EFFECT OF CARBONATE CONTENT ON THE PETROPHYSICAL PROPERSITY OF THE WUFENG-LONGMAXI SHALES IN THE SICHUAN BASIN, CHINA

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The Wufeng–Longmaxi shale is commonly accepted to be the best shale for shale gas exploration and development in China. Changning and Fuling are the two depositional centers of the Wufeng Formation and Longmaxi Formation in the Sichuan Basin. However, there are significant differences in the gas content of the Wufeng–Longmaxi shales between these two areas. These two major shale gas fields in the Sichuan Basin, Weiyuan–Changning and Fuling, have proven geological reserves of 0.16×1012 m3 (5.65×1012 ft3) (Zou et al., 2016) and 0.60×1012 m3 (21.19×1012 ft3), respectively. The gas reserve in the shale gas production intervals of the Changning and Fuling fields are in the range of 2.4–5.5 m3/t (84.8–194.2 ft3/t) and 4.7–7.2 m3/t (166.0–254.3 ft3/t), respectively (Zou et al., 2016). Authors have observed a significant variation in the gas production from different parts of the Wufeng-Longmaxi shales. For example, the initial test output of average single well in the Fuling shale gas field (more than 30 wells) is 33.4×104 m3/d (1179.5×104 ft3/d) (Zou et al., 2016). However, the shale gas production of the Changning shale gas field is much lower, the initial test output of average single well in the YS108 well area (more than 20 wells) and N201 well area (more than 20 wells) in the Changning shale gas field is 21.2×104 m3/d (749.7×104 ft3/d) and 13.5×104 m3/d (476.7×104 ft3/d) (Zou et al., 2016), respectively. Therefore, the heterogeneity of the high-quality shale interval in the Changning shale gas field is very strong (Jia et al., 2017) and the initial test output is relatively low and uneven.

In this study, two shallow wells named Shuanghe-1 and Sanquan-1 were drilled in the south and southeast of the basin, respectively. The petrophysical properties, pore structure of organic matter (OM), mineralogy and tectonic compressional deformation of the Wufeng-Longmaxi shales from both wells, together with Jiaoye4 from the Fuling shale gas field, were comprehensively investigated and compared. The results indicate that organic-rich shale intervals (TOC >2.0 wt.%) in both Sanquan and Jiaoshiba town have high pore volume and low carbonate content, whereas organic-rich shale interval in Shuanghe town has much lower pore volume but higher carbonate content. Basically, in Shuanghe-1, both total pore volume (Vtotal) and total specific surface area (Stotal) of the organic-rich shale samples with very similar TOC content decrease by approximately 30% when the carbonate content of the shale increases by 10%, especially when the carbonate content is in the range of 10%-20%. Additionally, the OM pores could be visibly undeveloped and even isolated in a restricted pore space due to carbonate dissolution and reprecipitation, resulting in lower shale pore volume and connectivity. High carbonate content may be one critical geological factor that is responsible for the lower gas content in the Wufeng–Longmaxi shale reservoirs in the southern Sichuan Basin.

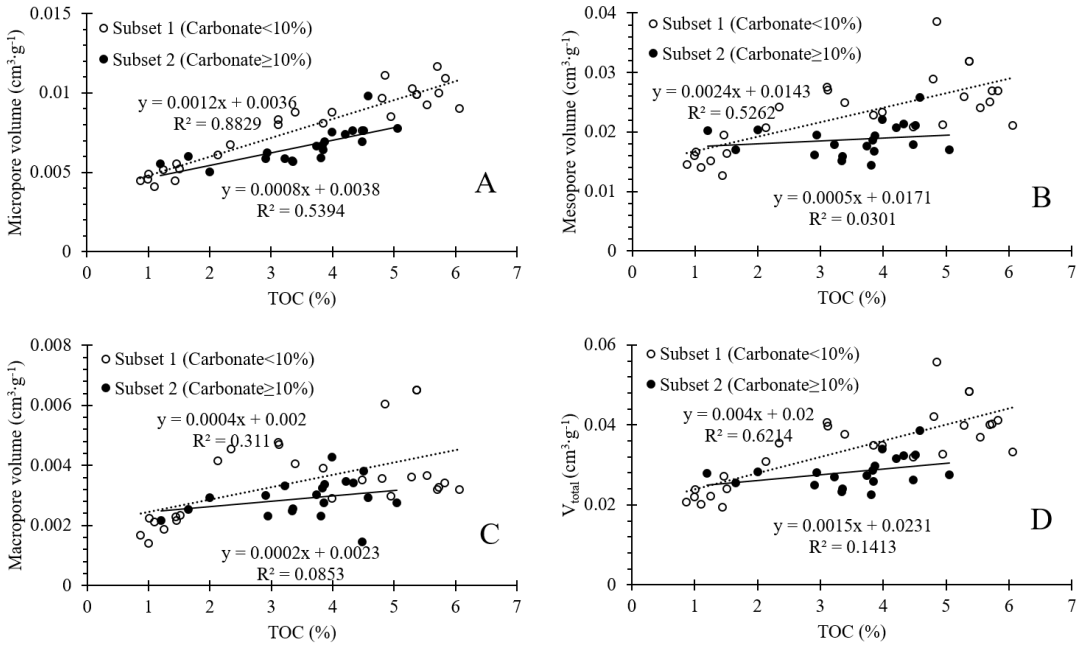

Figure 1 *Relationship between the nanopore volume and total organic carbon (TOC) in the well of Shuanghe-1. The nanopore volume of the subset 2 (carbonate ≥10%) is beneath the regression line of the nanopore volume of the subset 1 (carbonate <10%), indicating higher carbonate content can lead to lower nanopore volume. (A) Relationship between the micropore volume (Vmic) and TOC; (B) Relationship between the mesopore volume (Vmes) and TOC, showing a large deviation of the mesopore volume off the regression line; (C) Relationship between the macropore volume (Vmac) and TOC; (D) Relationship between the total pore volume (Vtotal) and TOC. Vtotal = Vmic + Vmes + Vmac.*