

Pore Network and Gas Adsorption Potential Evolution of a Marine Shale During Organic Matter Maturation

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Abstract

Pore development and evolution in organic-rich shales is predominantly related to organic matter (OM) thermal maturation. In order to study the OM and pore network evolution of the shale during its maturation, a suite of shales across a maturation gradient were derived from one low-mature Xiamaling marine shale by hydrous pyrolysis at different heating temperatures. Geochemical characterization, such as hydrocarbon product component, yields, Rock-Eval, and Leco-TOC analyses, were used to characterize the kerogen type and OM transformation stages. Ar-ion milling field-emission scanning electron microscopy (FE-SEM), image-based point-counting and low-pressure gas physisorption (CO₂ and Ar) were applied to characterize the pore network (pore type, size, shape, distribution, volume and surface area). Additionally, high-pressure methane adsorption was used to investigate the methane adsorption potential. The result shows that pore evolution exhibits a good correspondence to hydrocarbon generation. The Dominant pore type at the bitumen generation stage is mineral-related pore. The Presence of shrinkage OM pores and micro-fractures contribute to increasing meso- (d 2-50 nm) and macropore (d>50 nm) volumes, whereas declined micropore (d<2 nm) volume is related to bitumen infilling. During the oil window, bubble-like OM pores related to oil generation and expulsion predominate. Less amount of modified mineral pores related to the development of two-phase hydrocarbon inclusions were also observed. High expulsion efficiency leads to a limited decline of pore volume because of bitumen infilling. During the oil cracking stage, modified mineral pores largely increased. Transformation of large-

size bubble-like OM pores to small-size spongy OM pores (associated with cracking of oil and/or bitumen to gas and corresponding rearrangement of OM structure) make a contribution to increased micropore volume, as well as decreased meso- and macropore volumes. During the wet gas cracking stage, large abundance of spongy OM pores develop in highly transformed OM, leading to a significant increase of pore volume. Furthermore, the evolution of gas-adsorption potential is largely controlled by micropore structure. The adsorbed methane density equivalent (absolute methane adsorption capacity divided by micropore volume) revealed that the shale gas loading potential gradually decreases in micropores during thermal maturation.