AAPG Datapages/Search and Discovery Article #90305 ©2017 AAPG Africa Region, Geoscience Technology Workshop, Exploration and Development of Unconventional Hydrocarbons, Cape Town, South Africa, June 20-23, 2017

SYN- AND POST-DEPOSITIONAL DEVELOPMENT OF PORE SYSTEM AND MINERALOGY IN THE POTENTIAL GAS SHALE OF THE PERMIAN WHITEHILL FORMATION OF SOUTH AFRICA

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ABSTRACT

Since the technologically efficient exploitation of economic hydrocarbon reservoirs in shales, increasingly more research has been devoted to identifying and characterizing pore systems within shales. However, only a handful of these studies focused on the development of porosity in thermally mature unconventional reservoirs. In this study, the evolution of porosity and pore geometry in the Permian Whitehill Formation is addressed with the aid of ultrathin sections (2x3 cm, 10-20 μm thick) and field emission scanning electron microscopy (FE-SEM) on samples with mean random vitrinite reflectance values ranging from 1.03 to 4.07% Ro. We document a positive covariation of thermal maturity and porosity for vitrinite reflectance values between 0.92% Ro and 2.58% Ro in samples with total organic content (TOC) greater than 2.03 wt.%. In samples with vitrinite reflectance value >2.58% Ro, a strong negative covariation of thermal maturity and porosity was detected, such that for everyone unit increase in vitrinite reflectance, porosity decreased by about 4.5 vol.%. The positive covariation of thermal maturity and total porosity recorded here is unsurprising and have been documented previously in many gas shales. However, the dramatic decrease in porosity restricted to samples from localities that experienced advanced maturation (Ro > 2.58%) is viewed as an evidence that porosity decrease is directly related late thermal decarboxylation of organic matter. This opinion is supported by the presence of pores and micro-fractures infilled by fibrous mineral grains and residual fluid inclusions generated from re-precipitation of framework grains, including carbonates, clays, silicates, and phosphates previously dissolved by organic acids (carboxylic, phenolic) generated during thermochemical decarboxylation of sulphur-rich OM. Our findings do not only fill important gaps in the understanding of organic pore development, including processes that create, preserve, and destroy porosity, but the porosities described here are also key to gas transfer from shale matrix to induced fractures during fracture stimulation programs.