure in aquifer	J_{2W}	water productivity index of aquifer		

The equation (1) suggests that water cut declines along with aquifer pressure decline.

It also suggest that water cut grows with decline of the petroleum reservoir pressure and decreases when petroleum reservoir pressure grows.

For the case of aquifer pressure is higher than that of petroleum reservoir: $b > 0 \Leftrightarrow p_2^* > p_1^*$,

which means that if aquifer pressure is higher than petroleum reservoir pressure then production increase will lead to the water cut decline.

For the case of aquifer pressure is lower than that of petroleum reservoir: $b < 0 \Leftrightarrow p_2^* < p_1^*$,

which means that if aquifer pressure is lower than petroleum reservoir pressure then production increase will lead to the water cut growth.

In practical applications, the equation (1) is often considered through the weighted average values:

(4) $$Y_W = \frac{\langle q_W \rangle}{\langle q_L \rangle} = a + b \cdot \langle q_L \rangle^{-1}$$

where

$\langle q_W \rangle$, $\langle q_O \rangle$	are weighted average of q_W and q_O

There are different ways to calculate weighted average of the dynamic variable, for example:

t-weighted average	q-weighted

$\langle A \rangle_t = \frac{1}{t} \int_o^t A(t)\, dt$	$\langle A \rangle_q = \frac{1}{Q(t)} \int_o^t A(t)\, q(t)\, dt$

Cases

Case 1

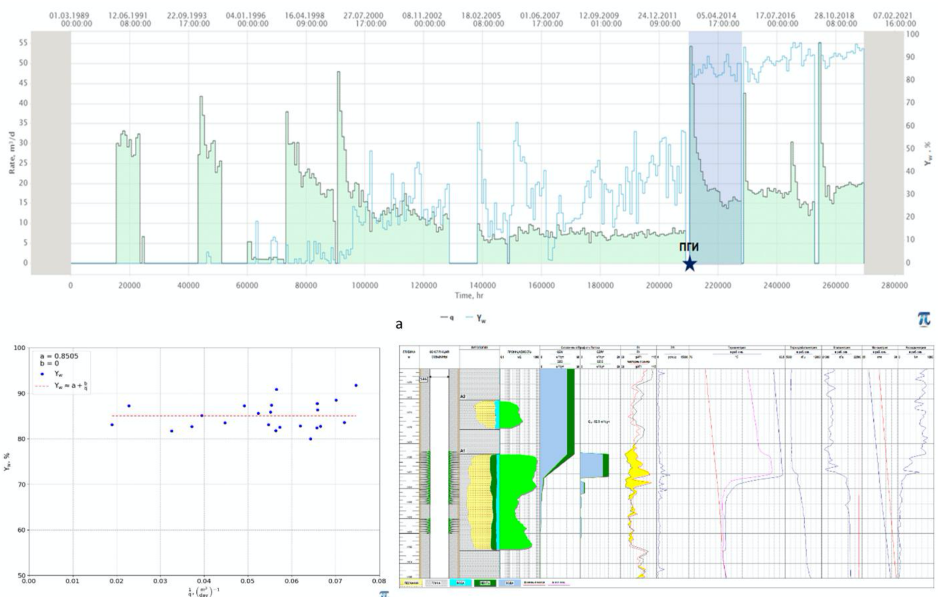

Fig. 4 – Good Water

Case 2

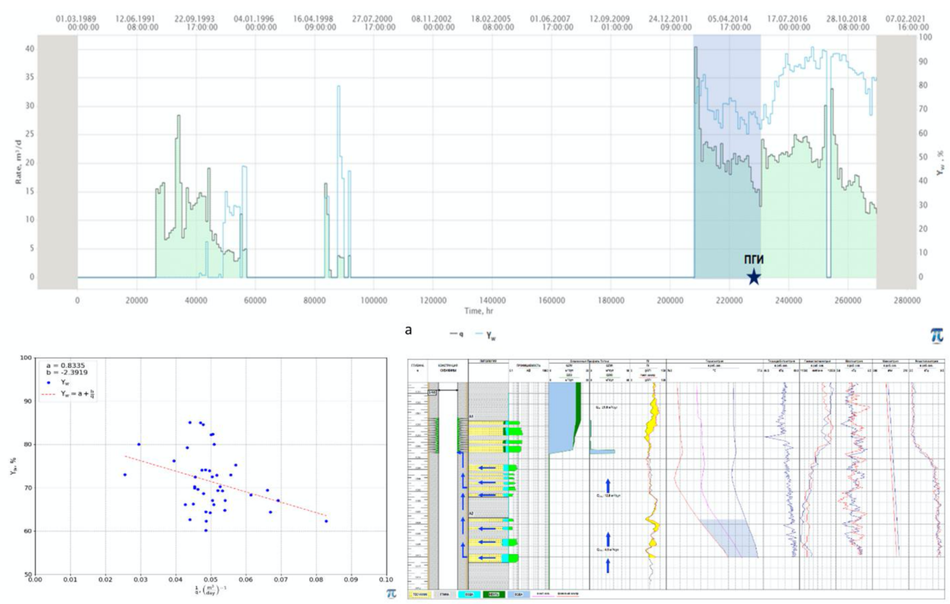

Fig. 5 – Bad Water with low pressure

Case 3

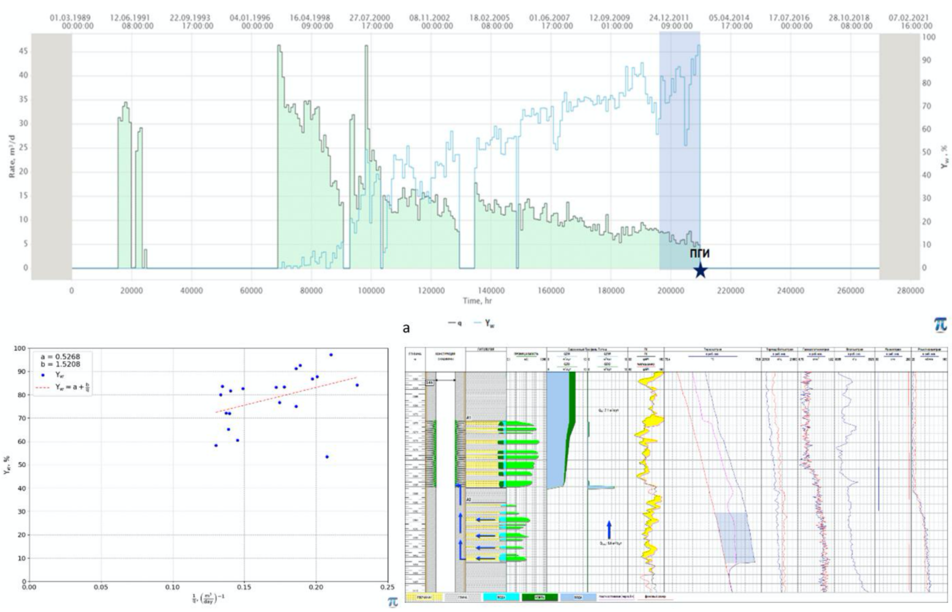

Fig. 6 – Bad Water with high pressure

See Also

Petroleum Industry / Upstream / Production / Subsurface Production / Field Study & Modelling / Production Analysis / Watercut Diagnostics