 Volume 8 Issue 1, 2022
DOI: 10.6919/ICJE.202201_8(1).0099

Reservoir Characteristics and Fluid Properties Logging Identification Method of Chang81 in Pengyang-Pingliang Area, Ordos Basin

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Abstract

With the introduction of a new round of demand for stable production and higher production, the oil exploration work in the Ordos Basin has gradually moved from the central part of the basin to the peripheral areas of the basin with a lower degree of exploration. The Chang81 reservoir in the Pengyang-Pingliang area, located on the southwestern edge of the basin, is obviously better, with thicker sand bodies, and the physical properties of the reservoir are also significantly better than those in the middle of the basin. The matching relation between resistivity and three porosity, natural gamma ray and natural potential was established by cross plot method. The identification standard of fluid properties of chang81 in the study area was established by digging out the information of reservoir lithology, physical property, oil and water content.

Keywords

Reservoir Characteristics, Fluid Properties, Chang81 Reservoir, Reservoir Characteristics, Ordos Basin.

1. Introduction

The Ordos Basin is a residual inland craton basin formed by the superimposition of multiple tectonic movements(Sun,1980;Li 2004;Wang 2011;Bai 2013). It is the sedimentary basin with the earliest formation history and the longest evolution time in my country. It is also the second largest land-based sedimentary basin and an important energy base in China. There are many sets of sedimentary systems since the Paleozoic in the basin. Among them, the Yanchang Formation is a set of important oil and gas reservoirs developed on the inland lacustrine delta sedimentary bodies, which are distributed in the study area.

The Pengyang-Pingliang area is structurally located on the southwestern edge of the Ordos Basin, straddling the Tianhuan Depression and the western marginal occlusion zone, and its geological conditions are different from the central part of the basin. Chang 8 in the study area is the main oil-bearing zone. The oil reservoirs are mainly distributed in Xiaoxian area, and Shangxinzhuang has also made a breakthrough. Through the core photos and fluorescence photos, it can be found that the oil-bearing properties of different blocks in the same block at different depths are very different, but the identification of the oil and water properties of the reservoirs in the work area is still unclear, which cannot meet the needs of oilfield development. Conventional logging technology plays an important role in the identification and evaluation of conventional oil and gas reservoirs. This paper takes the Chang81 sub-oil layer with better oil-bearing performance in the Chang 8 oil layer group as the research object. On the basis of the research on the formation cause of the oil layer in the work area, the characteristics and sensitive information of the oil layer in the "four characteristics" relationship are searched for, from the resistivity and the three In the matching relationship of porosity, natural gamma, and spontaneous potential, the lithology, physical properties, oil-bearing water and other information of the reservoir are deeply excavated, so as to achieve the purpose of identifying oil and water layers.

2. Geological Setting

The Ordos Basin is a multi-cycle superimposed basin developed on the North China Craton and located in its western part. It is the sedimentary basin with the earliest formation history and the longest evolution time in my country(Li ,2004).

The Pengyang-Pingliang area is structurally located on the southwestern edge of the Ordos Basin(Fig.1), straddling the Tianhuan Depression and the western marginal occlusion zone, and its geological conditions are different from the central part of the basin(Shao,2021). The western part of the study area is located at the southern end of the western marginal occlusion zone, with a stratum dip angle of 3-4°, strong tectonic activity, strong uplift and denudation, and later tectonic activity transformation and relatively developed folds; The eastern part of the study area is located at the southern end of the Tianhuan Depression. Compared with the western part, it is relatively gentle, with relatively stable tectonic activity, no large-scale structures, and occasional faults. However, a series of nose-like uplifts with obvious directional distribution and parallel arrangement are developed in the slope area.

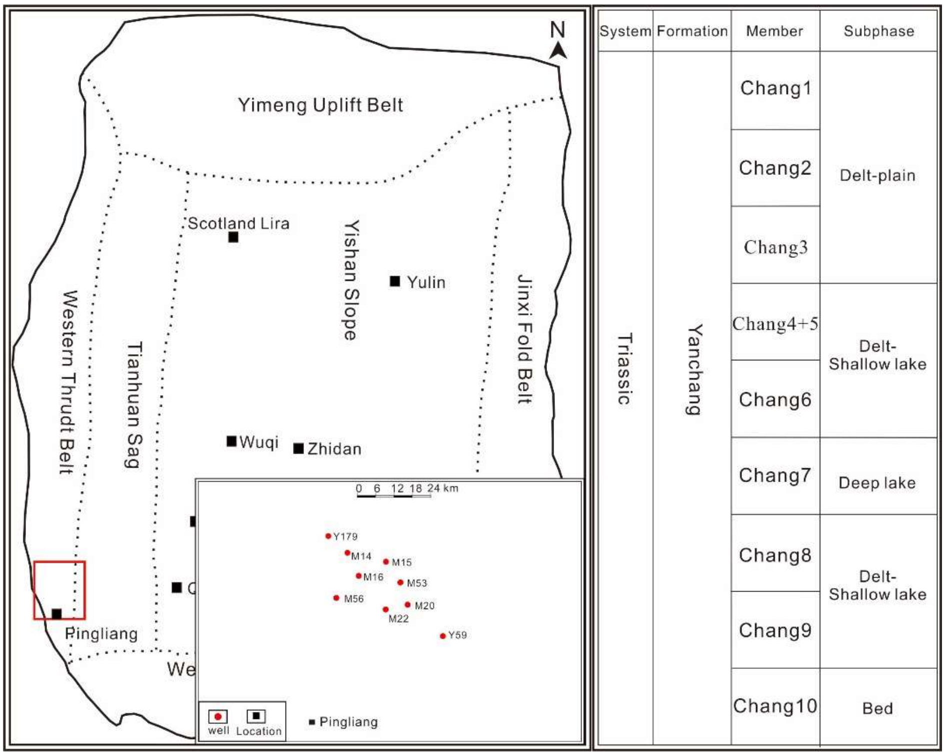

Fig. 1. Location map of the study area

3. Reservoir Characteristics

Pengyang-Pingliang area is located at the edge of the lake basin, which is closer to the direction of the sediment source. From the sedimentary point of view, compared with the central part of the basin, the scale and grain size of sandy deposits in Chang8 area should be larger, and the reservoir conditions should be better, which will lead to the difference of oil and gas distribution characteristics between chang8 area and the central part of the basin.

Through the analysis and interpretation of logging data from more than 100 wells in the Pengyang-Pingliang area, the thickness of the sand body of the Chang81 layer has been counted in different blocks (Table. 1). It can be seen that the average thickness of the sand body in the study area is between 21.7 and 32.1 m, and the sand body gradually thickens upward from northeast to southwest. The thickness of the Chang81 formation is mostly between 35 and 45 m, and the ratio of sand to the average is more than 50%. The scale of the sand body is obviously better than that of the Chang81 oil layer group in the basin. Relatively homogeneous thick sand bodies (thickness>10m) are widely developed, and single sand bodies extend far in the direction of the provenance, up to 10 km. Because the provenance direction of the work area is basically consistent with the tendency of the tectonic slope, such long distance extending thick sand bodies can act as the channel of oil and gas lateral migration.

Table 1. Statistical table of sand body thickness of different block Chang81 in the study area

block	Min(m)	Max(m)	Ave(m)
Yanwu-Sancha	2.7	52.2	26.3
Sangejiao	6.9	48.1	25.6
Wugou east	4.4	38.8	21.7
Shangxinzhuang-Guoyuan	7.7	41.1	22.0
Xiaoxian	8.8	48.4	30.1
Pingliang east	14.9	55.2	32.1

Chang81 in Pengyang-Pingliang area belongs to delta plain subfacies (Liu, 2021), and the sandbodies are mostly delta fluvial deposits. Compared with chang81 oil formation in the basin, the hydrodynamic conditions are stronger, the sediment grain size is coarser, and the reservoir physical properties are better. Compared with different areas in the central part of the basin, reservoir chang81 in Jiyuan and Huachi areas in the central part of the basin mostly has a porosity of 3-12% and a permeability of less than 0.3mD, while reservoir Chang81 in Work area has a porosity of more than 12% and a permeability of more than 0.9mD(Fig. 2), indicating that the reservoir physical properties are obviously better.

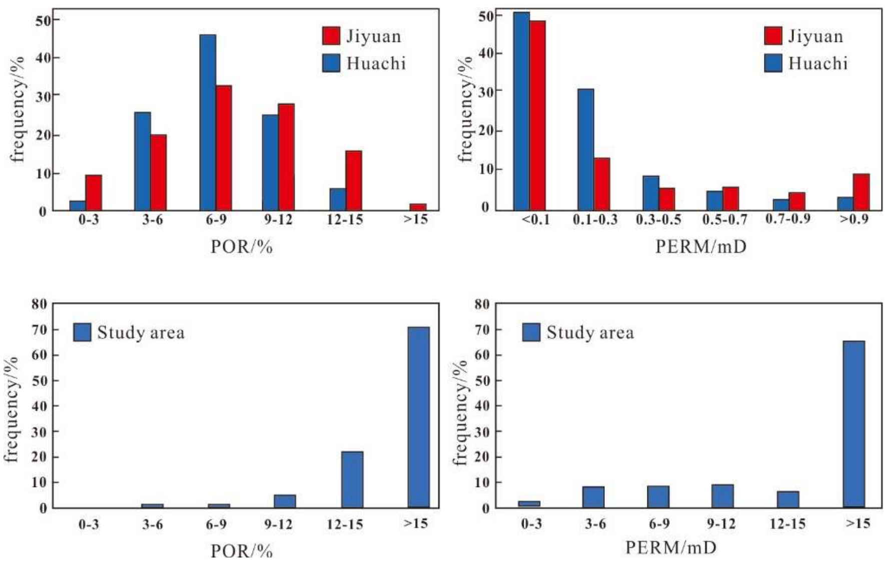

Fig. 2. Histograms of porosity and permeability distribution in the study area and central basin

ISSN: 2414-1895 DOI: 10.6919/ICJE.202201_8(1).0099

4. Fluid Properties Logging Identification Method

Conventional logging plays an important role in the identification and evaluation of conventional oil and gas reservoirs. Based on the study of the formation causes of oil layers in the work area, the characteristics and sensitive information of oil layers in the relation of "four characteristics" are searched, and the lithology, physical property, oil and water content of reservoirs are excavated from the matching relation between resistivity and three porosity, natural gamma ray and natural potential, so as to achieve the purpose of identifying oil and water layers. This paper mainly adopts the intersection chart method.

4.1 The Intersection Chart Method

The intersection chart method is one of the most commonly used methods for quantitative identification of oil and water. When identifying oil layers, this method mainly selects the logging response values of different oil and water layers to intersect, so as to determine the range of variation of the logging response values of the oil layer (Yang, 2010). In the study of this paper, the RT-AC rendezvous chart, RT-DEN rendezvous chart and RT-Sw rendezvous chart were established using the data of part of the well test in the block. It can be seen from the intersection diagram that the plate method can well identify oil layers, oil-water layers, dry layers and water layers.

(1) Intersection diagram of AC-RT

Based on the analysis of 34 reservoir test data from 23 Wells in the study area, the resistivity of the oil layer is greater than 11Ω/m, the acoustic interval transit time is greater than 242μm/s; The resistivity of the oil-water layer is 7-11Ω/m, and acoustic interval transit time is greater than 242μm/s; water The layer resistivity is less than 7Ω/m, the acoustic interval transit time difference is greater than 242μm/s, and the dry layer acoustic interval transit time difference is less than 242μm/s. In all the test oil layers, there are 11 oil layers, 6 oil-water layers, 11 water layers, and 4 dry layers. The electrical properties and oil-bearing characteristics of different fluids can be clearly and intuitively seen by using the acoustic time-travel-resistivity crossplot(Fig. 3).

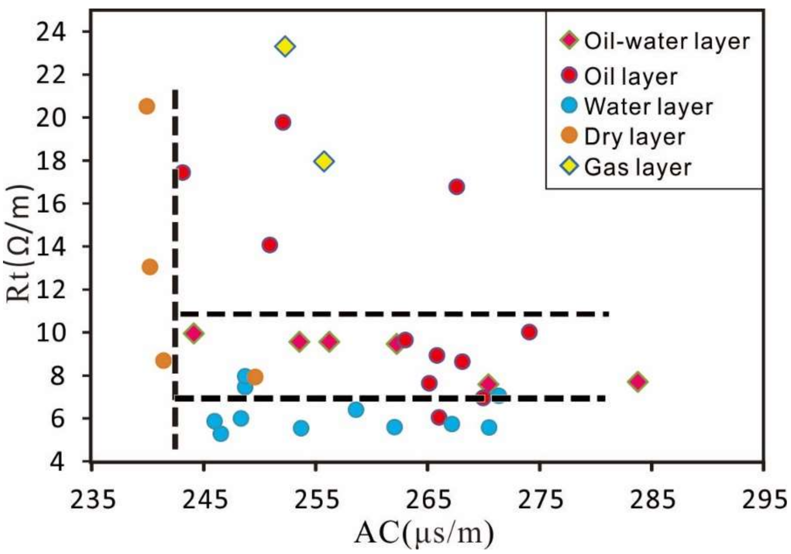

Fig. 3. The AC-Rt Intersection chart

(2) Intersection diagram of DEN-RT

Through the analysis of oil test data of 39 layers of 26 wells in the study area, the resistivity of the oil layer is greater than 11Ω/m, and the density is 2.3-2.42g/cm3; The resistivity of the oil-water layer is 7-11Ω/m, and the density is 2.1-2.42 g/cm3; The resistivity of the water layer is less than 7Ω/m, and the density is less than 2.45 g/cm3(Fig. 4). Among all the test oil layers, there are 11 oil layers, 2 gas layers, 6 oil-water layers, 15 water layers, and 7 dry layers. The boundary between oil and water

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layers can be identified by density difference, and fluid properties can be identified by combining resistivity characteristics. Therefore, the lower limit and distribution law of each layer can be intuitively identified in the crossplot.

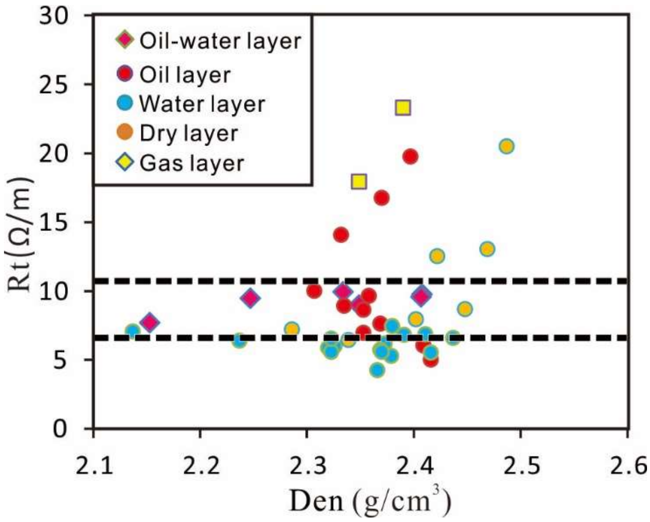

Fig. 4. The DEN-RT intersection chart

(3)Intersection diagram of Rt-Rw

Through the analysis of oil test data of 34 layers of 26 wells in the study area, the resistivity of the oil layer is greater than 11Ω/m, and the water saturation is less than 70%; the resistivity of the same layer of oil and water is 7-11Ω/m, and the water saturation is 55-70%; water Layer resistivity is less than 7Ω/m, water saturation>70% . There are 11 oil layers, 2 gas layers, 6 oil-water layers, 15 water layers and 7 dry layers. Through the Rt-Rw intersection chart you can intuitively see the relationship between oily characteristics and electrical characteristics(Fig. 5).

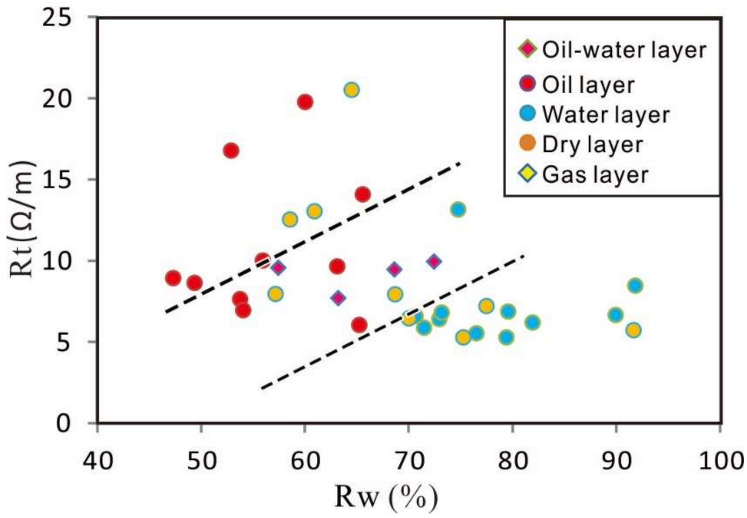

Fig. 5. The Rt-Rw intersection chart

Through the analysis of the above-mentioned multiple charts, the relationship between reservoir lithology, electrical properties, oil content, and porosity is integrated, and the lower limit values of logging parameters of different layers are obtained(Table. 2).

Table 2. Lower limit value of logging parameters of fluid properties in study area chang81

type	Rt(Ω/m)	AC(μm/s)	Den(g/cm3)	Sw(%)
Oil layer	>11	242—274	2.3-2.42	<70
Oil-Water layer	7—11	238—284	2.1-2.42	55-75
Water layer	<7	>240	<2.45	>70
Dry layer	/	<242	/	/

4.2 Influence Factors of Fluid Property Identification

Comparing the oil test results of M53 and M20 Wells in the study area, it is found that the resistivity of Chang8 reservoir in M53 well is 17.25Ω/m, water saturation is 45.77%, density is 2.36g/cm3, acoustic time difference is 258.81µs/m. The reservoir resistivity of Chang8 in Well M20 is 9.64Ω/m, water saturation is 63.12%, density is 2.36g/cm3, and acoustic time difference is 265.83µs/m. The intersection chart method was used to judge that well M53 and Well M20 chang8 were oil layers. But the test data showed that well M20 produced oil and well M53 produced water. This obviously does not agree with the logging interpretation.

According to the characteristics of Chang81 reservoir in the study area, the chang8 sand body has large sedimentary scale, coarse grain size and better physical properties compared with the middle part of the basin. Thick homogeneous sand bodies with thickness greater than 10m are developed in large quantities, and low-amplitude structure plays an important role in controlling the distribution of oil and gas. In the reservoir profile of Y47-M61 well (Fig. 6), M53 well is located in the low part of low-amplitude structure, and M20 well is located in the high part. In addition, the cores of both Wells contain oil, which indicates that the Chang8 reservoir of both Wells was enriched with oil and gas in a certain geological period. However, due to the later structural adjustment, Well M53 is in the low part of low-amplitude structure, while Well M20 is in the high part of low-amplitude structure, and oil and gas gather at well M20(Fig. 7b). As a result, the core of Well M53 contains oil, but the oil test results in water((Fig. 7a)). Therefore, when using logging method to identify reservoir fluid properties, factors such as structure, sand body, migration and transport condition system should be fully combined to effectively avoid misjudgment.

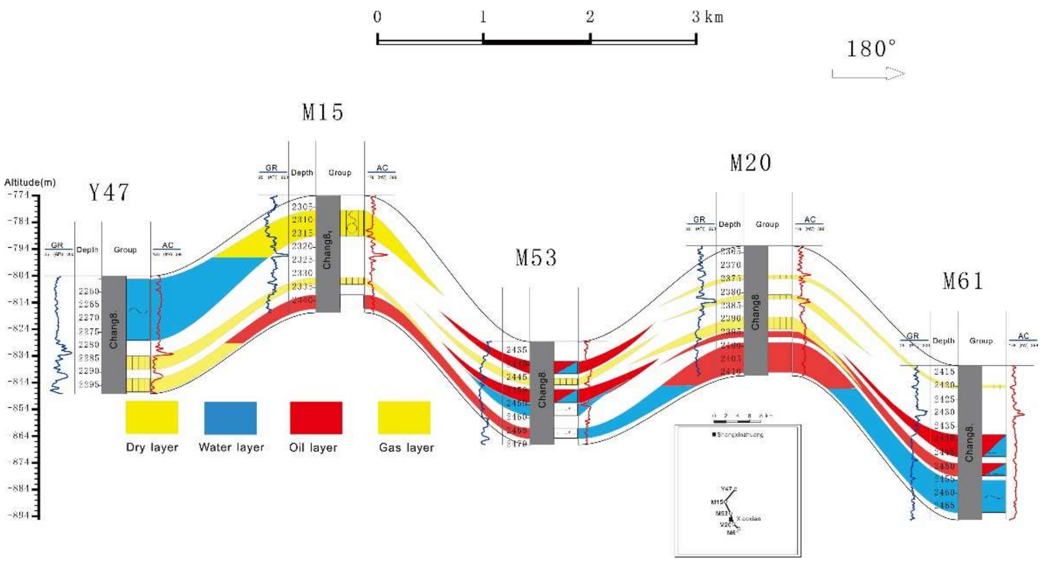

Fig. 6. Well Y47-M61 reservoir interwell profile

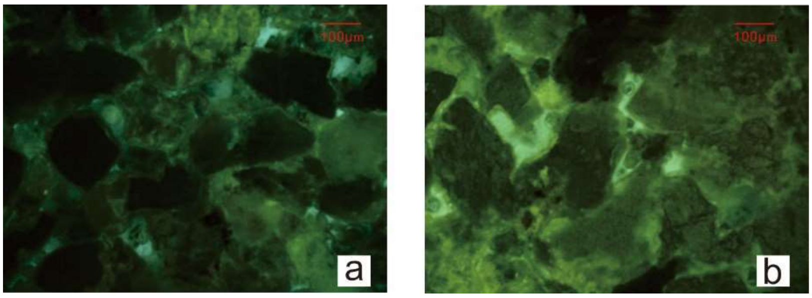

Fig. 7. Fluorescence photos of Chang81 reservoir in Pengyang-Pingliang area

5. Conclusion

(1) Compared with the middle part of the basin, the thickness of chang81 reservoir in Pengyang-Pingliang area of Ordos Basin is 35 ~ 45m, and the average sand-ground ratio is more than 50%. The sand-body size of Chang81 reservoir in pengyang-Pingliang area is obviously better than that of chang81 reservoir in the basin. The porosity of Chang81 reservoir in the study area is more than 12%, and the permeability is more than 0.9mD, indicating that the reservoir physical property is obviously better.

(2) By using crossplot method, the criterion of fluid property of chang81 in the study area is established, and the influence of structural evolution characteristics on reservoir should be paid attention to when using logging method to identify reservoir.

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