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中上扬子区海相页岩气储层孔隙结构非均质性特征

陈尚斌，秦勇，王阳，张寒，左兆喜

Pore Structure and Heterogeneity of Marine Shales in the Middle-Upper Yangtze

CHEN Shang-bin，QIN Yong，WANG Yang，ZHANG Han，ZUO Zhao-xi

摘要/Abstract

摘要：

页岩气储层存在从纳米尺度到宏观尺度的非均质性。采用多种实验数据，分析中上扬子地区筇竹寺组与龙马溪组页岩气储层孔隙结构与微观非均质性、孔隙演化规律及影响因素。研究认为，筇竹寺组与龙马溪组属良好页岩气发育层位，黑色页岩厚度一般分别大于100m和50m。筇竹寺组孔隙度、总孔容和孔比表面积等孔隙结构参数均低于龙马溪组，差异性较大。龙马溪组以微孔—过渡孔占绝对优势；孔隙结构参数变异系数及核磁共振弛豫时间T_2特征均表明筇竹寺组非均质性更强；最利于储气的微孔不稳定，较少存在渗流型孔隙，各级孔隙间连通性弱；龙马溪组微孔稳定，具渗流型孔隙，连通性好。高成熟度利于有效孔隙形成，有机酸可促进溶蚀孔发育，机械压实作用造成粒内孔和粒间孔减少，黏土矿物通过自身形态转变和层间水排出影响孔隙。储层所受多期构造应力场相似，形成张性和剪性裂隙网，增加储集空间、连通性和渗透性；物质成分及其成岩演化是孔隙结构主要内因，也是孔隙演化本质，孔裂隙显著受*TOC*和石英等物质影响；*TOC*和石英含量与总孔容和孔比表面积呈正线性关系，黏土矿物含量与之呈负线性关系。

关键词: 孔隙结构, 非均质性, 海相页岩气储层, 中上扬子地区

Abstract:

The composition and structure of shale gas reservoirs show remarkable heterogeneity from macro-scale to nano-scale.By comprehensively analyzing various experimental data,the pore structure,micro-heterogeneity and the affecting factors,along with pore evolvement rule of both the Qiongzhusi Formation and Longmaxi Formation in the Middle-Upper Yangtze were characterized.Both formations are organic enriched with shale thickness more than 100m and 50m,respectively.However,the porosity,pore volume,specific surface area and other parameters of the shales differ prominently and the Longmaxi Formation represents a better pore structure parameter.The micropore and transitional pore are the dominant pore type in the Longmaxi Formation,which is unlike the Qiongzhusi Formation,whose pore volume of samples is quite centralized in certain interval with poor connectivity.The variation coefficient of pore structure and the NMR relaxation time (T_2) indicate that the Qiongzhusi shale is of higher heterogeneity,and the micropore volume,which is the key space for gas occurrence,differs between samples in the Qiongzhusi shale and represents a weak connectivity.These two shales experienced similar external factors,such as multiphase tectonic stress field deformation,and formed tensional and shear fissure network,which increased the reserving volume,connectivity,and permeability.Composition and the diagenesis modification are the main internal factors and the nature of pore evolvement,and the pores and fissures are mainly influenced by the organic matter,quartz,and other compositions.*TOC* and quartz content represent a positive liner correlation with pore volume and specific surface area,while clay content is negative.High maturity is beneficial in forming effective pore network because the dissolution of organic acid.Compaction leads to the volume decrease of inter-and intrapartical pores,and the draining of interlayer water as well as mechanical deformation of clay impacts on the pore structure,too.

Key words: Pore structure, Heterogeneity, Marine shale gas reservoir, The Middle-Upper Yangtze

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