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Research on Interwell Connectivity in Volcanic Gas Field

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Abstract: *Volcanic reservoir is an essential part of China's hydrocarbon resources. The study of interwell connectivity is the foundation for studying the spatial distribution of reservoirs, evaluating developing reserves, and reasonable development scheme. However, because of multiple superposed volcanic rocks which were erupted at different stages, fractures, complex gas water relations, and highly heterogeneity, how to estimate interwell connectivity in early development stage accurately and effectivelyis the key to draw up development scheme and deploygas wells.*

This paper presented comprehensive analysis methods which combine the analysis of static and dynamic data, volcanic rock fine description, fluid properties and the relationship appraisement between gas and water. Firstly, the main volcanic edifices were recognizedbased on the seismic reflection structure and characteristics of volcano eruption products; then, the location of gas water interface by resistivity difference were identified. Pressure test data was analyzed to judge the interwell connectivitybased on the same fluid system in the same gas reservoir. Finally, taken SN volcanic gas field as example, three volcanic edifices were identified. Each volcanic edifice was not communicated with each other. In the same volcanic edifices, the interwell connectivity is also different because of the influence of the fault.

Inter well connectivity method presented in this paper was effect way to directly guide the volcanic gas field development and production, which has a very good reference and guidance for similar gas reservoir.

Keywords: *Volcannic gas, Interwell connectivity, dynamic analysis*

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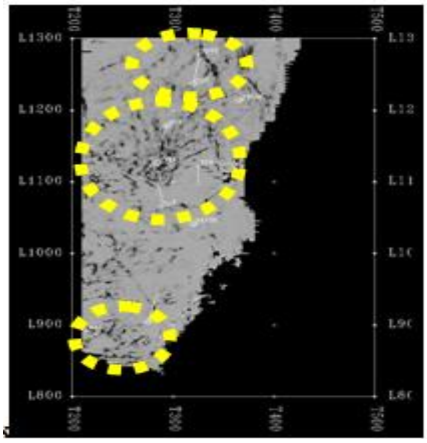
I. Introduction

Volcanic reservoir is an essential part of China's hydrocarbon resources. The study of interwell connectivity is the foundation for studying the spatial distribution of reservoirs, evaluating developing reserves, and reasonable development scheme. However, Because of multiple superposed volcanic rocks which were erupted at different stages, fractures, complex gas water relations, and highly heterogeneity, how to accurately and effectively estimate interwell connectivity in early development stage is the key to draw up development scheme and deploygas wells effectively.

Taking the volcanic gas reservoir in SN gas field as an example, seismic, logging, geology, testing and production dynamic analysis were applied, and the interwell connectivity of volcanic gas reservoirs were studied by a variety of methods, which provides a foundation for the scheme deployment and well development.

1. Spatial distribution of volcanic rock

Figure1 Characteristics of seismic coherence body of SN gas field



The analysis of the macro seismic reflection structure indicates that the main volcanic rocks in the south of SNgas fieldare composed of three different forms of reflection, reflecting three volcanic activities(Figure 1). The first structure reflects the shield volcanicedifices formed by the early basic lava overflow, and the second structures reflect the layer volcano and the third structures are late volcaniclastic eruption. From the coherent body figure, it can be seen that there is a radial and ringlike characteristic near well YS1. It shows that the main volcanic edifice in the SN gas field is near the well YS1; there are similar features near the well YP7 with incomplete shape; and there is a crater in the northwestern well YP4 on the north side of well YS1 (Figure 2).

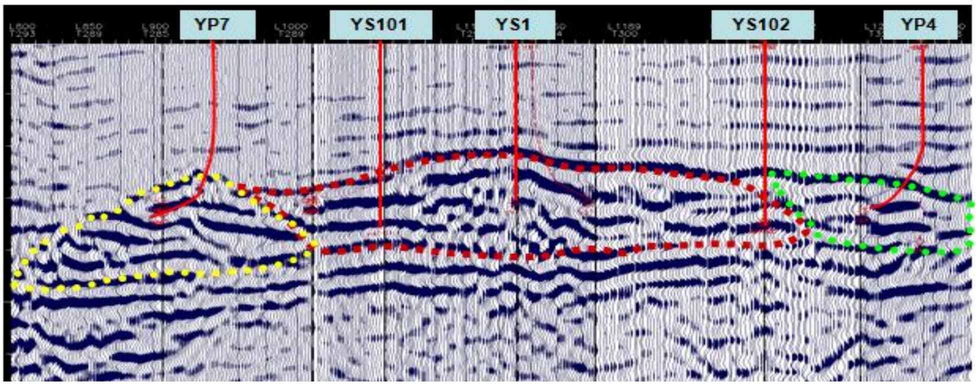


Figure 2 Seismic profile of SN gas field

According to the seismic reflection structure and the characteristics of the eruption products, the main volcanic edifices in the SN gas field were analyzed. It is believed that there are 3 volcanic eruptions vertically and 3 volcanic cones laterallyin the SN gas field. Large reservoir thickness and wide distribution of main volcanic edifice near well YS1. The volcanic structures represented by well YP7 and YP4 area have the large thickness near the crater. Through analysis of the macro seismic reflection structure, volcanic organizations are separated from each other and are not connectedwhich forms multiple reservoir systems.

2.Fluid property analysis

Literatures reported that the characteristics of fluid heterogeneity in oil and gas reservoirs, which can be used as the basis for judging the connectivity of oil and gas reservoirs. In a well-connectedreservoir, the fluid will achieve a dynamic balance. If there is a vertical geological barrier, it will impede the mixing of oil &natural gas and present the discontinuity of the oil (natural gas) in vertical direction.If the oil and gas reservoirs are connected to each other, the difference in the composition of the crude oil (natural gas) is not obvious due to the partial or complete elimination of the lateral migration and filling of the oil (natural gas).On the other hand, if the reservoirs are separated, the heterogeneity of the fluid will remain for a long time due to various reasons such as differences in oil (gas) sources, biodegradation in crude oil (natural gas) etc.. Therefore, the heterogeneity of fluid properties in oil and gas fields can be used as the basis for inferring the vertical and lateral connectivity of reservoirs. Wells with the same or similar fluid properties may be connected, but on the contrary, they are not connected.

Table 1 listed the fluid components of the gas wells in the SN gas field.There are great differences in the fluid components of different volcanic edifices. The CO_2 content in the fluid of the well YS1 area is 20~25%, the CO_2 content in the fluid of well YP7 area is 5% and the CO_2 content in the fluid of the wellYP4 is 43%. Different CO_2 content in fluid existed in different volcanic structures.Components indicated that fluid cannot migrate horizontally between the volcanic structures to achieve material balance, so different volcanic edifices have their own separate natural gas reservoir and gas water systems.

Table1 Fluid component content table in SN gas field

Well Number	volcanic edifice	CO_2 Content
YS1	The same volcanic edifice	20.74%
YS101		24.21%
YS102		24.75%
YP1		24.64%
YP4	independent	43%
YP7	independent	Less than 5%

3 Gas and water distribution

Based on the logging response characteristics of volcanic rocks, the resistivity difference method and the double porosity overlap method are used to qualitatively identify the gas and water layers and delineate the position of gas-water interface. 2 wells were drilled at the gas-water interface of SN gas field. The depth of the gas water interface of well YP4 is 3824m.Well YP7 was drilledat the gas water transition zone, where the gas water interface wasexplained below 3790 meters. Well YS1, YP1, YP3 and YP9 were drilled atnatural gas enrichment area of main volcanic edificelocated; well YS101 was not drilled in the water layerand the gas-water interface was identified as 3794m. Well YS102 waslocated at low position and the gas-water interface was identified as 3780m. From the log interpretation results, the gas-water interface of the SN gas field is not uniform (Figure 3). The distribution of the gas and water system on the plane is mainly controlled by the volcanic rock. The different volcanic rocks are not connected to each other and belong to different gas and water systems; in the same volcanic rock, there are many gas and water systems.

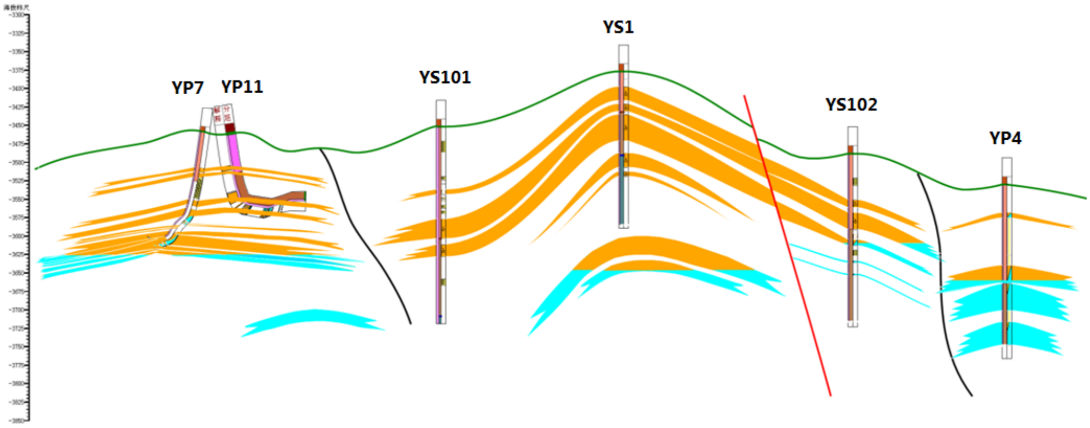


Figure3 gas-water interface in SN gas field

4 Pressure analyses

The analysis of pressure system is an important basis for judging interwell connectivity. Pressure data is the most direct data to determine interwell connectivity. Each well in the same gas reservoir is in the same hydrodynamic system, and the pressure at any point in the gas reservoir is related to its depth.

According to the pressure measurements in the SN area, the depth and pressure in the well YS1 and YP1 are the same. According to the volcanic edifice and tectonic mechanisms analysis, wellYS1, YP1 and YS101 should be in the same volcanic edifice. The pressure curves of the 5 wells showed that the pressure vs depth is in the same line of well YP1, YS1 and YS101; the pressure of the well YS102 are high and the pressure of the well YP4 and YP7 wells are lowin the same depth (Fig. 4). TheSN gas field has multiple pressure systems, and volcanic tectonic structures and faults all have a certain separation of the pressure system.

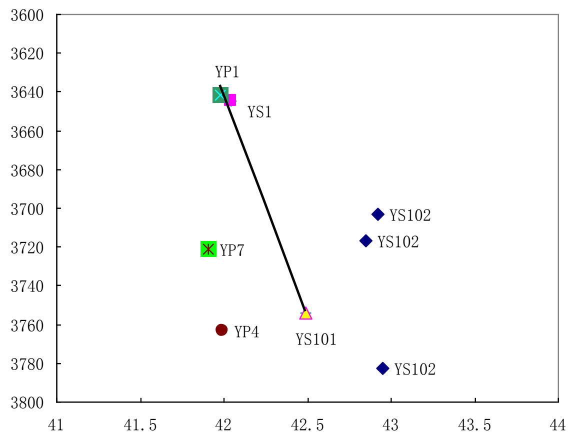


Figure 4 The relationship between pressure and depth of gas reservoir in SN area

The production data of four wells (YP1, YP3, YP9, YP7) in SN gas field indicated that change trend of tubing pressure of YP1, YP3 and YP9 is the same even different time to put into production.The tubing pressure of well YP7 is decreased rapidly which is different from the change trend of the otherthree wells. Production data indicated that there is good interwell connectivity between YP1, YP3 and YP9 and terribleinterwell connectivity with YP7 well.

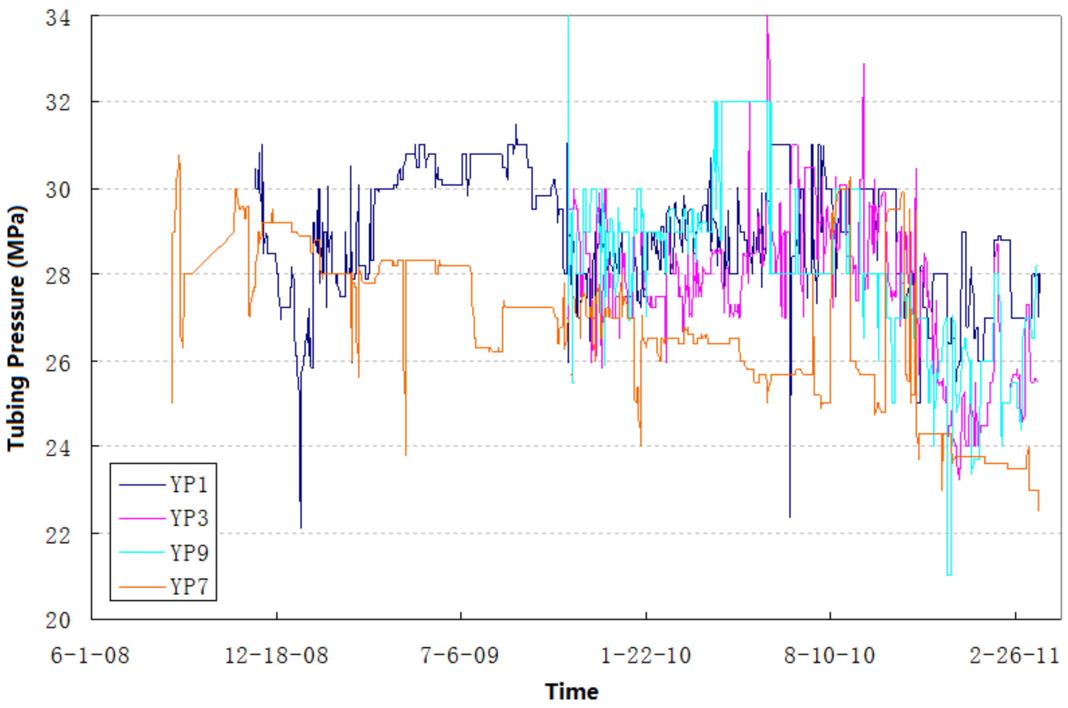


Figure5 Tubing pressure of gas well in SN gas field

To sum up, there is three volcanic edifices of SN gas field, which are not connected each other. In the same volcanic edifice, the connectivity between wells is different due to faults. Taking YS1 well area as an example, dynamic and static data analysis shows that the well YP1, YS1, YP3 and YP9 are connected, but are not connected with YS102 well.

II. Conclusions

1）Static and dynamic analysis proved that three volcanic edifices in the SN gas field are not connected to each other, which laid thefoundation for the well deployment and enhancement of reserve recovery degree.

2）Various ways should be used to determine the connectivity between wells because of complicated interwell connectivity of volcanic reservoirs.

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