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Formation of nanoporous pyrobitumen residues during maturation processes within the Barnett Shale (Fort Worth Basin)

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Hydrocarbon generation processes occur within organic-rich shales as a response to increases in thermal maturation. Shale gas reservoir quality is thought to be largely dependent on the extent to which solid organic material has been converted to pore space during catagenesis. Although pores may drastically vary in variety and abundance within differing shales, the occurrence of nanopores within organic particles has recently been documented for an important number of gas shale systems (i.e. Barnett, Haynesville, Utica, Eagle Ford, Woodford, Horn River, Marcellus, Posidonia ...). However, despite their ubiquitous nature, the formation and the geochemical nature of these nanoporous organic compounds remain unclear. Here, we present the characterization of samples from the organic-rich Mississippian Barnett shale gas system (Fort Worth Basin, Texas, USA) at varying stages of thermal maturation. Using a combination of compositional organic geochemistry and spectromicroscopy techniques, including synchrotron-based scanning transmission X-ray microscopy (STXM – data collected using the CLS 10ID-1 STXM beamline) and transmission electron microscopy (TEM), we document a net increase in sample geochemical heterogeneity with increasing maturity. In addition to the presence of bitumen in samples of oil window maturity, very likely genetically derived from thermally degraded kerogen, the formation of nanoporous pyrobitumen has been inferred for samples of gas window maturity, likely resulting from the formation of gaseous hydrocarbons by secondary cracking of bitumen compounds. By providing in-situ insights into the fate of bitumen and pyrobitumen as a response to the thermal evolution of the macromolecular structure of kerogen, the present contribution constitutes an important step towards better constraining hydrocarbon generation processes occurring within unconventional gas shale systems.