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Review Article

Pore Structure and Acoustic Characteristics of Shaximiao Formation in Sichuan Basin

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Abstract

With the deepening of exploration and development, the natural gas development in Sichuan Basin has entered the stage of tight gas exploitation. There are significant differences between tight gas and conventional natural gas resources, which are embodied in more complex pore structure and lithology. These differences make it difficult to predict the "dessert" development area of tight rocks. Therefore, it is necessary to study the pore structure characteristics, petrophysical characteristics and formation fluid of tight sandstones. In this paper, through CT scanning and thin section identification, the characteristics of rock micro pore structure in Qiulin area are found, and the petrophysical characteristics of tight rock reservoirs are found through P-S wave experiments. The research shows that the pores of Shaximiao Formation in Qiulin area are large, with pore diameter distribution of 0.05~0.5mm and the pores are relatively developed, with an average porosity of more than 10%. The study of rock physical properties shows that dense rock Poisson is higher than conventional carbonate rock and shale, and has the characteristics of low acoustic wave velocity and low Young's modulus.

Keywords: Tight sandstone; geological exploration; pore structure; acoustic characteristics; P-S wave experiment

Introduction

The lithology of Shaximiao Formation in Qiulin gas field is mainly a set of dark purplish red mudstone mixed with grayish green and grayish white sandstone, with a thickness of 1100m~1300m. Taking "foliated shale" as the boundary, the Shaximiao formation is divided into two segments, namely, Sha1 and Sha2, of whichSha1 is 200-260m thick and Sha2 is 1000-1100m thick. According to statistical analysis, there are 23 river sand formations in Shaximiao Formation of Qiulin gas field and its surrounding areas. According to the principle of bottom-up, the main sand formations of Shaximiao Formation of Qiulin gas field are numbered. At present, the gas wells drilled in Shaximiao formation are mainly distributed in No. 8 sand formation of Sha2 1 sub section, and the sand formations are stably distributed along the river [1-5].

Method

In this experiment, samples from ql17 and ql18 wells are selected, and the sample information is as follows:

Sample type	*Porosity range*	*Quantity*	*Proportion%*
Plunger sample	Less than 8%	9	20.93
Plunger sample	8%~12%	15	34.88
Plunger sample	Greater than 12%	19	44.19

Table 1: Sample porosity statistics.

A total of 42 cores of Shaximiao Formation in Qiulin block were selected for this study, including 9 cores with porosity less than 8%, accounting for 20.93%, 15 cores with porosity between 8% and 12%, accounting for 34.88%, and 19 cores with porosity greater than 12%, accounting for 44.19%. It can be found that the tight sandstone core of Shaximiao formation has large porosity and good oil and gas reservoir space.

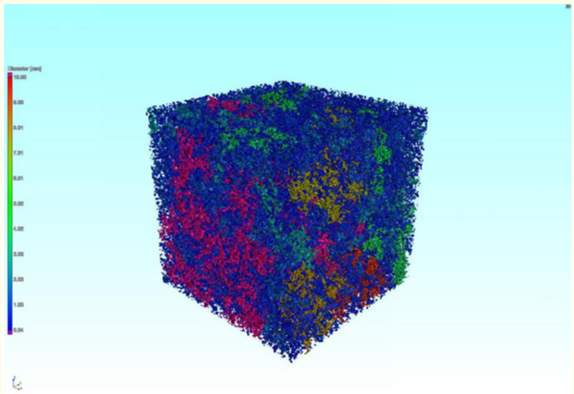

Figure 1: CT scan of core.

In order to further study the pore structure characteristics of Shaximiao Formation reservoir, CT scanning and electron microscope experiments were carried out, and a more accurate pore structure image and model of tight rock were obtained. From the CT scanning diagram, it can be found that the pores in tight rock are relatively developed, most of the connecting space is about 1um in diameter.

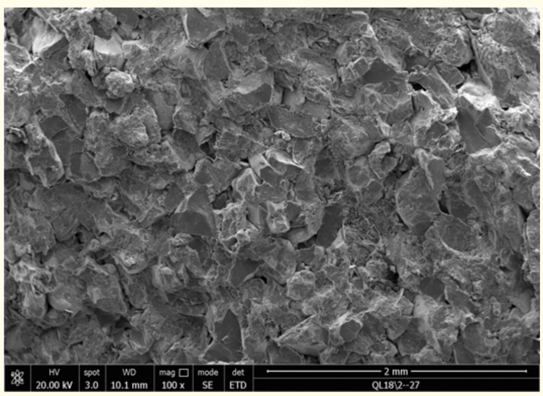

Figure 2: magnification of electron microscope experiment picture (100x).

First of all, the complete picture of the rock is seen under the 100x electron microscope. The dissolution phenomenon is obvious, and the intergranular residual pores are relatively developed.

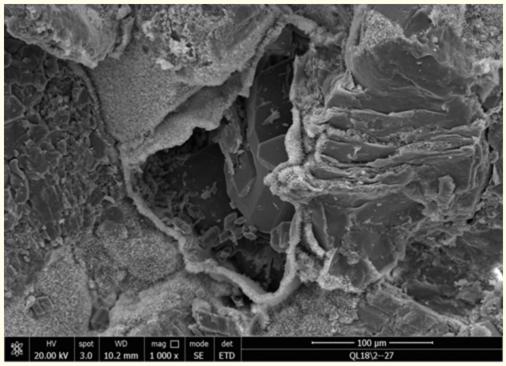

Figure 3: Magnification of electron microscope experiment picture (1000x).

Particle dissolution, residual chlorite liner, blade like chlorite distribution between particles, feldspar grains.

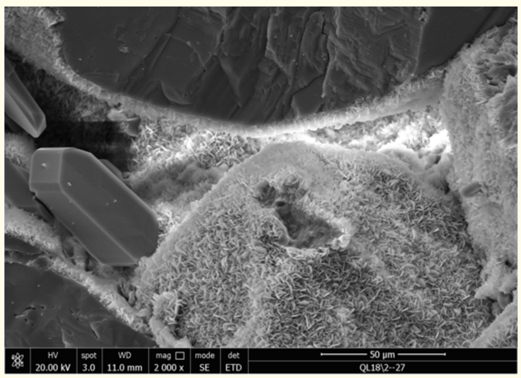

Figure 4: Magnification of electron microscope experiment picture (2000x).

Intergranular residual pores and roaring channels have good connectivity. Intergranular foliated chlorite is distributed in a cushion, and tabular albite can be seen. The sample has developed pores and good connectivity. The common pore types are mainly dissolution pores and intergranular residual pores. The cementation types are mainly liner type, filling type and enlarged type, and the cements are mostly blade chlorite and tabular albite.

This experiment adopts the rtr-1500 P-S wave joint measurement system of GCT Company in the United States. The P-S wave joint measurement system can carry out rock uniaxial compression deformation test, triaxial compression strength test and rock acoustic wave test. It uses the axial actuator to move, gradually apply pressure to the rock, and test the deformation records of the rock. The pressure chamber where the test sample is placed can apply confining pressure and temperature to the test sample, simulate the deformation of rock under the condition of formation temperature and pressure, and measure the young's modulus and Poisson's ratio of rock. At the same time, in the process of testing rock deformation, the electromagnetic wave transmitter and receiver are used to measure the P-wave and S-wave velocities of rocks under different conditions and deformation degrees.

Results

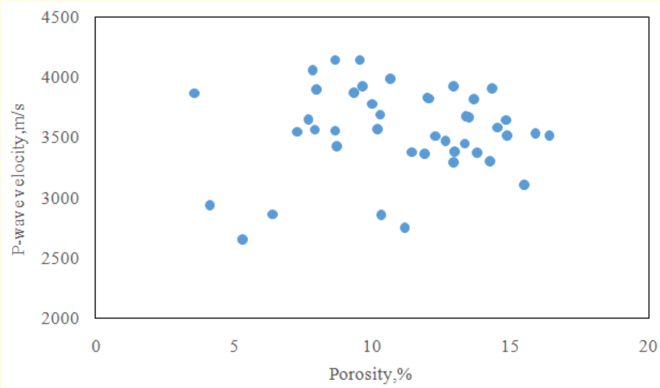

Figure 5: Relationship between P-wave velocity and porosity of tight sandstone.

Through experimental analysis, the P-wave velocity of tight sandstone is concentrated in the range of 2500m/s~4500m/s. With the increase of porosity, the P-wave velocity does not change significantly.

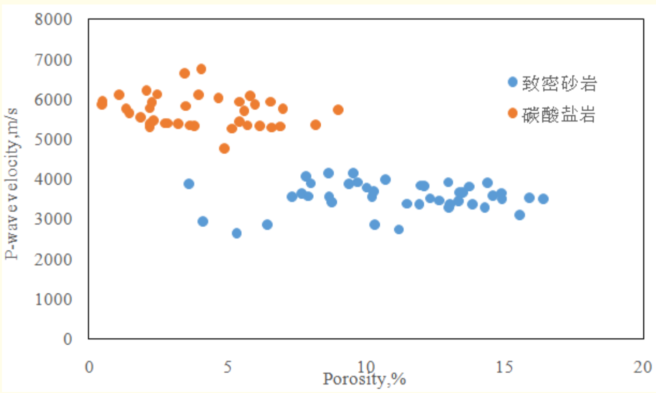

Figure 6: P-wave velocity difference between tight sandstone and carbonate rock.

Through experimental comparison, the difference of P-wave velocity between tight sandstone and carbonate rock is analyzed. The porosity of tight sandstone core is higher than that of carbonate rock, and the P-wave velocity is lower than that of carbonate rock.

Conclusion

1. The lithology of Shaximiao Formation in Qiulin gas field is mainly a set of dark purplish red mudstone mixed with greyish green and greyish white sandstone. 23 stage channel sand formations are developed, and the sand formations are stably distributed along the channel;
2. The core porosity of Shaximiao Formation in Qiulin block is high, and the porosity of most samples is more than 12%, which has good oil and gas storage space;
3. The intergranular pores of dense sandstone are developed, dense pore structure can be seen under CT, and some pores have good connectivity;

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4. Acoustic wave experiment is to measure the P-wave velocity of rock under different conditions. In the experiment, the P-wave velocity of dense sandstone does not change obviously with porosity;
5. The longitudinal wave velocity of dense sandstone is concentrated in the range of 2500m/s ~ 4500m/s, which is lower than that of carbonate rock.

Future Enhancements

By changing the frequency of the acoustic wave in the experiment, the experimental results are closer to the field results.

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