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Whole-Aperture Pore Structure Characterization and Its Effect on Gas Content of the Longmaxi Formation Shale in the Jiaoshiba Area, Sichuan Basin

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In recent years, the pore structure of shale is studied through many qualitative and quantitative techniques. Quantitative methods mainly include the low temperature gas adsorption (N_2 and CO_2), the high-pressure mercury injection, the small angle X-ray scattering, and the nano CT, etc. The content and adsorption ability of adsorption gas are mainly obtained by CH_4 isothermal adsorption experiment. The content and storage capability of free gas are mainly obtained by porosity and pore volume of shale. The surface area has directly influence on adsorption ability, while the pore volume directly influence on storage capability of free gas. Therefore, the comprehensive knowledge of pore volume and surface area has an important guiding significance to the shale gas content and accumulation.

Based on the effectiveness of different test methods, the micropore (<2.0nm) characteristics were obtained by CO_2 adsorption, the mesopore (2.0-50.0nm) characteristics were obtained by N_2 adsorption, and the macropore (>50.0nm) characteristics were obtained by high-pressure mercury injection, taking the Longmaxi Formation Shale of Jiaoshiba area as an example. Furthermore, the adsorption capacity of shale was obtained by methane isothermal absorption experiment.

In terms of pore volume, the micropore volume is average 0.0056 mL/g, accounting for about 35% of the total pore volume. The mesopore volume takes the largest proportion of 41%, with an average of 0.0066 mL/g. The macropore volume is average 0.0039 mL/g, accounting for about 24% of the total pore volume. Therefore, the mesopore has the largest contribution to the pore volume of shale, following are micropore and macropore. In addition, anyone of the micropore, mesopore, and macropore may dominates the total pore volume in different samples.

In terms of surface area, the micropore surface area is average 16.31m^2/g, accounting for about 76.87% of the total surface area. The mesopore surface area is 4.63m^2/g, as the macropore surface area is only about 0.01m^2/g. Therefore, the micropore has the largest contribution to the pore surface area of shale, following are mesopore and macropore.

In terms of the affection of pore structure on gas content, there is a good positive correlation between micropore surface area and adsorption methane, showing that the adsorption methane content increased gradually with the increase of micropore surface area. The relationship between the surface area and adsorption methane of mesopore and macropore is poor, mainly because of the mesopore and macropore provide limited surface area, which do not have a decisive action on the methane adsorption capacity. Therefore, the micropore controls the content of adsorbed gas as has larger surface area. The free gas is mainly provided by pore volume of shale. The content of free gas will increase with the increase of pore volume. About 76% of the total pore volume is provided by micropore and mesopore. Therefore, the pore volume of micropore and mesopore mainly controls the storage capability of free gas. The macropore has a weak effect on the storage capability of free gas, while it is the main migration pathway of free gas.

In conclusion, the micropore is very important on adsorption gas and free gas in shale, but easy to be ignored, which should be studied strengthen. Understanding the whole-aperture pore structure characterization, especially the contribution of micropore, has an important guiding significance for shale gas exploration and development.

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