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Study on the Variation of Remaining Oil in Extra High Water Cut Stage in Multi-Layer Sandstone Reservoirs

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Abstract: Using reservoir engineering method, the dynamic monitoring method, core analysis of block of remaining oil has carried on the detailed research, established for determining remaining oil, the control model of layer in laminated containment has carried on the detailed research, summarizes the influence factors of remaining oil distribution, which laid a foundation for residual oil exploration.

Keywords: Reservoir; Surplus oil; Dynamic condition; Distribution; High water content.

INTRODUCTION

Is the main characteristic of multi-layer sandstone reservoir layer, sand body shape is complex, vertical lithologic changes frequently, plane channel sand, thin sand layer, outer table and mudstone zone interlock, different types of reservoir and different parts of the same type, thickness and permeability of extraordinary disparity. As the research field of plane and longitudinal residual oil distribution law, at the high water-cut stage on the basis of 3 d geological model is established to carry out the numerical simulation research, the application has a hidden multi-layer sandstone reservoir numerical simulation technology research of remaining oil distribution, by thin layer simulation, fine reservoir history matching, reconstruct reservoir development history in the past, to show the distribution of remaining oil saturation in reservoir space. And by using reservoir engineering and small layers of sedimentary facies, dynamic analysis and other methods, comprehensive dynamic description and predict reservoir, obtained good results.

REMAINING OIL DISTRIBUTION

Vertical residual oil distribution

Each small layer on the longitudinal there is a certain difference in the water, remaining oil distribution in not sees water layer and water layer not watered-out zone and water zone of low water cut parts. Main layer and the main development effect is large, rather than using difference between main layer is bigger also, mainly for the use of reservoir sedimentary type different level uneven [1]. Major reservoir water at the bottom of the heavier, remaining oil saturation is low, the top of the water is weak, the remaining oil saturation is high, the main enrichment region for residual oil. The main reservoir, the remaining oil is mainly distributed in outer front I class, outside front II, III outside front sand body. Such as (table 1).

Table 1: Apricot north fine before the potentialities and longitudinal residual oil distribution

Reservoir types	Sedimentary type	The actual reserves（104t）	Da reserves（104t）	Remaining reserves（104t）	Oil production（104t）	Recovery degree（%）
A class of reservoir	The river	1504.57	1578.65	862.36	716.29	45.37
Three types of reservoir	In the front	274.50	284.58	183.21	101.37	35.62
	Besides I	1037．73	1070.04	609.20	460.84	43.07
	Besides II	379.95	390.25	224.60	165.65	42.45
	Besides III1	299.62	300.49	182.06	118.43	39.41
	Besides III2	170.06	174.68	112.63	62.05	35.52
	Besides IV2	50.41	50.54	34.98	15.56	30.79
	Subtotal	2212.07	2270.57	1346.67	923.90	40.69
Total		3716.64	3849.22	2209.04	1640.19	42.61

From outer frontal type I to IV class reservoir, as conditions for the development of reservoir variation, the use of level gradually reduce, experimental zone recovery degree is 42.61%, type of reservoir that is

fluvial facies recovery degree was 45.37%, 40.69%, three kinds of reservoir recovery degree was 35.62%, in front of the reservoir recovery degree outside the front type I reservoir recovery degree was 43.07%, the front outside class II reservoirs recovery degree was 42.45%, the outside front 1 class III reservoir recovery degree is 39.41, outer frontal III2 class reservoir recovery degree is 35.52%, front outside class IV reservoir recovery degree is 30.79%. Three kinds of reservoir remaining oil potential mainly exist in the front outside class I, II and III reservoir, accounting for 83.80% of the total surplus reserves.

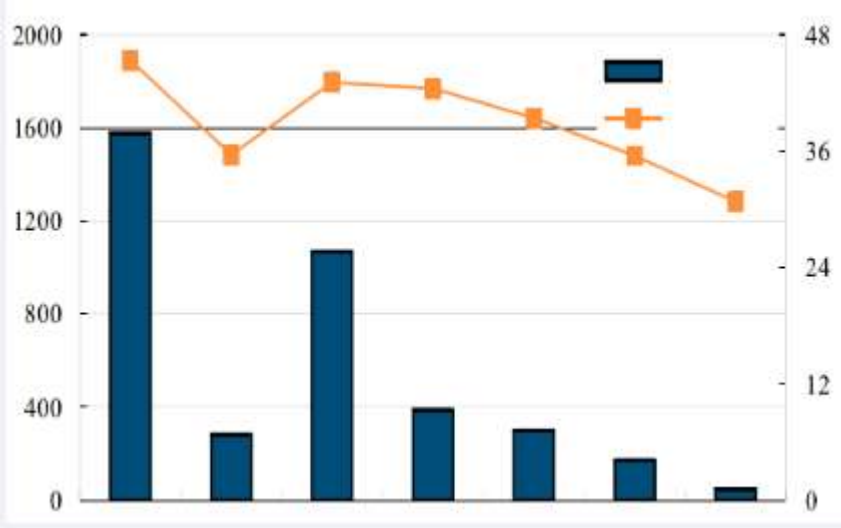

Fig-1: Different sedimentary reservoir mathematical model the contrast degree of reserves and production

Grey relational analysis of the basic forecast calculation

Plane of remaining oil distribution type mainly has the following kinds: irregular marginal region of large sand body, or sand body is formed by various obstructions segmentation retention area; Poor into the distribution of the reservoir, due to the thin reservoir, poor physical property, reservoir caused by the use of poor or not used to form a piece of the distribution of remaining oil; Intense area lithology change, the main sand body has large area of water, the surrounding the edge or bypass form poor reservoir or untabulated reservoir; The existing well pattern control type; Imperfect injection-production system type.

In major reservoir, the remaining oil is mainly distributed in the pattern of control of distributary channel sand body, fault near and shunt difference between thin reservoir areas, among other things, and form a strip and flake of remaining oil enrichment region [2]. In the major reservoir remaining oil only scattered in the body or the main lithology between sand sheet untabulated reservoir physical property variation, or is stranded area, and the remaining oil distribution is smaller.

Table 1: Apricot north fine potential in different remaining oil distribution of sedimentary facies

Sedimentary microfacies	Numerical reserves		Reserves producing situation			Remaining reserves	
	Reserves (104t)	Proportion (%)	Oil production (104t)	Proportion (%)	Recovery degree (%)	Reserves (104t)	Proportion (%)
Underwater distributary channel/channel sand	1472.89	38.27	678.16	41.35	46.04	794.73	35.98
Main body thin layer of sand/abandoned channel	991.61	25.76	440.66	26.87	44.44	550. 95	24.94
The thin layer of sand/HeJian sand	794.83	20.65	317.82	19.38	39.98	477.04	21.60
Off-balance sheet	589.82	15.32	203.56	12.41	34.51	386.26	17.49
Total	3849.18	100	1640.19	100	42.61	2208.99	100

Different sedimentary facies of remaining oil is statistics are shown in table 2-7. Experimental zone of underwater distributary channel/channel sand recovery degree was 46.04%, the remaining reserves of 794.73 x 104 t, accounting for 35.98% of the total surplus reserves; Body thin layer of sand/abandoned channel recovery degree was 44.44%, the remaining reserves of 550.95 x 104 t, accounting for 24.94% of the total surplus reserves; The main body thin layer of sand/HeJian sand recovery degree was 39.98%, the remaining reserves of 477.04 x 104 t, accounting for 21.60% of the remaining total reserves; Off-balance sheet sand body recovery degree lowest, only 34.51% remaining reserves of 386.26 x 104 t, accounting for 17.49% of the total surplus reserves.

Research results show that due to the frontal category, front three categories and external front four types of sand body reservoir outside the development, enrichment of remaining oil is relatively.

RESIDUAL OIL DISTRIBUTION FACTORS

Formation and distribution of residual oil is influenced by many factors, such as reservoir structure, reservoir sedimentary characteristics, sand body distribution, reservoir heterogeneity, pattern and water injection, production fluid volume, etc. [3]. Will tell from the geological conditions, generally for the phase transition and heterogeneity of reservoir lateral, structure of ups and downs and fault caused by cutting, rhythmic inside the seepage formation heterogeneity and cross-hole retention area, etc. Will tell from the human factors, mainly is the oilfield injection-production system adjustment problems. For water injection development oilfield, its influence factors mainly include the following aspects:

1. The influence of the reservoir heterogeneity, oil reservoir heterogeneity is widespread, and is the key factors that affect the distribution of remaining oil.

By the geometric shape of reservoir sand body, connectivity, thickness, porosity and permeability of space changes caused by the plane heterogeneity, directly affect the surface water oil displacement efficiency and sweep volume. Single layer thickness of reservoir, due to restricted by intra formational heterogeneity, injected water to promote its uneven, especially positive rhythm reservoirs, greatly reduces the water flooding thickness coefficient. For layered reservoir and interlayer heterogeneity is one of the major issues first revealed in the water injection development. Because at present most of oil commingling, serious interlayer interference, the injected water along the high permeability layer, forming strong water flooded area, and low permeable formation reservoir is not or very little water quantity, water flooded degree is low, so as to control the reservoir plane and vertical residual oil distribution.

2. The influence of tectonic position fault edge, high structure parts are mostly hydrodynamic retention area, weak degree of water flooding, and remaining oil distribution is more blocks.

Apricot 1 ~ 2 size fault six eastern area, a total of development, of which 213-1 # fault strike for the north to the east, extension length are above 1.0 km, 202 #, 214 # fault extends maximum of 3.26 km. Formed at the fault of the remaining oil potential is tremendous, the proportion of remaining oil enrichment region geological reserves of blocks is bigger. And in 99 simulated layers, there are different degrees of lithologic pinch out; it directly affects the interwell connectivity of reservoir and the reservoir the perfection of injection-production system, thus affecting the rule of oil-water movement within the reservoir and the distribution of remaining oil.

3. The influence of injection-production relationship of injection-production system perfect degree, the size of the injection-production well spacing, oil and water Wells well number, water injection and water flooding mode affects the distribution of remaining oil.

On the longitudinal residual oil distribution and is close to the heterogeneity of the reservoir. Is given priority to with plain distributary channel sand and underwater channel sand major reservoir, because of the influence of the intra formational heterogeneity, the top of the positive rhythm thick oil reservoir has certain residual oil [4]. From the statistic water flooded condition, thickness of layer in low water and water flooded, accounting for 17.8% of the total thickness, low reservoir at the top of the water and the thickness of the water was 38.6%. This part of the remaining oil is the major reservoir remaining oil in the main form, but it is difficult to use conventional water flooding development.

Plane residual oil distribution is mainly affected by the influence of injection-production relation, the proportion is 39.51%. The major reservoir remaining oil potential, mainly concentrated in the thin and poor reservoirs untabulated reservoir, give priority to with imperfect injection-production pattern.

CONCLUSIONS

Multi-layer sandstone reservoir is studied for determining main development contradictions, interlayer and plane are analyzed, the main contradiction inside the layer, and the contradiction between residual oil scattered and potentialities and increasing difficulty, invalid injection-production cycle contradiction, structure adjustment and including imbalance of contradictions.

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