

Relationship between oil-water distribution and reservoir at the top of Badaowan Formation in Chepai 7 well area of northwestern margin, Junggar Basin

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Abstract

In view of the unclear understanding of the relationship between oil-water distribution and reservoir at the top of Badaowan Formation in Chepai 7 well block. Based on the data of mud logging, logging and the seismic and related information, a comprehensive use of various technical means, such as connected wells facies, seismic facies, sedimentary facies, seismic attribute analysis, seismic wave impedance inversion and stratum slices, etc., were used to deeply study the oil-water relationship and reservoir distribution in the study area. The results show that sand body annihilation and disconnected are the main control factor for the complex relationship between oil and water. There are three relatively independent underwater distributary channel sand bodies in the top of Badaowan Formation in Chepai 7 area. Among them, the sand body of well Chepai 7 is not connected with that of well Che 369, and the sand body of well Che 369 is not connected with that of well Che 5027. The sand body of well Chepai 7 and Well Che 5027 is favorable reservoir for oil production, while the sand body of well Che 369 produces water. This study has gained a breakthrough understanding of the oil-water relationship and reservoir distribution at the top of Badaowan Formation in Chepai 7 well area. It is an important guiding significance for the development of the area.

Keywords

Junggar Basin, Chepai 7 well area, Badaowan Formation, oil-water relationship, reservoir prediction.

1. Introduction

Well block Chepai7 is located in the north of Chepaizi Oilfield on the northwest edge of Junggar Basin [1-2]. In recent years, many wells at the top of Badaowan Formation in well block Chepai7 have produced oil and some wells have produced water. At the same time, some of the adjacent wells produce oil and water in the same layer, and there are oil and water in low parts and water in high parts. The relationship between oil and water is complex and the relationship between oil and water and sand body distribution is unclear. Combined with the oil test results, this paper will study the oil-water distribution and favorable sand body distribution in the study area by comprehensively using the theories and technical means of well connected facies, seismic facies, sedimentary facies, seismic attribute analysis, seismic wave impedance inversion and seismic sedimentology, so as to predict the relationship between oil-water distribution and favorable sand body, so as to provide geological basis for the further development of the area.

Abundant oil and gas resources are stored in Jurassic in the northwest margin of Junggar basin. There are many oil and gas production layers. Jurassic is an important production layer in the study area [3-6]. In the early stage, the research scope of sedimentation and sand body distribution is large, which is the whole Chepaizi area or Chepaizi uplift, including Chepai7 well area. Specifically, there are few published data on the fine sedimentary analysis and sand body

distribution of Jurassic in Chepai 7 well area [7-8]. It is the first time to study the oil-water relationship and the distribution of favorable sand bodies in this area. Based on the analysis of the characteristics of heavy mineral content, sandstone thickness, sandstone clastic composition and sedimentary paleogeomorphology, Tan Jian and Yang Kai believe that there are two provenance systems in the Jurassic Badaowan Formation in Chepaizi area, namely, the provenance system of Zaire mountain in the northwest and the provenance system of yilinheibiergan mountain in the Southwest. The provenance system of yilinheibiergan mountain extends far and spreads widely; At the same time, combined with the analysis of petrological characteristics, grain size analysis and logging data, it is considered that there are fan delta, braided river delta and swamp lake in Badaowan Formation of Jurassic in Chepaizi area [9-10]. Through sequence stratigraphic analysis, combined with core data observation, logging data and seismic attribute slicing, Dong Xuejie believes that braided river delta front subfacies are mainly developed in the north and middle of Chepaizi area, among which the main microfacies are braided river delta underwater braided river channel and inter tributary Bay, sheet sand, estuary bar, distal sand bar, etc., and shore shallow lake subfacies are developed in the edge area; The plane distribution of Jurassic sedimentary facies in Chepaizi area has strong inheritance, but there are local differences [11].

2. Regional geological overview

Chepai7 well block is located in the north of Chepaizi Oilfield on the northwest edge of Junggar Basin and in the east of Chepaizi uplift. Chepaizi uplift is a secondary positive structural unit of Junggar basin. Chepaizi uplift is connected with Shawan depression in the East, Zaire mountain in the west, Sikeshu depression in the South and Kebai fault zone in the North (Fig. 1) [12]. Qigu formation (J_3q), Xishanyao Formation (J_2x), Sangonghe Formation (J_1s) and Badaowan Formation (J_1b) are developed in Jurassic in Chepaizi area. The sedimentary facies of Chepaizi area is mainly fan delta [6, 9-10]. Badaowan Formation in well block Chepai7 can be divided into four sand layer groups J_1b_1, J_1b_2, J_1b_3 and J_1b_{4+5} from bottom to top. The lithology is mainly pebbly sandstone, siltstone, fine sandstone, mudstone and thin coal seam (Table 1). In the south of well block Chepai7, a NW trending North Fault of well che82 is developed, and in the west, a nearly NS trending and NE trending East fault of well che62 is developed (Fig. 2).

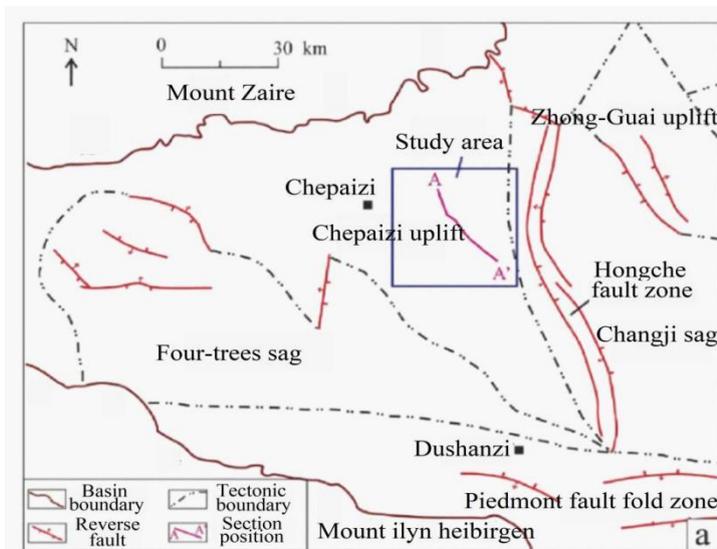


Figure1: Tectonic location of Chepaizi uplift and research area in Junggar Basin

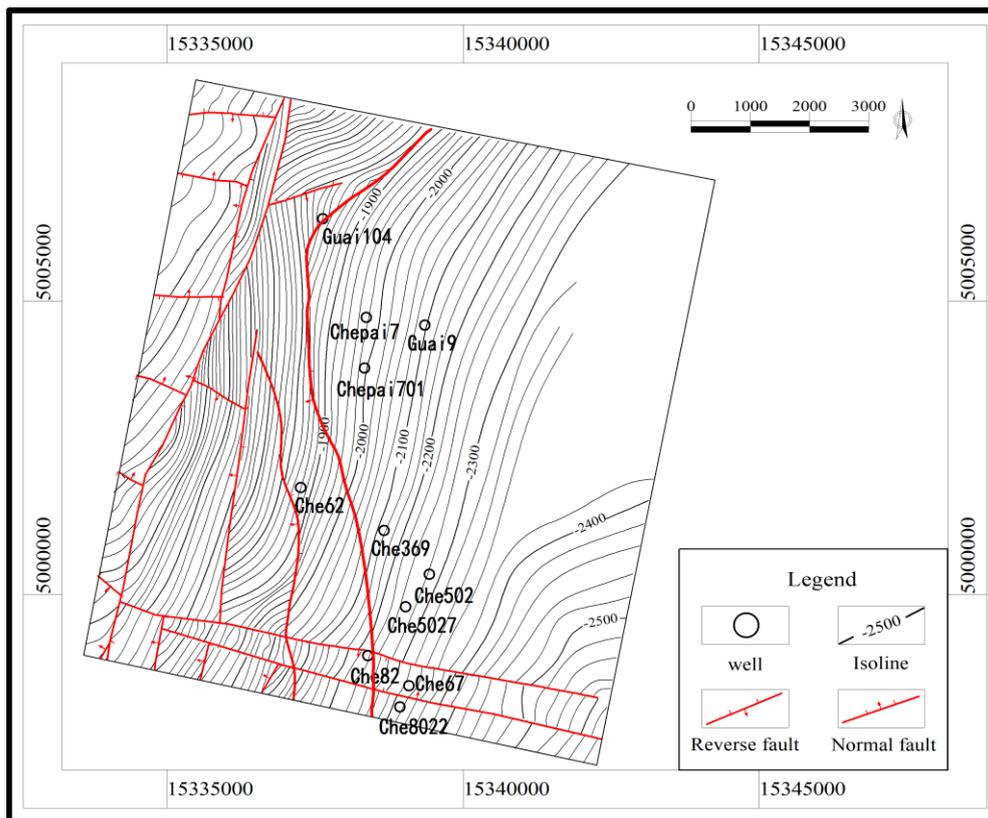


Figure2: Top structure of Badaowan Formation in well block Chepai 7

Table 1: Stratigraphic distribution of Jurassic system in Chepaizi area

Stratum				Lithology description	Unconformity scale	Tectonic movement
System	Series	Formation	Section			
Junggar System	Upper series	Qigu Formation (J _{3q})		The lithology is gray gravelly unequal grained sandstone and gray sandy conglomerate.	Regional unconformity	Yanshan movement I
	Middle series	Xishanyao Formation (J _{2x})		The upper lithology is brown mudstone and gray pebbly argillaceous sandstone; The middle part is brown mudstone and brown yellow gray argillaceous sandstone; The lower part is white sandy small conglomerate and unequal grain sandstone.	Local unconformity	Yanshan movement II
	Lower series	Sangonghe Formation (J _{1s})		The lithology is gray sandstone and mudstone, intercalated with silty mudstone interbedding.	Local unconformity	
		Badaowan Formation	J _{1b4+5}	The upper lithology is mainly gray argillaceous sandstone and une	Regional unconformity	

		(J _{1b})	J _{1b3}	qual gravel sandstone, intercalated with coal seams; The lower part is mainly gray sandy conglomerate, intercalated with coal seams.		
			J _{1b2}			
			J _{1b1}			

3. Sedimentary characteristics at the top of Badaowan Formation

3.1. Analysis of sedimentary facies of connected wells

According to the data of logging, well logging and oil testing, based on the research and division of single well sedimentary facies and sedimentary cycle of key wells in Chepai7 well area and the analysis of oil testing results [13-15], the comprehensive well connection profile of well Che5027 - well Che502 - well Che369 - well Chepai701 - well Chepai7 in the near south-north direction is established (Fig. 3).

It can be seen from Figure 3 that during the sedimentary period of Badaowan Formation, the water body showed an upward trend. The middle and lower part of J_{1b4+5} section in the upper part of Badaowan Formation is mainly composed of mudstone and silty mudstone; Thin coal seams and sand layers are developed at the top of this section. Some wells produce oil and some wells produce water. The sedimentary facies at the top of Badaowan Formation in chepai 7 well block is mainly fan delta front subfacies, which is composed of five sedimentary microfacies: underwater distributary channel, underwater distributary channel, estuary bar, distal bar and sheet sand; And swamp facies is developed. At the top of J_{1b4+5} section of Badaowan Formation, from top to bottom, well Che 5027 develops swamp facies and sheet sand, well Che502 develops swamp facies and underwater distributary channel, well Che369 develops swamp facies and sheet sand, well Chepai701 develops swamp facies and underwater distributary channel, and well Chepai7 develops underwater distributary channel and swamp facies.

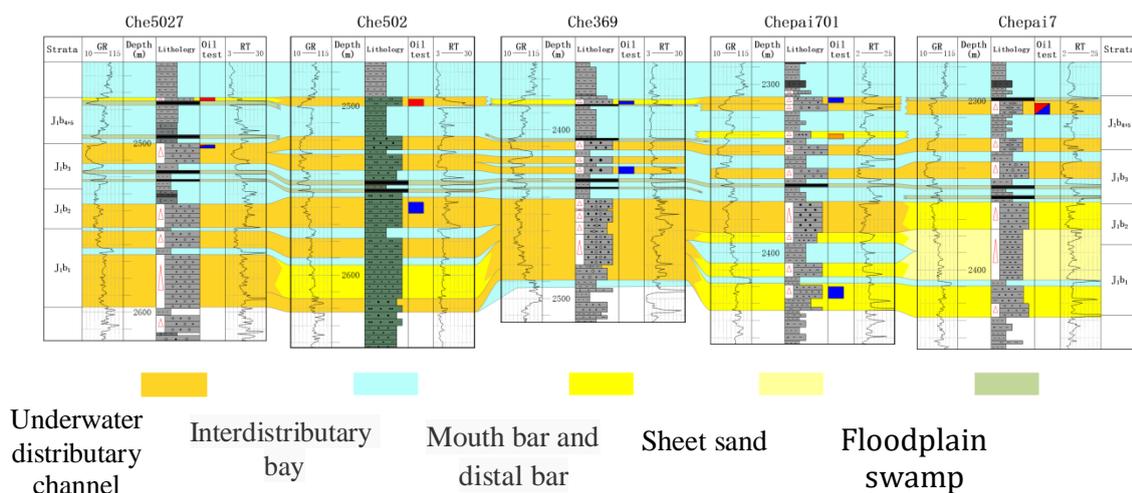


Figure3 :Sectional view of the sedimentary facies of the connected well

3.2. Plane distribution of sedimentary facies

Combined with well connected sedimentary facies analysis, seismic facies, seismic attribute analysis, seismic wave impedance inversion and seismic sedimentology analysis, the plane distribution of sedimentary facies at the top of J_{1b4+5} section is studied.

Fig. 4 shows the seismic phase diagram of the window 15ms down from the top of Badaowan Formation in Chepai7 well block. The seismic facies map reflects the basic shape of the fan delta

at the top of Badaowan Formation, preliminarily shows the basic distribution range of fan body and sand body, and also shows that the material source comes from the west, which is basically consistent with the sedimentary microfacies corresponding to the top of Badaowan Formation in Fig. 3. Combined with the understanding of fan body and sand body distribution in the seismic amplitude and frequency attribute slice and wave impedance inversion slice at the top of Badaowan Formation, the sedimentary facies plan at the top of Badaowan Formation is prepared as shown in Fig.5.

According to the seismic facies, seismic amplitude and frequency slices, the boundary of the three sand bodies is relatively clear. The sand body of well Chepai7 may not be connected with the sand body of well Chepai701 and well Che369; The sand bodies of well Chepai701 and well Che369 may not be connected with the sand bodies of well Che502 and well Che5027. In this way, the sand body where well Chepai7 is located is the same oil-water layer, the sand body where well Chepai701 and well Che369 are located produces water, and the oil production of the sand body where well Che502 and well Che5027 are located should comply with the law of sedimentology. The annihilation and disconnection of the sand bodies lead to different liquid production properties of the three sand bodies, which is the control factor of complex oil-water relationship.

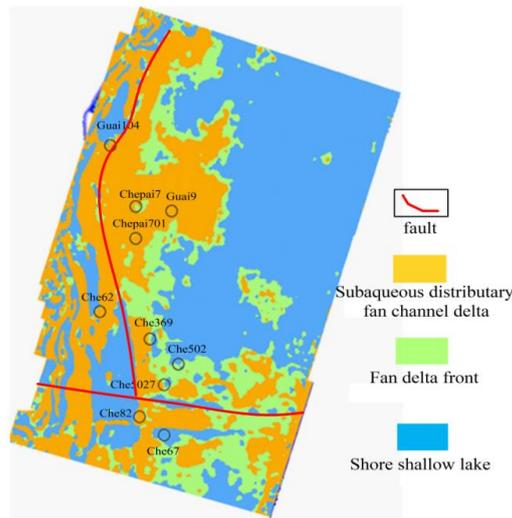


Figure4:Seismic phase diagram of the top Badaowan Formation in Chepai 7 well area

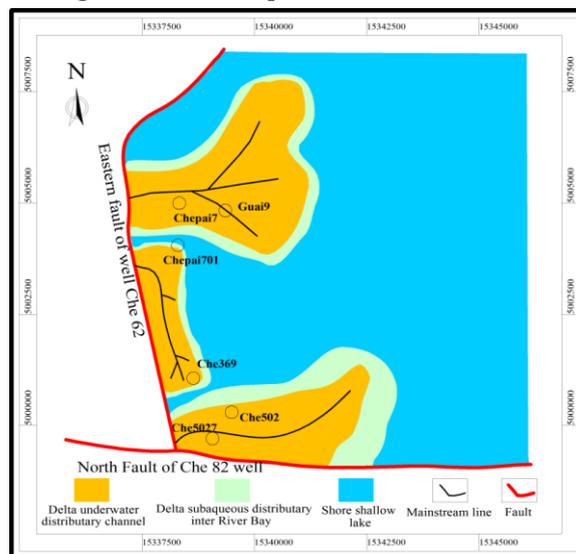


Figure5: Sedimentary facies of the top Badaowan Formation in Chepai 7 well area

4. Oil water relationship at the top of Badaowan Formation

Fig. 3 shows that according to the oil test results, the top of Badaowan Formation is in the same sand formation. Well Che 5027 and well Che 502 produce oil, well Che 369 and well Chepai 701 produce water, and well Chepai 7 is the same oil-water layer. According to Fig. 2, well Chepai 7 is at a higher structural position than well Chepai 701 and well Che 369, and well Che 369 is at a higher structural position than well Che502 and well Che5027. This is inconsistent with the normal oil-water relationship (that is, the oil layer in the same layer is located in the high part of the structure and the water layer is located in the low part of the structure). What is the relationship between reservoir sand bodies?

First of all, it can also be seen from Figure 3 that the sand bodies at the top of oil or water production layers of well Che 5027, well Che 502, well Che 369 and well Chepai 701 are above the coal seam, while the sand bodies at the same oil-water production section of well Chepai 7 are below the coal seam. At least, it can be explained that although these sand bodies are located at the top of Badaowan Formation, the sand bodies at the same oil-water production section of well Chepai 7 may not be the same sand body as those of the other four wells.

5. Prediction of favorable sand body at the top of Badaowan Formation

5.1. Analysis of seismic attribute characteristics at the top of Badaowan Formation

Based on the fine interpretation of the seismic geological horizon of Badaowan Formation, this paper cuts the stratigraphic slices of relevant seismic attributes at the top of Badaowan Formation. The seismic amplitude and frequency stratigraphic slices at the top of Badaowan Formation are shown in Fig.6.

Fig. 6 reflects the distribution characteristics of sand body at the top of J_1b_{4+5} section in terms of seismic amplitude and frequency attributes [16-20]. Sand bodies are characterized by strong amplitude (black) and continuous distribution in seismic amplitude slices, while non sand bodies are characterized by weak amplitude (red). Therefore, the distribution range of sand bodies can be delineated; The sand body amplitude of the production wells represented by well Chepai7 and well Che502 is stronger, and the sand body amplitude of the production wells represented by well Chepai701 and well che369 is slightly weaker. Sand bodies near well Che 5027 - well Che 502 and well Chepai701 - well Che 369 are mainly banded; Well Chepai7 and well Guai9 are distributed in a flower shape, the sand body boundary is relatively clear, and the material source comes from the West.

The sand body is characterized by medium frequency or high frequency and continuous distribution on the seismic frequency slice, in which red is low frequency, green is medium frequency and blue is high frequency. The distribution range of the sand body can be delineated according to the frequency difference. The sand body is also distributed in strip and flower shape, the sand body boundary is relatively clear, and the material source comes from the West. The sand body where the oil producing wells represented by well Chepai7 and well Che502 are located is green medium frequency, which is actually one of the basis for the oil-bearing of these two sand bodies, while the sand body where the oil producing wells represented by well Chepai701 and well Che369 are located is blue high frequency.

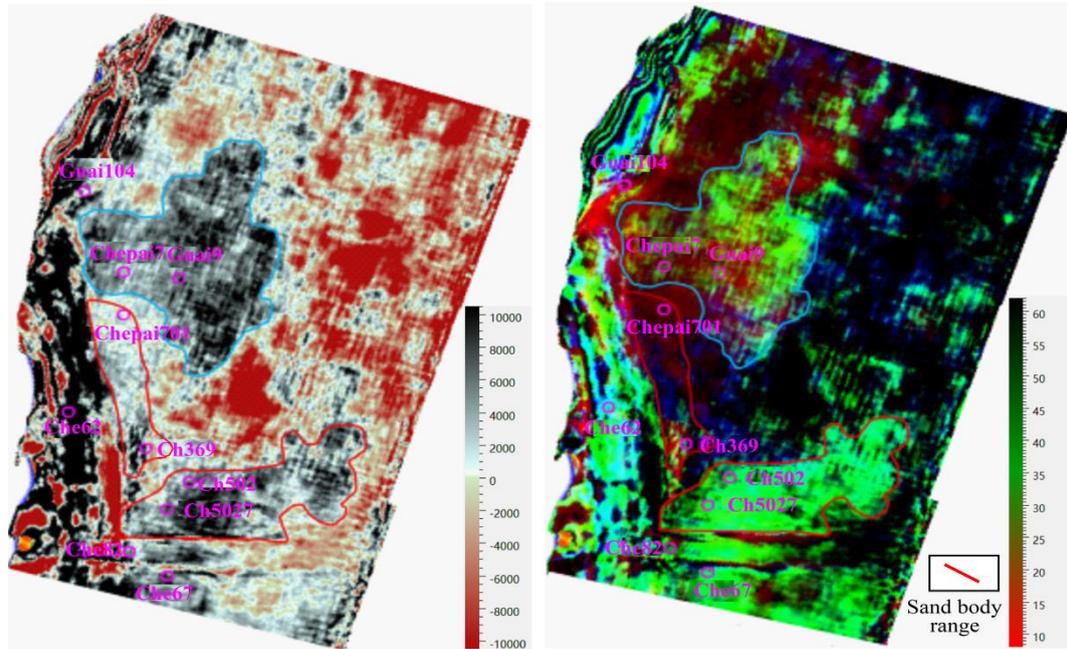


Figure6 :The seismic amplitude stratigraphic slice (left) and seismic frequency slice (right) of the top part of J_{1b4+5} pass the oil producing section of well Che 5027, Che 502, Che 369, Chepai 701, Chepai 7

5.2. Top wave impedance inversion of Badaowan formation

In order to more accurately predict the distribution range and mutual relationship of reservoir sand bodies at the top of Badaowan Formation in well block Chepai7, the wave impedance characteristics of sand and mudstone at the top of Badaowan Formation in key wells are studied [19-20]. The results show that the seismic wave impedance can distinguish sand and mudstone. The wave impedance value of mudstone is below 9000, while the wave impedance value of sandstone is greater than 9000 (Fig. 7). The wave impedance inversion results (Fig. 8) more clearly show that three relatively independent sand bodies are developed in the oil and water production section of Chepai7 well area at the top of Badaowan Formation, and their independent boundaries are clear, including Chepai7 well Guai9 sand body in the north of the study area, chepai 701 well che369 sand body in the middle and che502 well che5027 sand body in the south. The provenance comes from the west of the region, and the sand body is distributed from west to East (or southeast), with clear characteristics and gradually annihilated. Wave impedance inversion stratigraphic slice (Fig. 8) is basically consistent with seismic facies (Fig. 4) and seismic amplitude and frequency stratigraphic slice (Fig. 6), which reflect the distribution characteristics of sand body, and the resolution of wave impedance inversion stratigraphic slice is higher. Combined with the distribution of oil and gas production layers at the top of Badaowan Formation in Lianjing section, the sand bodies of Chepai7 well Guai9 well and Che502 well Che5027 well are the most favorable reservoirs, both producing oil and gas, and are the most favorable reservoir sand bodies for edge expansion or production increase in the next step.

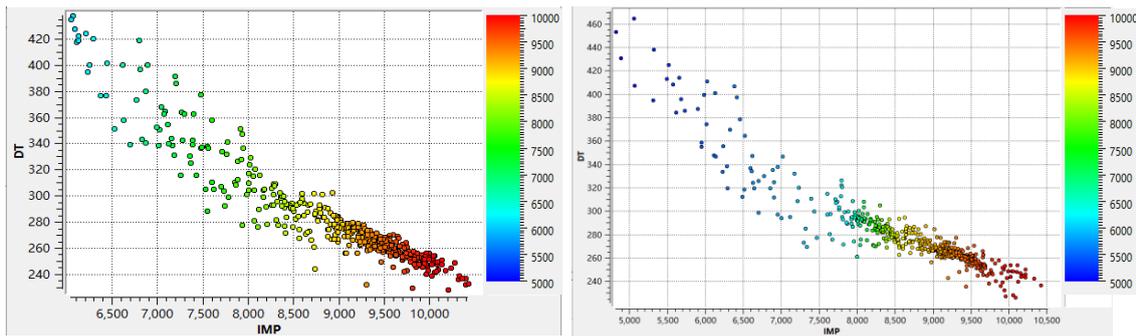


Figure7: Wave impedance plate of well Guai 9 (left) and well Chepai 7 (right)

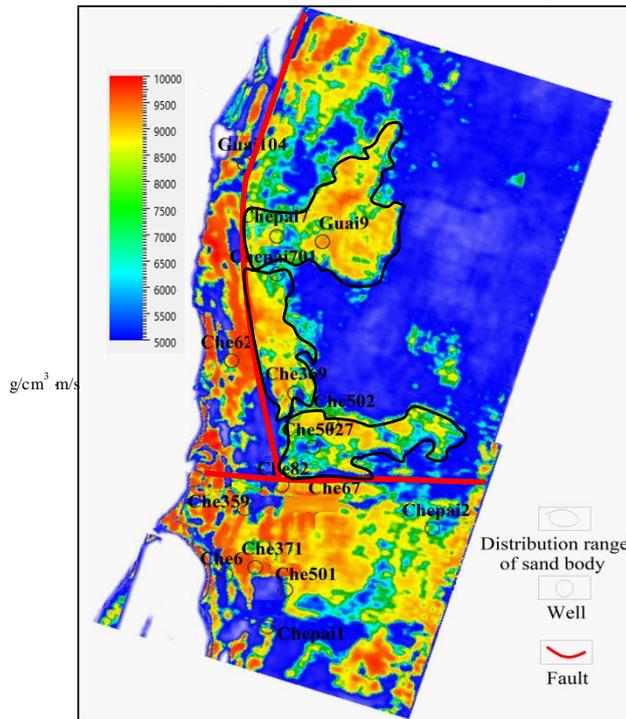


Figure8: Wave impedance inversion stratigraphic slice at the top of Badaowan Formation of Chepai7 well area

6. Conclusion

(1) The sedimentary facies at the top of Badaowan Formation in well block Chepai7 is mainly fan delta front subfacies, which is composed of five sedimentary microfacies: underwater distributary channel, underwater distributary channel, estuary bar, distal bar and sheet sand, and three fans are developed on the plane; At the same time, swamp facies and shore shallow lake facies are developed.

(2) The oil-water relationship at the top of Badaowan Formation of well Chepai7 is complex. The oil-water distribution of the same sand formation does not conform to the law that the oil layer is located in the high part of the structure and the water layer is located in the low part of the structure. The oil or water producing sand bodies of well Che5027, well Che502, well Che369 and well Chepai701 at the top of Badaowan Formation are above the coal seam, and the sand bodies of the oil-water producing section of well Chepai7 are below the coal seam, not the same sand body.

(3) The combination of seismic facies, seismic amplitude and frequency stratigraphic slice and seismic impedance inversion stratigraphic slice can accurately predict the plane distribution law of sand body at the top of Badaowan Formation and its relationship. Three relatively independent sand bodies are developed near the oil producing section at the top of Badaowan

Formation, and the oil-water relationship is independent of each other. The oil-water relationship is controlled by sand body distribution and sand body annihilation.

(4) The most favorable reservoir sand bodies of J_1b_{4+5} sand formation at the top of Badaowan Formation are well Chepai7- well Guai9 sand body in the north and well Che502 - well Che5027 sand body in the south. These two sand bodies produce oil and are favorable reservoir sand bodies for further development. The sand body of well Chepai701 - well Che369 in the middle is a non favorable reservoir and produces water.

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