The Numerical Discrete of Movement Intensity of Hailaer Oil Field

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Abstract. The oil & gas distribution inside the sag is obviously different from the Daqing placantieline, some complex problems are ubiquity such as the large-area oil poors in the secondary depression center, the complex distribution of oil and water, the poor gravititional differentiation etc. Hailaer sag is one of the main hydrocarbon generation unit in the Songliao basin, and a large number of oil and gas has been found. The distribution of oil and gas in Hailaer sag and Daqing placantieline are obviously different, and the main reason maybe the difference of tectonic intensity. By quantitative description of tectonic intensity in strata section, the period of oil migration is considered to begin after Nenjiang group deposited. The numerical simulation results combined the quantitative description show that the gentle dip angel and weak fault activity in Hailaer sag makes low driving force of second migration. Oil and gas migration distance is short, the direction is discrete, oil is full of sag but the trap fullness is low.

Keywords: Hailaer Oilfield; Numerical Discrete; Periods of Tectogenesis

1. Introduction

Hailaer sag of Songliao basin is a secondary tectonic unit in the central depression that lies adjacent to the west of Daqing Placantieline, its northeast part is Mingshui terrace, Suiling anticlinal belt and Suihua deppresion, while the southeast part is Chaoyanggou anticlinal belt, which seems like a trangle sag surrounds by five positive tectonic belts. Its geographical position is on the Northern Songliao basin.

It has been proved in current research that the Hailaer sag also supply hydrocarbon to its interior except to the Daqing placantieline, that the Songfangtun, Shengping, Xujiaweizi, Yongle, Zhaozhou and Yushulin field has been successively found inside the Hailaer sag.

2. The relationship between tectonic movement and the hydrocarbon migration

Formation of high abundance hydrocarbon accumulation depends on the hydrocarbon migration efficiency which contains three aspects about the changes of hydrocarbon migrati's distance, velocity and pathway [1]. Buoyancy force is the major dynamic force to the secondary migration, the other active force such as the hydrodynamic force, capillary force, subsurface thermodynamic force, structural dynamic force etc which can be superimposed upon the buoyancy force [2]. The major passageway of the secondary migration is the pore, fracture and crack, the difference of the throat radius reflects the physical property and affect the migration efficiency [3].

The dip angel of structural surface determines the buoyancy force when the hydrocarbon migrate in the sand bodies. The mainly dynamic force of hydrocarbon migration is the buoyancy caused by the density difference between the hydrocarbon and water.

It could be inferred that buoyancy force gradient can be used to measure the dynamic force of secondary migration, which is in connection with the value of buoyancy force in unit horizontal distance, the oil & water density difference and the strata dip angle.

$$\frac{dF}{dL} = \frac{\Delta\rho g H}{L} = \Delta\rho \cdot tg\,\alpha \tag{1}$$

F represents the height of hydrocarbon column, α represents the state dip angle, *L* represents the horizontal distance, *H* represents the vertical distance, $\Delta\rho$ represents the density difference between hydrocarbon and water.

3. Tectonic strength analysis of the Hailaer sag in different sedimentary periods

Strata crooked and cracked under the regional tectonic stress, there are some research methods in the tectonic geology [4], but most of them are complex. This paper designs a simplified quantitative indication of the tectonic movement intensity in section:

$$S = (L_2 - L_1) / L \tag{2}$$

S represents the target layer deform rate from sedimentary period S_2 to S_1, L_1 represents the target layer section length in the sedimentary period of S_1, L represents the vertical projection length of section line.

The profiles of the paleostructure morphology in the Hailaer sag during each geological period show that the structures were gentle and tectonic activities were weak during the Nen-2 member, Nen-3 member and Nen-4 member periods. The study area deposited greatly associated with the folding during the Nen-5 member period, Daqing placantieline in the western part begins to uplift, while the whole entry into the period of violent tectonic activities. Fig. 1 quantitatively shows the deformation rate of each period, Nen-5 member becomes the separatrix of the tectonic active stage and stable stage, and this is also the time of hydrocarbon escape from the source rock of Qing-1 member, the large scale expulsed hydrocarbon can migrate and accumulate along the T2-T1-1 fault, Therefore, the sedimentary end of Nenjiang formation is the main period of oil & gas migration and accumulation in the studied Putaohua oil member (Fig. 2).

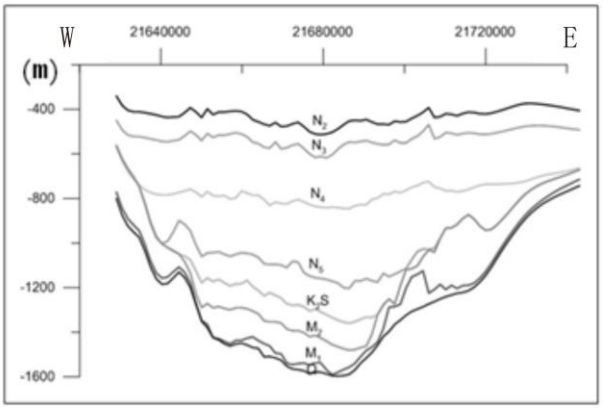


Figure 1. Structural profile of Putaohua layer in different geological period

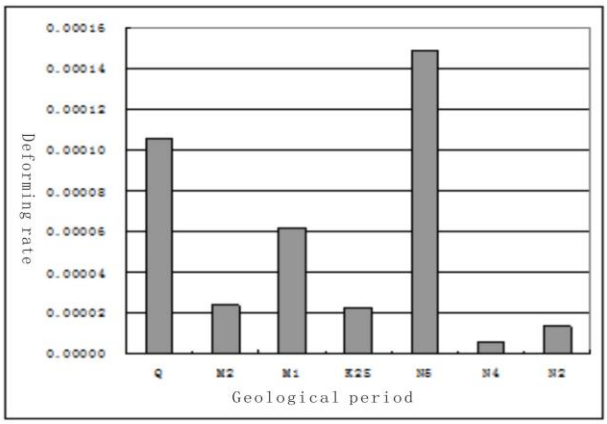


Figure 2. Tectonic deformation degree of Putaohua layer in different geological period

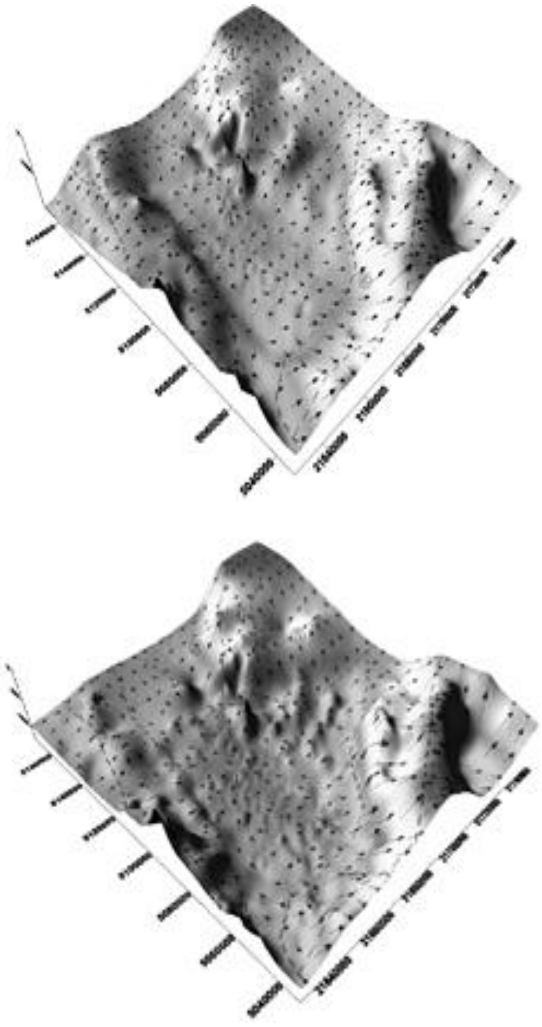
4. The influence of tectonic movements of Hailaer sag on the hydrocarbon migration

Direction of paleofluid are analyzed according to the structural shape of each period. If the migration can be seen as the rainwater flows along the paleotopography, the flow direction could be the biggest descending speed of the slope(from high to low), the flow speed is the function of the

terrain slope, the larger the slope is, the bigger the flow speed would be. The oil flow is just opposite to the water, for the migration direction is from lower to upper part impulse by the buoyancy [5].

Hereby, slope in the space domain of structural surface (namely the strata dip angle) can be depicted by the directional derivative in mathematical sense [6].The slope can be given by the directional derivative along the prescriptive direction. Though discerning the paleo tectonic contour map of different periods, taking value according to the fixed transverse & longitudinal distance, finally formed the data file for calculation. The first directional derivative of the Putaohua oil layer in the Hailaer sag can be made by the software based on this principle, as shown in Fig. 3. The direction of arrow represents the flow migration direction, and its length represents the slope, namely the oil & gas migration intensity.

Daqing placantieline uplifted obviously during the Nen-5 member period, the strata dip angle varies form 4 ‰ to 5 °.It turned into favorable oil & gas accumulation zone that the indication of hydrocarbon migration is obvious, and the migration intensity strengthened largely. During this period the line of Weixing-Songfangtun-Mofantun tends to uplift, the indication of the disordered migration direction become definite, this proved the structure paleotopography is important to the oil & gas accumulation in the Hailaer sag.



1-Hailaer sag; 2-Daqing placantieline; 3-Mingshui terrace; 4-Suiling anticline belt; 5-Suihua sag; 6-Chaoyanggou terrace

Figure 3. Ancient tectonic morphology and fluid migration direction of northern Songliao Basin in geological history

5. Conclusion

Tectonic movements caused the strata crooked, cracked, subsidence and uplifted, and the inclined strata which caused by the tectonic movements become crucial to the production of buoyancy. The tectonic intensity matched the hydrocarbon expulsion process can determine the period, direction and intensity of hydrocarbon migration during the periods of tectogenesis. Inclined strata can produce sufficient and long-distance hydrocarbon migration in large area, which can then differentiate oil & gas & water and fill the trap with a large number of aggregated hydrocarbon, such as the Daqing placantieline. On the other hands, while the hydrocarbon migration distance is short and hydrocarbon accumulation amount is small in the area with the gentle inclined strata and simple structures, which would cause the trap unsaturated and the oil & water distribution complicated, such as the Hailaer sag.

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