IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

A Hydrocarbon Migration and Accumulation Characteristics of the Chang 9 Reservoir Group of the Yanchang Formation in Upper Triassic of Ordos Basin

To cite this article: Pengpeng Gao *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **310** 052012

A Hydrocarbon Migration and Accumulation Characteristics of the Chang 9 Reservoir Group of the Yanchang Formation in Upper Triassic of Ordos Basin

Pengpeng Gao[1,2], Shengli Gao[1,2], Fenggang Wen[3,] and Fengbo Gao[4]

[1]Xi'an Shiyou University, Xi'an710065, China

[2]State Key Laboratory of Continental Dynamics (Northwest University), Xi'an, 710069, China

[3] Research Institute of Shaanxi Yanchang Petroleum (Group)Co Ltd.

[4]Shaanxi Yanan Petroleum Corp. Ltd.

[*]Corresponding author's e-mail: ycsygp@126.com

Abstract. Groups of reservoirs were found in the deep zones of Upper Triassic Yanchang formation and the feature of hydrocarbon source rocks, the characteristics of overpressure and genesis mechanism of abnormal overpressure was studied in this paper. The factors of accumulation in lower part of Yanchang formation are different, which could be divided into three types: controlling reservoir, paleo structure controlling reservoir and reservoir controlled by pressure & paleo structure. It is shown that the reservoir distributed in where hydrocarbon source developed, the delta-front and gravity-flow sediment are the main areas for the ultra-low-permeability reservoirs and the places of low-overpressure are the preferential places for hydrocarbon migration & accumulation.

1. Introduction

In recent years, with the advance of technical means and expansion of the exploration field, groups of reservoirs had been found in the deep zones of Upper Triassic Yanchang formation. One of the most representatives is Zhidan oilfield found in southwestern of Ordos Basin with high-quality reserves of more than 400 tons in underwater fan, and Chang 9 member of Yanchang formation achieved good exploration results of 12.3m^3/d per well showing the great potential, and it will be an important layer in the future. The important influence of oil and gas has been overcharged into low permeability and then hydrocarbon accumulated in the tight reservoir (Li and Li,2010). The Chang 9 member or reservoir belongs to the tight oil with low porosity and low permeability and study on rules of the migration, accumulation, and oil and water distribution was taken (Hao et al.2002; Wang and Li,2007; Cao et al.2018; Ma et al.2018).

The overpressure formed by the source rock during the main hydrocarbon generation period is the main driving force for oil migration to the tight reservoir (Magara 1981; Zhang et al.2018). This paper is the first study revealing the overpressure players in the tight reservoir of Chang 9 oil group in Zhidan Oilfield and repents a case study linking the overpressure role in the petroleum accumulation.

2. Characteristics of overpressure

The sound wave compaction curve is established based on logging and other data, and the principle of equivalent equilibrium depth calculates the excess equilibrium pressure. It should note that due to the irreversibility of rock compaction, the compaction curve reflects the compaction state of the formation at the maximum buried depth, and the calculated overpressure is the pressure of the maximum buried depth of the formation.

2.1. Vertical distribution characteristics

The formation pressure structure refers to the developmental characteristics of the vertical overpressure system, the transition relationship between the overpressure system and the overlying normal pressure system. The formation pressure structure is closely related to the accumulation and preservation of oil and gas. The pressure structure of the overpressure basin can be divided into three basic types (figure 1): a mutant type (A type) pressure structure, a graded type (B type) pressure structure, and a stacked type (C type) pressure structure.

The shale of Lijiaban, namely the second largest source rock of Ordos Basin in China, is generally developed throughout the study area and can be used as a cap layer. The sealing property is very good, and the A-type pressure structure is relatively developed. However, there are great difference of pressure presentation in different area due to the difference of sedimentation-deposition rate and filling lithology.

According to the morphological characteristics of the overpressure of Chang 9 member reservoir, the overpressure in the study area can be identified into two types: a mutant type (A type) pressure structure and a stacked type (C type) pressure structure. There are two pressure systems in the vertical direction, the hydrostatic pressure system is mainly developed in the upper part, the overpressure system is deep in the middle, and there is no obvious transition zone in the middle, showing the mutant contact, reflecting the structural characteristics of the mutant in the first mutant type (figure 2). A plurality of pressure systems is developed vertically in the stacked type (C type) pressure structure. Two overpressure systems are developed under the hydrostatic pressure system, a significant transition zone developed between two different pressure system as shown in Figure 3, and the overpressure system was developed in vertical direction due to the mudstone of Chang 9 grows discontinuously in the Well Z394.

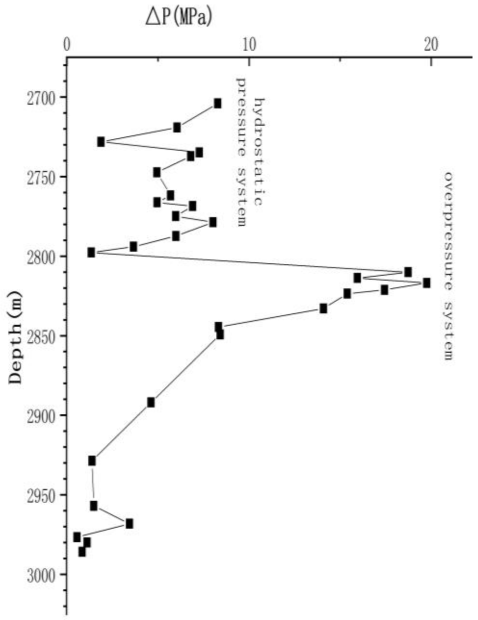

Figure 1. A mutant type (A type) pressure structure in Well Z3222

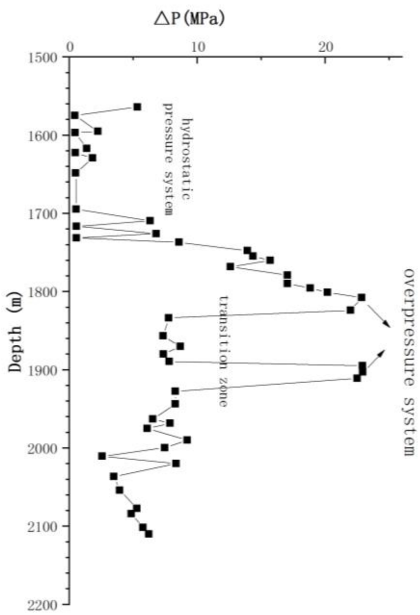

Figure 2. A stacked type (C type) pressure structure in Well Z394

2.2. Lateral distribution characteristics

It is found that existence of two types of pressure of A and C is closely related to the distribution of Chang 9 mudstone. Generally, the thick layer of mudstone develops in a place where the pressure structure is developed and C type developed in the place where the mudstone always is discontinuous, which fully demonstrates that mudstone (shale) is the most important type of rock that produces overpressure.

The highest residual pressure distribution horizon (greater than 10 MPa), generally more than 15 MPa, mainly concentrated on the top of Chang 9 member and good continuity in the south, and it's the length exceeds 50 Km from the Well Z355 to Well X28. The pressure is reduced, and the continuity is deteriorated; the residual pressure in the middle and lower sections of Chang 9 member and the Chang 10 member is generally small, most of which is <10 MPa. The overall overpressure difference between the top part of Chang 9 member and the whole Chang 9 member is generally more than 10 MPa, which provides sufficient power for oil to migrate downward. At the same time, the overpressure difference between the top part of Chang 9 and the Chang 8 member is generally more than 10 MPa, which is conducive to oil and gas migration upward (figure 3).

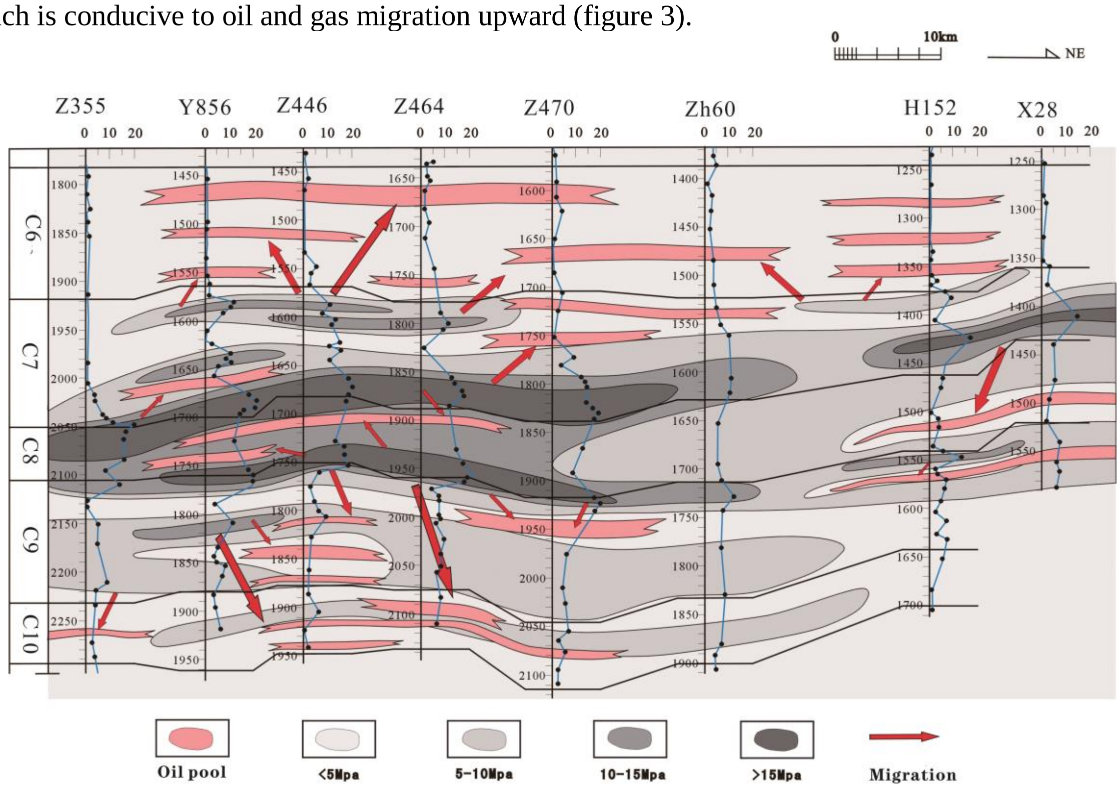

Figure 3. Schematic diagram of overpressure from Well Z446 to Well Z470 well in Zhidan oilfield, Ordos Basin, China.

The higher overpressure difference generally developed in top part of Chang 9, and the overpressure difference is the main driving force for oil migration. The high-value region in the background of the vertical overpressure difference is the main place for oil and gas accumulation where lots of wells drilled with good oil test.

3. Genesis mechanism of abnormal overpressure

The abnormal overpressure refers to the phenomenon that the pressure on the pore fluid is higher than the hydrostatic pressure, and its genesis mechanism includes elements of sedimentary compaction, tectonic action, hydrothermal pressurization, mass production of hydrocarbons and non-hydrocarbon gases, diagenesis, and other factors can cause abnormal high pressure in the formation (table 1).

The genesis mechanism of abnormal overpressure for Chang 9 reservoir are mainly the under compaction caused by uneven compaction. The faster deposition and sedimentation rates and hydrocarbon generation which can make organic / kerogen converted to petroleum resulting in a significant increase in pore volume.

Table 1. Types of genesis mechanism of abnormal overpressure.

Mechanism types		Characterization
Change in pore volume of rock	vertical load (undercompaction)	Areas with faster deposition and sedimentation rates, overpressure is caused by uneven compaction.
	lateral extrusion stress	Pore volume is reduced due to the horizontal structural compression of the rock, such as local and regional fractures, folds, diapir, earthquakes, etc.
	secondary cementation	Cementation happens: $CaSO_4$, NaCl, $CaCO_3$, etc. can be used as a closed covering (pressure cap layer). The crystals growth in the reservoir causes a decrease in pore space, which can make a direct increase in pore pressure.
Volume change in pore fluid	aquathermal pressuring	Formation temperature increasing causes fluid to expand led to pressure to increase.
	Epigenesis	Post-deposition modification (boundary water release): (1) conversion of montmorillonite and mixed clay into illite (smectite dehydration); (2) conversion of gypsum to anhydrite
	Hydrocarbon generation	Organic / kerogen converted to oil or gas resulting in a significant increase in pore volume
	Hydrocarbon cracking	The thermal cracking of organic molecules starts at 120-140 ° C depending on the deposit depth. When the temperature exceeds 180 °C, almost all hydrocarbons can convert into methane gas (dry gas).
Fluid pressure change	Percolation	The difference in brine concentration in the formation fluid allows the fluid to pass through the semi-permeable membrane for conversion
	Fluild pressure	Territorial isopotential surface effects
	relative density difference	The relative density difference between solid and liquid

4. Coupling relationship between overpressure and reservoirs

The overpressure is not only an important source of power for oil and gas migration but also an important factor in controlling oil and gas accumulation under certain geological backgrounds. Therefore, studies on relationship between overpressure and reservoir plays a significant role in oil and gas exploration of the deep parts of Yanchang formation.

4.1. Abnormal overpressure is the driving force for oil migration.

The higher overpressure developed generally in top part of Chang 9, and its value is generally 4-8 MPa, exceeding 8 MPa in local area. There are also relative higher overpressure between the Chang 9 member and the top parts of Chang 10 member, and its value is generally 2-6 MPa, exceeding 6 MPa in local area demonstrates that the abnormal overpressure is the driving force for oil migration.

4.2. The zone with relative low pressure is the main place for petroleum accumulation.

The petroleum migrates from a place with high pressure to another one with low pressure, not only in the vertical direction, but also in the lateral migration, and then in the low-pressure zone or the relatively low-pressure zone. The high-value region in the background of the vertical overpressure difference is the main place for oil and gas accumulation where lots of wells drilled with good results.

5. Conclusion

The overpressure is the driving force for oil migration and the distribution of overpressure is major

IOP Conf. Series: Earth and Environmental Science **310** (2019) 052012 doi:10.1088/1755-1315/310/5/052012

zone for petroleum accumulation. The genesis mechanism of abnormal overpressure are hydrocarbon generation where organic / kerogen converted to oil or gas in a larger volume and Chang 9 reservoir ae mainly the under-compaction and aquathermal pressuring. The overpressure is the main controlling factor for hydrocarbon migration and accumulation in the main period of tight reservoir. To study the coupling relationship between overpressure and reservoir is important for exploration in the future.

Acknowledgments
Authors want to give many thanks to professor Hunjun Qu from geology department of Northwest University and colleagues and field engineers in the Institute of Shaanxi Yanchang Petroleum (Group) Co.LTD for their supplied some data and helpful comments.

Founding
The financial support has received from China Foreign Language Assessment Fund Project (ZGWYCPJJ2018137B) and Natural Science Basic Research Plan in Shaanxi Province of China (2019JM-359).

References
[1] Li, M., & Li, J. (2010). "dynamic trap": a main action of hydrocarbon charging to form accumulations in low permeability-tight reservoir. Shiyou Xuebao/Acta Petrolei Sinica, 31(5), 718-722.
[2] Hao, F., Zou, HY., & Jiang, JQ. (2002). Dynamics of petroleum accumulation and its advances. EARTH SCIENCE FRONTIERS. 7(3):11-21.
[3] W, ZL., & Li, YH. (2007). Analysis on main formation mechanisms of abnormal fluid pressure in the Upper Triassic, West Sichuan area. OIL & GAS GEOLOGY, 28(1), 43-50.
[4] Cao, Y., Liu, YZ., Chen, YG., Meng, WC., & Gao, PP. (2018). Hydrocarbon accumulation conditions and main controlling factors of Chang 7-Chang 9 in Yanchang Formation of Donghan Oilfield, Ordos Basin. LITHOLOGIC RESERVOIRS. 31(1):30-38.
[5] Magara, k. (1981) Mudstone compaction. Petroleum industry press, Peking
[6] Zhang, JH., Chang, XC., Yin, W., & Liang, JX. (2018). Overpressure and Hydrocarbon Accumulation in Tight Oil Reservoirs of Honghe Oilfield, Ordos Basin Journal of Xi'an Shiyou University (Natural Science). 33(5):13-20.