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Application of NMR on Quantificational Characterization of Tight Glutenite Reservoirs Pore Size

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Quantificational characterization of the microscopic pore structure is the key to evaluating tight reservoirs. Since tight reservoirs mainly develop nano-pores which are difficult to fully characterize pore throats' distribution by single conventional experimental method, there's an urgent need to establish a characterization method by jointing several conventional experimental methods.

The tight gas of Shahezi Formation in Xujiaweizi Fault Depression had made breakthroughs, the main pore types observed by the microscope were dissolution pores, intergranular pores and some micro fractures. The dissolution pores were combined by interparticle dissolution pores which dissolved cements and intragranular dissolved pores which dissolved the unstable components like feldspars and rock fragments. The intergranular pores were mainly the pores between crystals of illite/smectite and illite. The micro fractures improved the permeability of reservoirs greatly which were often developed in conglomerates. The remnant primary pores only local visible which were seldom developed. *

There is a tremendous amount of research shows that NMR T_2 spectra have close links with the pore size distribution curves which obtained by mercury injection. Since both of them can reflect the pore structure of rock, it's able to use mercury injection curves to calibrate the NMR T_2 spectra. However, the mercury injection curves were only able to reflect part of the larger pore space because the tight reservoirs have narrow pore throats and low pore connectivity. When the pore radius less than 50 nm, there was a big distribution discrepancy between T_2 spectra and capillary pressure curves. So the previous methods couldn't characterize micropores and mesopores of tight reservoirs well. The accuracy of nitrogen adsorption was restricted by samples because the macropores were destroyed, so this method was just effective for the micropores and mesopores. It turns out that the development trend of pore structures characterization techniques of tight reservoirs is the effective combination of various experimental methods. The advantage of NMR is that the measurement of pores are comprehensive, it can identify the pores larger than 10 nm. The disadvantage of NMR is that the measurement unit is relaxation time which needs to transformation. Thus, it's able to characterize the NMR T_2 spectra by combine the nitrogen adsorption and mercury injection.

The compound cumulative porosity curves which obtained by integrating the data of nitrogen adsorption and mercury injection were used to calibrate the value of C. Then we transformed the NMR relaxation time into pore radius by C. Specific experimental steps are as followes: (1) Transform the experimental data of nitrogen adsorption and mercury injection into porosity component (Fig.1a), (2) Obtain the cumulative porosity distribution curves (Fig.1b), (3) Determine the best calibration coefficient C (Fig.1c), (4) According to the optimized C, the NMR T_2 spectra were converted into pore radius, then the pore volume distributions of the full scale pore size in tight reservoirs were obtained (Fig.1d).

In this paper, the NMR T_2 spectra were calibrated by the method mentioned before and the pore size distribution characters of tight glutenite reservoirs of Shahezi Formation were analyzed. The pore radius of tight glutenite reservoirs was ranged from 2 nm to 100 μm (Fig.2a) and the distribution curves had two peaks: the larger pores were mainly distributed from 2 μm to 10 μm and the smaller pores were mainly between 10 nm to 100 nm. Totally, the geometric average aperture mainly distributed from 50 nm to 150 nm. The amount of the pores which their radius larger than 1μm were less than 20%, representing Shahezi tight reservoirs developed narrow pore throats and nano-grade pores (Fig.2b).

1 Introduction

Previous classifications of magmatic sulphide deposits in China are mainly based on metallogenesis, considering

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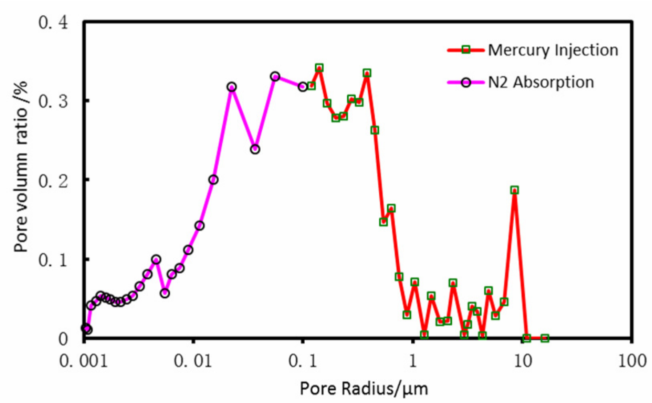
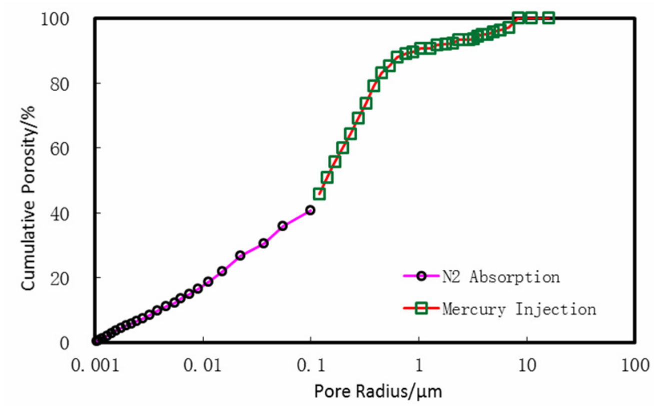
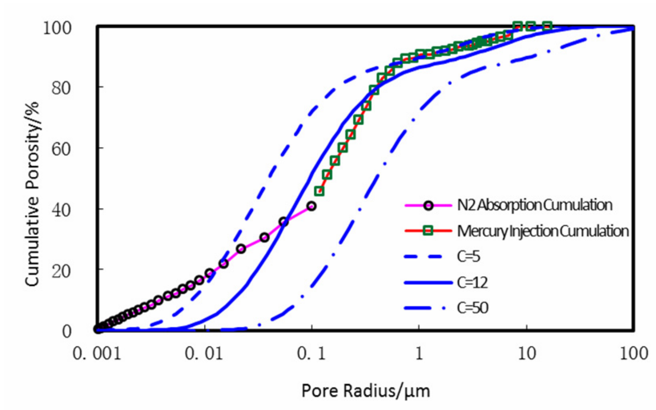


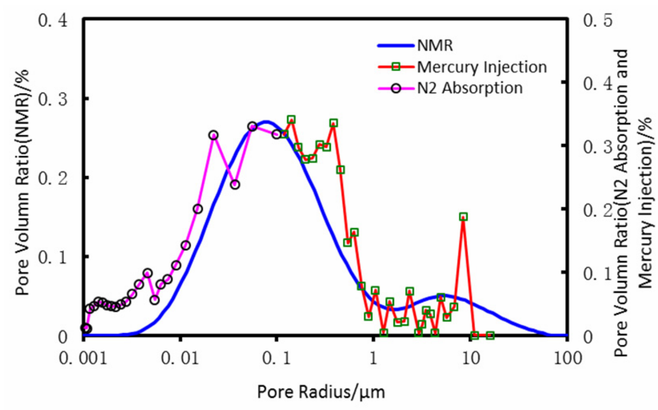
a. Porosity component diagram of N2 adoption and mercury injection



b. Cumulative porosity distribution combined N2 adoption with mercury injection

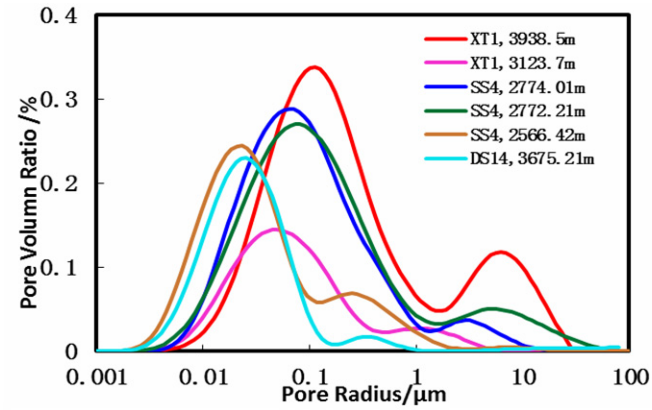


c. Cumulative porosity distribution of NMR

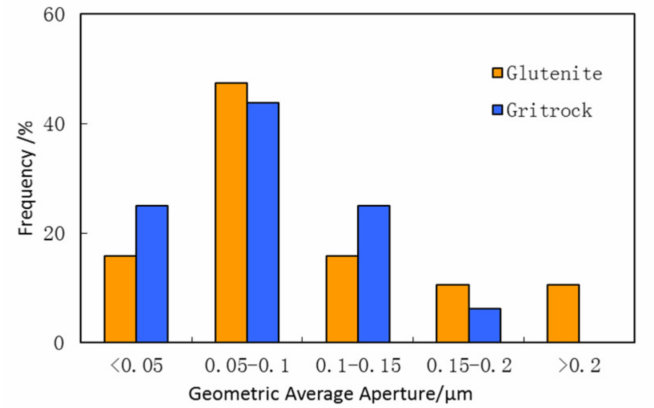


d. Pore size distributions of calibrated NMR,N2 adoption and mercury injection

Fig.1 Flow chart of NMR T_2 calibration by jointing nitrogen adsorption and mercury injection



a. NMR pore size distribution of Shahezi Formation



b. Geometric average aperture distribution chart

Fig.2 Pore size distribution features of Shahezi Formation

the controlling factors of geological settings and rock assemblage (Tang, 1997; Liu et al., 1998). These types of classification play a positive role in further prospecting and research. However, as the development of geological study, the factors of geological settings, volcanic-intrusive assemblages and small-intrusion metallogeny are more and more important in recognizing and discovering ore deposits. It is necessary to put forward a new classification to stress these factors.

During the 20th century, geologists pay more attention to looking for magmatic sulphide deposits associated with large-size layered complex, because the biggest magma deposits formed in large-size layered complex, such as the Bushiveld (Bushveld?) layered complex containing the biggest PGE deposit (Cawthorn RG, et al., 2002), with an area of more than 60′10^3 km^2. Another example is the Sudbury layered complex containing the second largest nickel deposit (Faggart et al., 1985), with an area of more than 1000 km^2. However, researchers explore China in different degrees, without discovering large layered complex except some magmatic sulphide deposits in small intrusions, among which there is the third largest nickel deposit (Jinchuan deposit) in the world. The area of the Jinchuan intrusion is only 1.34 km^2. Then, geologists pay more and more attention to small-intrusion metallogeny.

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