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The Quantitative Characterization of Heterogeneity Using Nanometer CT Technique on the Shale Reservoir

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1 Introduction

The unconventional shale oil - gas energy, with a huge resource potential, has attracted lots of attention in the world. The occurrence、a accumulation ability and even the flow of the shale oil - gas are seriously affected by characteristics of the reservoir space. Thus, studying the characteristics of the reservoir space of the shale has been the important research direction in the field of the exploration and development for shale oil - gas. The mud-shale is mainly consisted of inorganic mineralogical composition and organic matters. The different types, size and shape of pore - fracture system are formed in the processes of deposition and diagenesis, forming a complex reservoir space types. At present, we have a lot of methods for the characterization of reservoir space of the shale, including the casting thin sections, mercury-injection, and scanning electron microscope, nuclear magnetic resonance and CT and so on(Curtis et al., 2011; Tian et al.,2012;Yu et al.,2013). Among them, due to the unique advantage of 3D reconstruction, the CT technique has become an effective mean in the unconventional oil-gas reservoir characterization of micro - nano scale reservoir space(Zou et al.,2011).

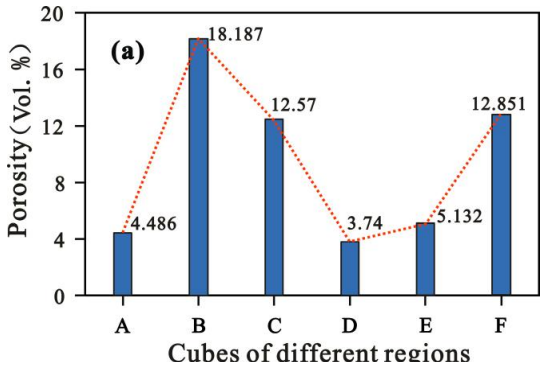

Fig. 1. The porosity of different regions.

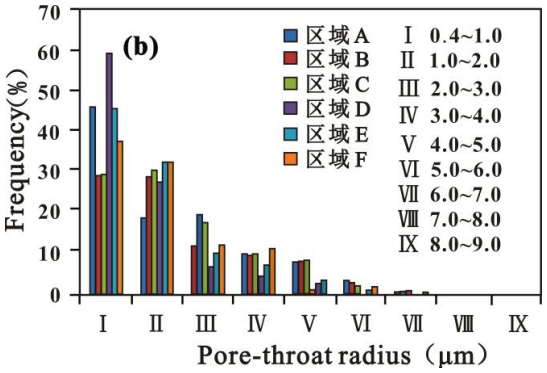

Fig. 2. The frequency histogram of different pore-throat radius

2 Methods

In this paper, taking the shale samples of Dongying sag in Jiyang depression in Bohai basin as the research object, firstly, these shale samples were carried on the CT scan (distinguishability of 400 nm) test; secondly, we reconstructed a cube with 0.48 mm x 0.48 mm x 0.44 mm (1188 pixel×1187 pixel×1187 pixel) by using the 3D reconstruction. Then, we chose six different areas (300 pixel×300 pixel×300 pixel) within the cube, to analyze reservoir space heterogeneity characteristics (such as porosity, pore size distribution, etc.). Results show that: (1) for a different modeling area, their porosity values vary widely (Fig.1), the maximum porosity is up to 18.187%, the minimum porosity is only 3.74%.Overall, the six regional average porosity is 9.5%; (2) with respect to different parts, distribution range of the six pore-throat radius is wide, ranging from the 0.4μm to 9.0μm(Fig.2), 0.4μm to 2.0μm as the main pore-throat radius distribution (All of regions are up to 80%); But the difference of pore throat radius of

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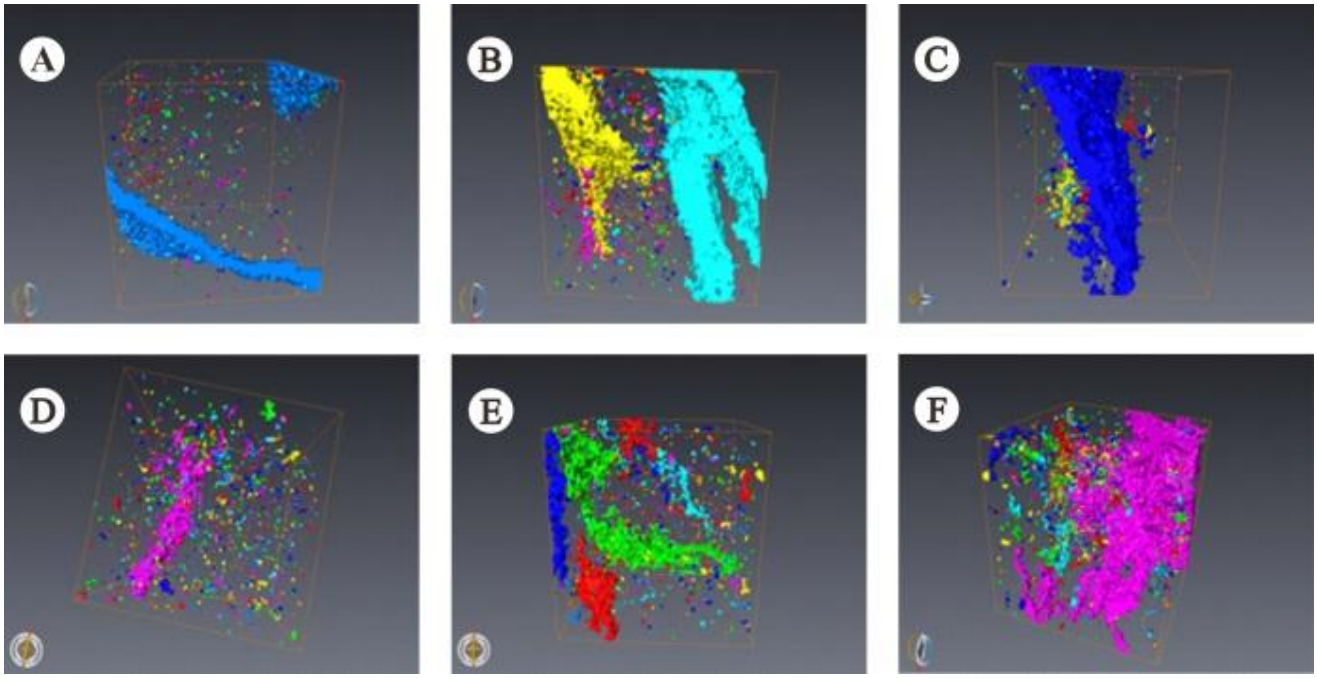

Fig. 3 3 D pore-throat images of different regions

different cube is big, these phenomena also indicate the heterogeneous characteristics of reservoir space of the shale.

According to the 3D reconstruction model on the same scale (300 pixel×300 pixel× 300 pixel), the hole-crack size, shape and spatial distribution characteristics of different modeling area are obvious different (Fig.3). The largest porosity of modeling area B has two cracks, one of them is crossing the whole area, contributing its total porosity; For the smallest porosity of modeling area D, it develops more disconnected and isolated hole (Fig.3).

3 Conclusion

The reservoir space of the mudstone-shale has a strong heterogeneity. Study shows that the greater different porosity and pore-throat scale of different cube areas, the stronger heterogeneity in the reservoir space. At the same time, this study also shows that the X-ray computed tomography (CT) scanning technology in the quantitative characterization of mudstone-shale reservoir spatial heterogeneity characteristics and visual display of 3 D-dimensional pore-throat distribution has a broad application prospect.

Acknowledgments

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