Characteristics and evaluation of tight gas reservoir in Shaximiao Formation, Northeastern Sichuan Basin

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Abstract. The reservoir of Shaximiao Formation is mainly composed of channel coarse sandstone and fine sandstone. The rocks are dense, the lithology is single and the thickness is large. The physical properties of Shaximiao Formation are not clear for the northeast Sichuan area. Based on field and core physical property analysis of Shaximiao Formation in Northeast Sichuan Basin, the characteristics of porosity and permeability of Shaximiao Formation are defined, the porosity-permeability relation chart is established, and on this basis, the tight reservoir of Shaximiao Formation was evaluated. The result show that the favorable reservoir is mainly located in the intersection area of channel sand, the reservoirs are mainly of III type, followed by the reservoirs of II type, and the I type are the least.

1. Introduction
Longitudinally, the Shaximiao Formation can be divided into the first member of Shaximiao Formation and the second member of Shaximiao Formation. The main types of sandstone reservoir space are intergranular pores, ingrain-soluble pores, mold pores, mica cleavage fractures and intergranular pores, and the dissolution pores are less developed. As a kind of reservoir seepage space, microfractures are relatively developed locally, but as a whole, the gas reservoir of Shaximiao Formation belongs to pore reservoir.

The reservoir space types of Shaximiao Formation sandbodies are as follows: (1) intergranular pores: including residual (remaining) intergranular pores and intergranular dissolution enlarged pores, which are mainly formed by incomplete filling of chlorite film or the ring edge formed by chlorite dissolution. It is the main pore type with different shapes and general connectivity between them. (2) Intragranular pores: they are formed by incomplete dissolution of feldspar and debris, and are honeycomb like. In the pores, automorphic small quartz occasionally grows, which reduces the size of the pores. This kind of pores are also important pore types. (3) Mold hole: formed by potassium feldspar is dissolved. This kind of large pores, though rare in the sand body, but widely exist, is also an important type of pores. (4) Intergranular pores and mica cleavage fractures: intergranular pores are the pores between crystals of mainly clay minerals (chlorite, illite). Both types of pores are small and common in reservoirs, but they have little reservoir significance.

2. Reservoir physical property characteristics

(1) Sha1 Member
According to the physical property analysis of field samples and core samples in Sha1 Member, porosity
is mainly between 2.8 ~ 9.9%, with an average of 3.6%, and permeability is mainly between 0.01~1.51×10^-3 μm², with an average of 0.251×10^-3 μm² (Fig. 1 and Fig. 2). According to the reservoir classification standard, when the porosity is less than 10%, it is a tight reservoir, and the channel reservoir of the first member of Shahejie is a tight reservoir.

![Fig. 1 Histogram of porosity frequency distribution in Sha1 Member](image1)

![Fig. 2 Histogram of permeability frequency distribution in Sha1 Member](image2)

According to the analysis results of 10 core samples of Sha1 Member in the study area, the relationship diagram of reservoir porosity and permeability (Fig. 3) is drawn. It is concluded that Sha1 Member 1 is a low-porosity and low-permeability reservoir with poor correlation between porosity and permeability, and permeability of some samples increases with the increase of porosity.

![Fig. 3 Relationship between porosity and permeability of Sha1 Member](image3)

(2) Sha2 Member

According to the physical property analysis of field samples and core samples from Sha2 Member, porosity is mainly between 2.1 ~ 6.2%, with an average of 3.8%, and permeability is mainly between 0.01 ~ 1.62×10^-3 μm², with an average of 0.55×10^-3 μm² (Fig. 4 and Fig. 5). According to the reservoir classification standard, the tight reservoir is defined when the porosity is less than 10%, and the channel reservoir of the second member of Sha2 Member belongs to the tight reservoir.
According to the analysis results of 6 core samples of the second member of the Sha2 Member in the study area, the relation diagram of reservoir porosity and permeability (Fig. 6) is drawn. It is concluded that the second member of the Sha2 Member is a low-porosity and low-permeability reservoir with poor correlation between porosity and permeability, and the permeability of some samples increases with the increase of porosity.

3. Reservoir Evaluation of Shaximiao Formation

The comprehensive evaluation criteria for Shaximiao reservoirs are: Type III favorable reservoirs are lithology siltstone, sedimentary environment is underwater distributary channel and sheet sand, sand to land ratio reaches 25%, porosity is 4%-6%; Type II The favorable reservoir lithology is siltstone, and the sedimentary environment is an underwater distributary channel and sheet sand. The sand-to-land ratio reaches 30%, and the porosity is 6%-8%. The favorable reservoir lithology of type I is fine sandstone and siltstone. The sedimentary environment is an underwater distributary channel, with a sand-to-land ratio of 35% and a porosity greater than 8%.

(1) Sha1 Member
Favorable reservoirs in the first member of Shaximiao Formation are mainly located in the confluence and spreading area of channel sand bodies, with type III reservoirs as the main type, type II reservoirs, and type I reservoirs the least.

(2) Sha2 Member
Favorable reservoirs of the second member of Shaximiao Formation are mainly located in the area where the sand bodies of the partial channel are converged, and the area is reduced compared with that of the
first member of Shaximiao Formation. It is mainly type III reservoirs, and type II reservoirs have the least type I reservoirs.

4. Conclusion
There are four types of reservoir spaces in Shaximiao Formation: intergranular pores, ingrain pores, mold pores, intergranular pores and mica cleavage fractures.

Through field analysis and core samples, the channel reservoirs in Sha1 Member and Sha2 Member, belong to low porosity and low permeability tight reservoirs, and the correlation between porosity and permeability is poor. The permeability of some samples increases with the increase of porosity.

Sha1 Member and Sha2 Member favorable reservoirs are mainly located in the confluence and spreading area of channel sand bodies, with type III reservoirs as the main type, type II reservoirs, and type I reservoirs the least.

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