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Analysis on the Member 1 of Liushagang Formation Water BreakthroughDistribution inBlock Huachang X of Fushan oilfield, Beibuwan Basin

Wenyan Feng
China Southern Petroleum Exploration & Development Corporation, Haikou, Hainan, 570216, China.

Abstract: - Water-free oil production period is the significant attention problem of oilfield development. To final determination the time of water breakthrough, it's supposed that one source –one convergence point seepage field. So we can derive it if according to Beckley-Leverett equation and use fractional flow equation which based on relative permeability after normalization. And then we can get almost one year water cut alignment chart (water logging state chart diagram) if we use way triangular interpolation to analyze the water cut change of production well. Finally we verify and calculate the water breakthrough time realistically, so this method is feasible.

***Key words: -** One source-one convergence, The time of water breakthrough, Water logging condition*

I. BLOCK GENERAL SITUATION

The depression in Hainan Fushan is located between northern Qiongbei hill and Qiongzhou strait, its height is between 0 and 200m. And its depression is Cenozoic, its shape presents triangles pattern on the plane. However, Huachang structure is located the middle of the Fushan depression and lied in Chengmai country Hainan province, which structure shape is influenced by Lingao fracture in northeast and Changliu fracture in northwest. The whole structural configuration is large faulted nose[1、2].

By May 2015, this fault block finishing drilling different kinds of drilling are 16, which included 12 producing oil wells and 4 water injection wells. Its average daily oil output is 6.3t and average daily water output is 1.81m³, and its cumulative oil production is 6.026×10^4t, cumulative water production is $0.546\times10^4 m^3$and the recovery percent is 3.2%. Although average water cut is 8%, different wells have different characteristic and the heterogeneity is serious. So the cumulative water-injected of the present block is $6.937\times10^4 m^3$[3、4].

II. RELATIVE PERMEABILITY CURVE NORMALIZATION

There are some cores in this block has tested relative permeability curve, for convenient calculation, so according to multi permeability, we can get a relative permeability curve after normalization[5-7]. We have applied the following equations to standardization processing of each core sample's experimental data.

$$S_w^* = \frac{S_w - S_{wi}}{1 - S_{wi} - S_{or}} = \frac{S_w - S_{wi}}{S_{w\max} - S_{wi}} \qquad (1)$$

$$K_{ro}^*(S_w^*) = \frac{K_{ro}(S_w)}{K_{ro\max}} \qquad (2)$$

$$K_{rw}^*(S_w^*) = \frac{K_{rw}(S_w)}{K_{rw\max}} \qquad (3)$$

On the standard curve, it can be divided n equal division, which from 0 to 1 on the horizontal ordinate. And then to get the each dividing point S_w*, each sample K_{ro}*(S_w*)and K_{rw}*(S_w*), thus we can make average standard relative permeability curve.

$$\left.\begin{aligned} \overline{K}^*_{ro}(S^*_w)_k &= \frac{\sum_{i=1}^{n}\left[K^*_{ro}\left(S^*_w\right)_k\right]_i}{n} \\ \overline{K}^*_{rw}(S^*_w)_k &= \frac{\sum_{i=1}^{n}\left[K^*_{rw}\left(S^*_w\right)_k\right]_i}{n} \end{aligned}\right\} \quad (4)$$

We would make arithmetic mean for each sample's eigenvalue S_{wi}、S_{wmax}、K_{romax}、K_{rwmax}, which make average value as the eigenvalue of average relative permeability. The calculating formula as the following

$$\left.\begin{aligned} \overline{S}_{wi} &= \frac{\sum_{i=1}^{n}\left(S_{wi}\right)_i}{n} \\ \overline{S}_{w\max} &= \frac{\sum_{i=1}^{n}\left(S_{w\max}\right)_i}{n} \\ \overline{K}_{ro\max} &= \frac{\sum_{i=1}^{n}\left(K_{ro\max}\right)_i}{n} \\ \overline{K}_{rwmax} &= \frac{\sum_{i=1}^{n}\left(K_{rwmax}\right)_i}{n} \end{aligned}\right\} \quad (5)$$

:

Next we would mean standardize each point S_w*、K_{ro}*、K_{rw}* on the relative permeability, the reduction formula as the following:

$$\left.\begin{aligned} S_w &= S^*_w \cdot \left(\overline{S}_{w\max} - \overline{S}_{wi}\right) + \overline{S}_{wi} \\ K_{ro}\left(S_w\right) &= \overline{K}^*_{ro}\left(S^*_w\right) \cdot \overline{K}_{ro\max} \\ K_{rw}\left(S_w\right) &= \overline{K}^*_{rw}\left(S^*_w\right) \cdot \overline{K}_{rw\max} \end{aligned}\right\} \quad (6)$$

According to the above formula, we can make a reservoir average relative permeability curve. The normalized average relative permeability curve in the Member 1 of Liushagang Formation of Huachang X block as shown in the figure 1.

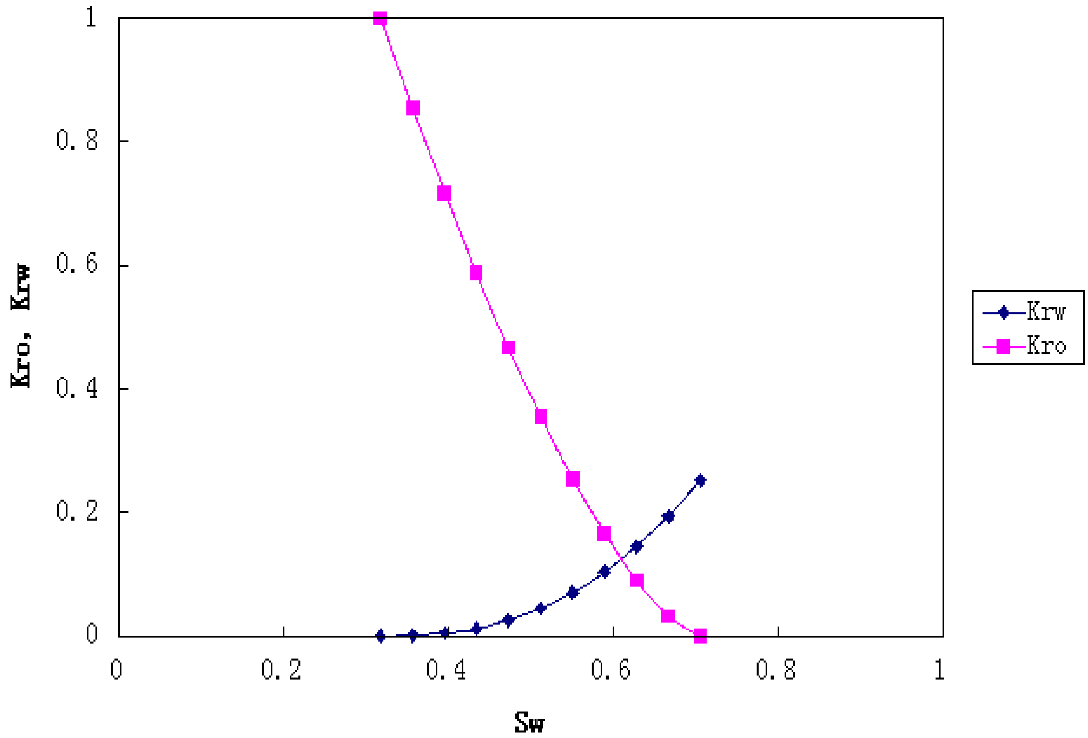


Figure 1 average relative permeability

III. WATER-FLOOD FRONT WATER SATURATION

Water cut change rule is researched on oil well water cut change situation as the increase of water saturation in stratum. In field performance analysis, the water cut is an important index. And its a ratio between productivity and total fluid production when water and oil produced at the same time. That is:

$$f_w = \frac{1}{1 + \frac{K_o}{K_w} \cdot \frac{\mu_w}{\mu_o}} \quad (7)$$

This is also called fractional flow equation.

For a reservoir, the viscosity ratio μw / μo is certain, so the water cut is only related to water-oil relat ive permeability ratio. Because relative permeability is a function of water saturation, water cut fW is also a function of water saturation S_W.

And then it would take the previous formula $\frac{K_{ro}}{K_{rw}} = \frac{K_o}{K_w} = a e^{-bS_w}$ into, which can reach

$$f_w = \frac{1}{1 + \frac{\mu_w}{\mu_o} a e^{-bS_w}} \quad (8)$$

After it take the partial of this with respect to water saturation according to water cut change, it woul d get:

$$\frac{\partial f_w}{\partial S_w} = \frac{\frac{\mu_w}{\mu_o} a b e^{-bS_w}}{(1 + \frac{\mu_w}{\mu_o} a e^{-bS_w})^2} \tag{9}$$

According to test material, the crude oil viscosity is 2.749mPa·s under the reservoir condition, and the water viscosity is 0.3027mPa·s under 94.44. After fitting, it will get as the following figure 2. Finally it would get $a=1.2\times10^6$, b=23.4.

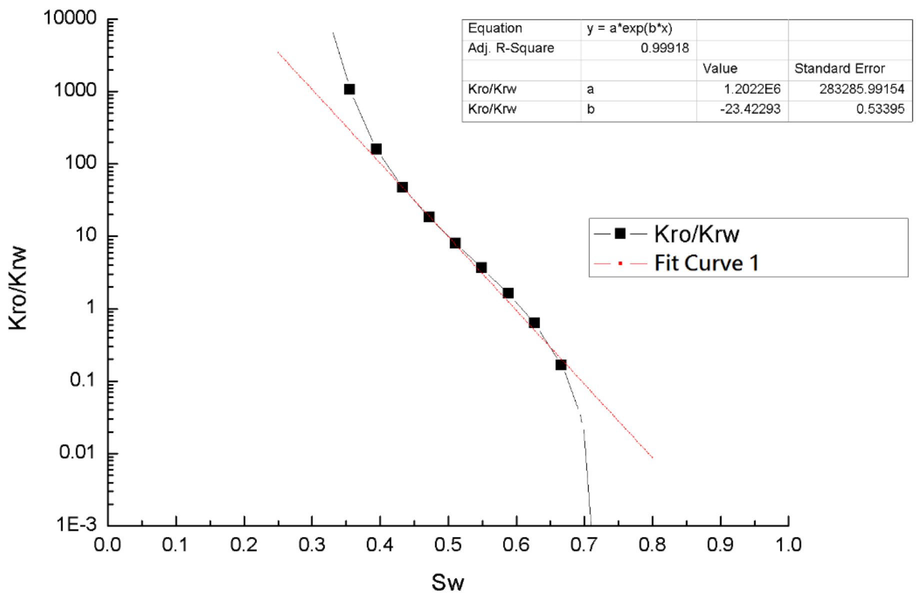


Figure 2 relative permeability curve fitting drawing board

According to Beckley-leverett formula of water-oil two-phase flow, it has

$$A(x)\Phi \frac{\partial S_w}{\partial t} + q_{t\theta} \frac{\partial f}{\partial x} = 0 \tag{10}$$

From the above formula we can get seepage velocity (V_{S_w}) when the water saturation is $S_{w.}$

$$V_{S_w} = \frac{dx}{dt} = \frac{-(\partial S_w / \partial t)}{\partial S_w / \partial x} = q_{t\theta} \frac{\partial f_w / \partial S_w}{\Phi A(x)} \tag{11}$$

In the formula, $\frac{\partial f_w}{\partial S_w}$ is a function of $S_{w,}$ it can get through water-oil relative permeability curve, which is in Figure 4.

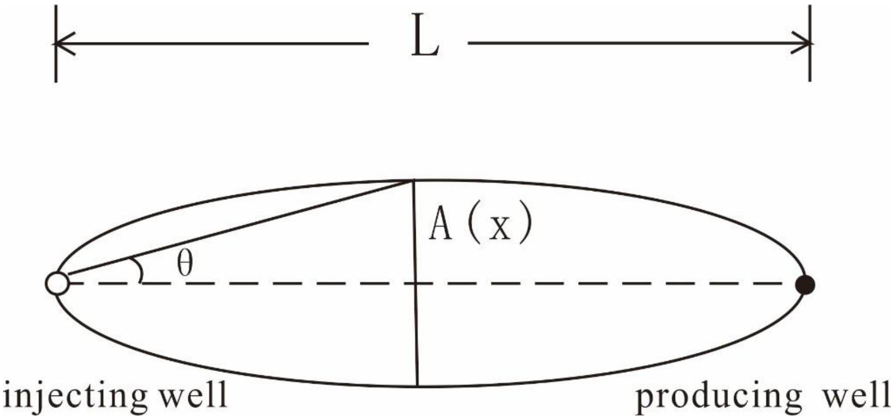


Figure 3 flow pipes sketch diagram between water-oil wells

As figure 3 assume, it can get main stream line as center line according to one source-one convergence point seepage field, so we can get formula 12 and 13.

$$A(x) = 2(\tan\theta)hx, x \le \frac{l}{2} \quad (12)$$

$$A(x) = 2(\tan\theta)h(1-x), x > \frac{l}{2} \quad (13)$$

And then put A(x) and solve (5), it would get water-flood frontal water particle reach the time of oil wells. That is

$$t_\theta = \frac{\frac{l^2}{4}(\tan\theta)h}{\frac{q_{t\theta}(\partial f_w / \partial S_w)S_{wf}}{\Phi}} \quad (14)$$

Swf is water-flood frontal water saturation, it can still be solves by fractional flow that water -oil relative permeability curve make with. It was supposed that well water injection rate is qt , and the water yield in the flow pipes is

$$q_{t\theta} = q_t \frac{\theta}{\pi} \quad (15)$$

And then take it into (14), let $\theta \to 0$, it will get water breakthrough time is

$$t_m = \lim_{\theta \to 0} t_\theta = \frac{\pi \Phi l^2 h}{4q_t(\frac{\partial f_w}{\partial S_w})s_{wf}} \quad (16)$$

In the formula, h represents reservoir thickness, m.; A(x) represents cross-sectional area at X point, ㎡; q represents injection fluid flow, m3/d; qt represents wells injection rate, m3/d; φ represents reservoir porosity, %; t represents water injection responding time, d; l represents water-oil well spacing, m; θ represents the angles between water-oil migration direction and main stream line, °; Sw represents water saturation, %;

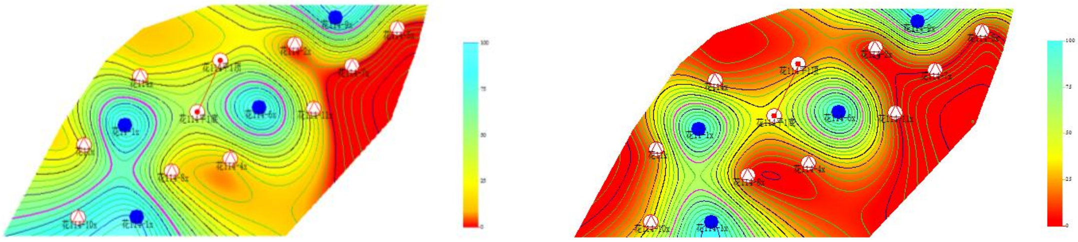
fw represents water cut, %; Swf represents water-flood frontal water saturation, %; tm represents water breakthrough time, d.

Figure 4 the relationship between water cut fW and water saturation SW

According to the above theoretic methods, we can get major reservoir IV formations of the faulted block, which well spacing is 250m, the effective thickness is 9.4m, the effective average porosity is 14.5%, we can get water-flood frontal water saturation $(\frac{\partial f_w}{\partial S_w})s_{wf} = 3.8$. Finally, we can calculate water breakthrough time is 688 days.

IV. WATER CUT CONTOUR LINE BOARD CONFIRMATION

The water-out diagram is base on logging of bitmap, and we can fill the data of the well water cut with each well position. If we get water cut contour spacing 5% as a rank difference according to each water cut variation range, and then we can use triangle interpolation algorithm to get water cut contour spacing through points. And also they are a multiple of water contour spacing. Next we use a smooth curve to connect the equal point of water cut data, and also use different colors to color different level water cut zone, finally, we can get water cut contour diagram, that is water logging state chart diagram. As figure 5(a) and 5(b) following, if we compare water cut contour diagram between the next half year in 2014 and the first half year in 2015, we can get all the production wells have water breakthrough and the water cut of northeast oil well is lower. That is this block has horizontal contradiction, which make the reserves proposal have exist difference in the plane, and oi-water interface carried forward in-homogeneous in horizontal direction. The main reason is plane heterogeneity, which relate to provenance.



（a）　　　　　　　　　　　　　　　　　　　　　　　　　　（b）

Figure 5 water cut contour diagram

According to $\frac{\partial f_w}{\partial S_w} = 6.4$ in figure 4 is the partial derivative of the peak, is also the water cut increased the fast, which the corresponding water cut $f_w = 63\%$ can be identified virtual water cut of water-flood front. In the figure 5, it can be drew a curve of $f_w = 63\%$, that is injected water line. According to reduced productive time, it can calculate water breakthrough time in low and medium water cut stage, which is more practical and the reason is reliable.

V. CONCLUSION

According to relative permeability curve after normalization, and then we use fractional flow equation to deduce water breakthrough time equation and calculate the breakthrough time on the Member 1 of Liushagang Formation Water Breakthrough Distribution in Block Huachang X of Fushan oilfield is 688 days. During low and medium water cut stage, we could get more practical water breakthrough rule and a reliable reason through compared water cut contour diagram, which can apply the actual computation in oilfield production.

VI. CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

VII. ACKNOWLEDGMENT

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REFERENCES

[1]. Guo F.Z., Xi T.D. and Meng X.G., et al. Analysis of water breakthrough rules of oil-well in low permeability reservoir. Journal of Northeast Petroleum University. Vol. 37（2013）No. 3, p. 87-93.

[2]. Chen M.F., Li X.F. and Shi J.H. , et al. Study on water breakthrough rule and main controlling factors for composite sandstone reservoir with edge and bottom water. Complex Hydrocarbon Reservoirs, Vol. 7(2014) No. 4, p. 45-49.

[3]. Sandro Aiango, Eduardo A, Heetor H.Perez. A new methodology to estimate fraeture intensity index for naturally fractured reservoirs. SPE 86935.

[4]. Qu G.H., Liu Y.K., Jiang S.D. Research on development factors affecting oil recovery of polymer

flooding. Energy Education Science and Technology Part A, Vol. 31（2013）No. 3, p. 1787-1794.

[5]. B.Palsson, D.RJDavies and A.C.Todd. Water Injection Optimized with Statistical Methods, SPE 84048.

[6]. Qu G.H., Gong X.G., Liu Y.K.New research progress of the demulsification of produced liquid by polymer flooding. Journal of Chemical and Pharmaceutical Research, Vol. 6 (2014) No. 1, p. 634-640.

[7]. Wang J., Liu H.Q. and Liu S.Y. A flooding law in horizontal wells of heterogeneous reservoirs with bottom water. Acta Petrolei Sinica. Vol. 31 (2010) No. 6, p. 970-974.

[8]. About the author: He has working on petroleum exploration and development, and the main research directions are reservoir assessment, development design. etc. fengwenyan@cnpc.com.cn