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Oil-Water Layer Recognition and Distribution of PI Reservoir in G Region

Yang Xiaoyu[1]; Li Huanxiang[2]; Liu Xiaowen[3]
[1]*College of earth science of Northeast Petroleum University, Daqing, Heilongjiang, China.*
[2]*College of earth science of Northeast Petroleum University, Daqing, Heilongjiang, China.*
[3]*College of earth science of Northeast Petroleum University, Daqing, Heilongjiang, China.*

Abstract： *Based on the comprehensive analysis of core、oil testing and logging data, this paper searched the cause of low-resistivity oil layer and high-resistivity water layer.Then oil-water layer logging interpretation chart was established by using RLLD and corrected RILD to identify oil-water layers. The log interpretation result shows there are 5 types of vertical oil-water distribution of single well in research area:pure oil layer type、oil to water layer type、oil-water layer type、pure water layer type、messy type. The vertical and horizontal oil-water distribution was finally concluded.*
Key words:*G region;PI reservoir; Oil-water layer recognition; Oil-water layer distribution*

I. INTRODUCTION

Oil-water layers recognition and distribution are the important part of petroleum exploration and development.People usually use conventional cross-plot methodbased on log curves 、reservoirs oil-water recognition based on WT and LSSVM and other kinds of method to recognize oil and water layers.Then the sand body distribution、tectonic evolution、seismic inversion、reservoir anatomy and other methods of geological bodies were adopped to proceed the study on oil-water layer distribution from different angels and levels.And years of exploration and development shows that the oil-water layer distribution in G region,under the influence of structure、 sedimentary、 diagenetic and other factors,is very complex. In order to reveal the oil-water layer distribution pattern within research area more precisely,on the basis of effective recognition oflow-resistivity oil layer and high-resistivity water layer,this paper establish oil-water layers interpretive standard by using core test and logging data. After the realization of quantitative interpretation of oil-water layer, oil-water layer distribution within research area could be achieved to guide subsequent development of oil field.

G region, distributed as long ribbon from south to north, is constructionally located in the south of Q-G depression of central down warping region in S basin. As a long-term inherited developed deep-water aphytal depression, it is generally reflect the tectonic pattern of “three nose structure、two depression and one slope”，including Xinzhao nose structure、Xinzhan nose structure、Aonan nose structure、Gulong syncline、Maoxing syncline and Yingtai slope. The mainly developed formations are Shahezi、Yingcheng、Denglouku、Quantou、Qingshankou、Yaojia、Nenjiang、Sifangtai and Mingshui layers from Cretaceous ，Paleogene and Neogene .After years of oil and gas exploration, a lot of important discoveries have been found. And the advantage of shallow buried depth、better physical property and higher production has made PI reservoir of Yaojia-one section one of the most important production zones.

II. OIL-WATER RECOGNITION

Under the sedimentary environment of delta front -lacustrine, PI reservoir in G region mainly deposited mouth bar、distal bar、sheet sand and underwater distributary channel sand-four kinds of sedimentary microfacies, which provided good storage space for forming reservoir. But the mutual effects of construction、deposition、diagenetic process and other kinds of factors causing poor reservoir properties and complex oil-water relationship within research area, thus uniform oil-water interface could not be found. As we can see from electrical characteristics, the resistivity among oil、oil-water and water layers are quite similar.The appearance of low-resistivity oil layer and high-resistivity water layer made it difficult for me to recognize oil-water layers.Therefore,based on the analyzed causes of low-resistivity oil layer and high-resistivity water layer,using abundant testing data,oil-water determination chart was established to increase the rate of logging interpretation within research area.

2.1 low-resistivity oil layer and high-resistivity water layer

As we can see from formation water salinity data and conductive mineral content of oil layer of P I reservoir in G region, it makes no differences between conventional reservoirs and low-resistivity oil layer、 high-resistivity water layer;the comparison of lithology data between low resistivity reservoir sample of 22 wells and conventional oil reservoir sample of 13 wells shows that low-resistivity oil layers have more araliaceous siltstone samples while calcium siltstone and fine-grained sandstone samples are less than conventional oil layer; X-diffraction analysis data shows that compared with conventional oil layers , low-resistivity oil layers have more illite、emanon mixed layer 、chlorite and less kaolinite; besides, the percentage of microspore volume in low-resistivity oil layer is significantly higher than conventional oil layers. In summary, through the comparison of lithology、properties、pore structure、clay minerals、formation water salinity and other factors between conventional reservoirs and low-resistivity oil layer、high-resistivity water layer，it turn out that low-resistivity oil layer has the characteristic of fine lithology、high clay content、strong additional electrical conductivity of clay、developed microspore and high irreducible water saturation while high-resistivity water layer were formed for the existence of residual oil and calcium.

2.2 Logging response of oil and water layers

Logging response characteristics of oil and water layers can provide preferred parameters when establishing oil-water identification plate. The four - property relationship research of reservoirs within research area shows that resistivity and three porosity logging curves can well reflect the properties and oil resistance of reservoirs. Typical oil layer has a large porosity and high resistivity when typical water layer has low resistivity.

2.3 Interpretive criteria of oil and water layers

G region was located in the central of G source depression during the deposition of PI reservoir, where has sufficient oil source. The relatively developed sandstone with poor horizontal connectivity was the favorable zones to form lithological hydrocarbon reservoir. Therefore, lithological is the mainly controlling factor of hydrocarbon accumulation when construction background controls differentiation of oil and water. The complexity of the geological background of the reservoir determined the diversification of reservoir type. So it is difficult for conventional GR-AC、LLD-GR、CNL-GR and LLD-AC cross plot to disguise oil layer, oil, oil-water layer and an aqueous layer.

The comprehensive analysis of core、 oil testing and logging data reveals that induction logging is more sensitive to low resistance component (water).But its vertical resolution is only 2m, while the layers which thickness less than 2m take a certain proportion of reservoir, making it difficult for induction logging to reflect actual reservoir value. So thickness and bed correction should be made with corresponding plate according to the instrument type. Most introduction series of this area are CSU series, thus it is reasonable to correct thickness and bed for induction logging by Schlumberger chart. Then oil-water layer logging interpretation chart was established by using RLLD and corrected RILD(Fig 1):63 layers out of 69 data points fit the chart, reaching the precision of 91.3% ; the two slashes divided the chart into three zones, the zone above line 1(RILD=0.9793RLLD－0.7704)is oil layer zone; the zone below line 2(RILD=0.6409RLLD－0.3296)is water layer zone; the zone between 2 lines is oil-water layer zone, including、oil-water layer and oily water layer. Finally, the logging data and test oil conclusions of 95 wells within this area shows the compliance rate of 85.4, which well reflects the actual situation.

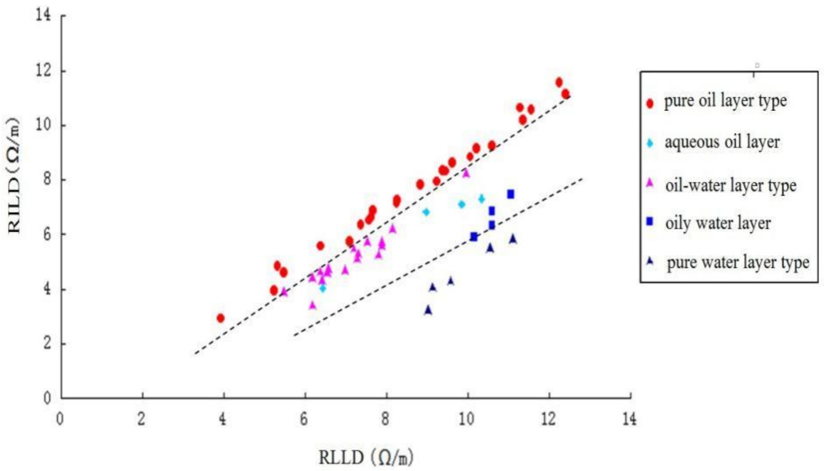

Fig 1 Oil-water layer logging interpretation chart

III. OIL-WATER DISTRIBUTION

Based on the oil-water distribution characteristics of different kinds of hydrocarbon reservoir, this paper concluded the vertical and horizontal oil-water distribution by using oil testing and logging data, considering the sedimentary and structural characteristics of research area. The foundation of analyzing hydrocarbon accumulation and oil-water distribution pattern was thus established, which also provide reliable basis for the exploration and development of oil fields.

3.1 Vertical oil-water distribution

Vertical oil-water distribution of single well is the basic of oil-water distribution. The research was carried out by using oil testing conclusion、electric log interpretation results of oil and water layer of each well. There are 5 types of vertical oil-water distribution of single well in research area: pure oil layer type(the sand bodies from top to bottom are mainly oil layer, barely have water layer or dry layer)、oil to water layer type(the top of sand body is oil layer or oil-water layer when the bottle is water layer)、oil-water layer type(the sand bodies are mainly oil-water layer, barely have water layer or oil layer)、pure water layer type(the sand bodies from top to bottom are mainly water layer, barely have oil layer)、messy type(there is not clearly distribution pattern of oil layer、water layer and dry layer, such as the top of sand body is water layer when the bottle is oil layer or oil-water layer).

Generally speaking， PI reservoir in G region is extensively developed in each small layers: Hydrocarbon bearing interval in uplifted area is quite long, usually from PI1 to PI6 small layers while oil layers could only be seen in PI1 and PI4-PI6 small layers in syncline area; and the slope area has the longest hydrocarbon bearing interval, which is from PI1 to PI8 small layers.

3.2 Horizontal oil-water distribution

The hydrocarbon is accumulated in the whole area under the control of four major geological factors-construction、fracture、sand body and physical properties. Uniform oil-water distribution pattern could not be found since oil-water distributions are quite different in each structural unit. The mainly well type in Gulling syncline is oil-water well,and there are a few pure water wells in eastern part when Maoming syncline contains a lot of pure oil wells. Xanthan nose structure mainly hold pure oil well of whole section and only a few water wells appear in the edge area, showing good oiliness in structurally high area. Generally the oiliness of the south wing is better than the north wing.Split by faults, there are not uniform oil-water interface among each block. Xin Zhao nose structure shows large numbers of alternate layer phenomenon of oil and water layers; Oiliness deteriorates from structural high to low area. Pure oil layer could only be seen in single small layer of each well in Adnan nose structure. Besides, the large dip difference caused by the mutual effects on fault strike and formation strike also has great influence on the oiliness of slope areas between Adnan nose structure and Maoming syncline.

Overall, the oil-water distribution of PI reservoirs in G region has horizontal zoning characteristics:The higher position of uplifted area develop placanticlinestructural reservoir of pure oil layer type and oil to water layer type while lower position develop oil to water layer type 、pure water layer type and messy type;slope area develop lithological reservoir of messy type、block reservoir and fault lithological reservoir of pure oil layer type or oil to water layer type and structurally lithological reservoir of pure oil layer type;Syncline area mainly develop lithological reservoir of pure oil type.

IV. CONCLUSIONS

The low-resistivity oil layer of PI oil group in G region is caused by fine lithology、high clay content、strong additional electrical conductivity of clay、developed microspore and high irreducible water saturation while high-resistivity water layer were formed for the existence of residual oil and calcium.

There are 5 types of vertical oil-water distribution of single well in research area: pure oil layer type、oil to water layer type、oil-water layer type、pure water layer type、messy type. The oil-water distribution of PI oil group in G region has horizontal zoning characteristics.

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