

# Hydrocarbon Expulsion Differences and Its Impacts on Gas Content in Lower Silurian and Lower Cambrian Shale Gas Systems

Ruiyin Liu<sup>1</sup>, Hao Xu<sup>2</sup>, Wen Zhou<sup>2</sup>

<sup>1</sup>College of Resources, Chengdu University of Technology; <sup>2</sup>State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology

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## Abstract

Nowadays, China has experienced a significant breakthrough in shale gas production. Most of the productive shales are found in the Lower Silurian Wufeng-Longmaxi shale and Lower Cambrian Qiongzhusi shale, Sichuan Basin, southwest China. However, the production and gas content of the Wufeng-Longmaxi shale are much greater than those of the Qiongzhusi shale. This paper provides a method to assess the preservation conditions and explain the differential fluid migration behaviour in shale gas reservoir, through the isotope geochemistry, pressure coefficients and bitumens distribution analyses. Observations in isotopically normal gases, low pressure coefficients and widespread distribution of bitumens proved an open petroleum system and fluid migration path of Lower Cambrian Shale caused by Tongwan tectonic unconformity, which resulted in poor gas content and low productivity. Carbon isotopic reversal ( $\delta^{13}\text{C}_1 > \delta^{13}\text{C}_2$ ) and hydrogen isotopic reversal ( $\delta^{13}\text{DC}_2\text{H}_6 > \delta^{13}\text{DCH}_4$ ) are observed in the Lower Silurian shale gas. Isotopically reversed gases suggest that the Lower Silurian shale gas is a sealed, self-contained petroleum system. Besides, isotope “reversals order” degree of shale gas has positive correlation with gas production. While, isotopically normal gases from the Lower Cambrian suggest that it is an open petroleum system. We propose that the Tongwan tectonic movement opened the petroleum system and induced the poor gas preservation in Qiongzhusi shale. We conclude that the Lower Silurian shale gas reservoir is an overpressurized system, with pressure coefficients ranging from 1.45 to 2.03. Overpressurization also indicates

that the gas is within a sealed and self-contained system. Good relationships have been found between shale gas production and pressure coefficients. However, there is a normal pressure system in the Lower Cambrian shale gas reservoir, which indicates that it is continued open system, which resulted in poor gas content and low productivity. Result of individual hydrocarbon isotope and biomarker analysis shows solid bitumens in Sinian Dengying Formation originate from Lower Cambrian source rock. The bitumens were mainly found 100 m below the Tongwan unconformity surface and widespread in the Sinian Dengying Formation observed by core slice. The Tongwan unconformity provided good “hydrocarbon migration tunnels” between the Sinian dolomite and Lower Cambrian source rocks and is the main cause of differential shale gas content and production performance.