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四川盆地焦石坝地区页岩气储层特征及控制因素

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Reservoir characteristics and controlling factors of shale gas in Jiaoshiba area,Sichuan Basin

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摘要

页岩气的生成和聚集具有不同于常规油气藏的独特规律,页岩气储层的研究是页岩气勘探与开发的核心问题。目前,对焦石坝地区页岩气储层的认识是相对有限的,需要对本区页岩气储层做进一步研究。基于大量实验室测试数据的统计分析显示:上奥陶统五峰组和下志留统龙马溪组目的层段总有机碳(TOC)含量介于0.55 % ~5.89 %,平均为2.54 %,且具有自上而下有机碳含量逐渐增加的趋势;基于全岩X-射线衍射分析方法,页岩中黏土矿物含量介于16.6 % ~62.8 %,平均为40.9 %,自上而下逐渐减少,脆性矿物含量自上而下逐渐增加,总量介于37.2 % ~83.4 %,平均为59.1 % ;基于氦气注入法检测了目的层段的孔隙度,实测氦气孔隙度介于1.17 % ~7.98 %,平均为4.61 %,目的层段孔隙度呈现出"两高夹一低"的三分性特征;稳态法水平渗透率介于0.002~335.209 mD,平均为23.785 mD;通过高压压汞法对储层孔隙结构进行了研究,大量的测试数据表明,介孔级别的孔隙发育,且介孔提供了主要的孔比表面积,而介孔和大孔对渗透率起主要的贡献;将氩离子剖光技术和扫描电镜(SEM)相结合对储层的孔隙类型进行了观察,总体表现为自上而下有机孔隙增加、无机孔隙减少;由解吸法测得总含气量介于0.44~5.19 m^3/t,平均为1.97 m^3/t,从上到下呈现出逐渐增大的趋势。研究表明,焦页1井海相页岩气储层发育的控制因素有矿物组成和有机质发育特征等。TOC是控制下部储层段的主要内在因素,也是提供页岩气储存空间的重要物质;成岩阶段晚期,黏土矿物组合发生变化,蒙脱石向伊利石转变,形成新的微孔隙,增加了储层的孔隙度,对上部储层段有较大影响;脆性矿物含量大于50 %,易于形成裂缝,可造成地层渗透性能的显著增强。总体来看,五峰组和龙马溪组的底部层段是优质储层,也是主要的产气层段。

关键词 : 页岩气储层, 孔隙度, 孔隙结构, 孔隙类型, 控制因素, 上奥陶统, 下志留统, 焦石坝

Abstract :

The generation and accumulation of shale gas has unique laws different from conventional hydrocarbon reservoirs. The study on shale gas reservoirs is a key issue in the exploration and development of shale gas. At present, the knowledge of shale gas reservoirs is relatively limited in Jiaoshiba area, for which a further study is required. Based on massive laboratory test data, the statistical analysis shows that the total organic carbon of Wufeng Formation, Upper Ordovician and Longmaxi Formation, Lower Silurian is ranged in 0.55 % ~5.89 % and has an average of 2.54 % in the target intervals, presenting a gradual increase trend from top to bottom. Based on whole-rock X-ray diffraction method, the content of shale clay mineral is ranged in 16.6 % ~62.8 % and 40.9 % on average, gradually reduced from top to bottom. The content of brittle mineral gradually increased from top to bottom, ranged in 37.2 % ~83.4 % and with an average of 59.1 % . The helium injection method was used to test the porosity of target interval. The measured helium porosity is ranged in 1.17 % ~7.98 % and 4.61 % on average, characterized by trichotomy of a low value between two high values. Based on steady-state method, the measured horizontal permeability is ranged in 0.002~335.209 mD and 23.785 mD on average. The reservoir pore structure has been studied using high pressure mercury injection method. Massive test data show that meso-pores are developed and provide the main specific surface area, while meso-pores and macro-pores make major contributions to permeability. The pore types were observed using SEM in combination with argon-ion milling technology. It is mainly shown that the organic pores increase while inorganic pores are reduced from top to bottom. Measured by desorption method, the total gas content is ranged in 0.44~5.19 m^3/t and 1.97 m^3/t on average, showing a gradual increase trend from top to bottom. Research results indicate that the development of marine shale gas reservoir in Well Jiaoye 1 is controlled by mineral compositions and the development characteristics of organic matters. The total organic carbon is not only a major factor to control the lower reservoir member, but also an important material to provide the storage space to shale gas. In the late diagenetic stage, the clay mineral assemblage was changed from montmorillonite to illite, so as to form new micro-pores, leading to an increase in reservoir porosity and great influences on upper reservoir members. The content of brittle mineral is more than 50 %, facilitating the development of fractures, so that the permeability performance of reservoirs will be significantly enhanced. In general, Wufeng Formation and the bottom of Longmaxi Formation are high-quality reservoirs as primary pay zones.

Key words : shale gas reservoir porosity pore structure pore type controlling factor Upper Ordovician Lower Silurian Jiaoshiba area

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