Comparison of Hydrous Pyrolysis Petroleum Yields and Compositions from Nigerian Lignite and Associated Coaly Shale in the Anambra Basin

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The Anambra Basin in southern Nigeria (antecedent to the Niger Delta) consists of the outcropping Paleogene Imo Shales (marine), the Neogene paralic Ogwashi-Asaba Formation, and the continental Quaternary Benin Sandstones, constituting the Tertiary Petroleum System of the Niger Delta. Source rocks for oil and gas in the delta have been described as predominantly terrigenous. In this study, the interbedded lignites and carbonaceous shales of the Neogene Ogwashi-Asaba Formation were mapped, sampled and subjected to sequential hydrous-pyrolysis (HP) experiments at 330°C for 72 hours and then at 355°C for 72 hours to characterize their oil and gas potential. Maceral analyses reveal about equal proportions (ca. 45%) of huminite and liptinite in the lignite, and a larger proportion of huminite (>70%)in the coaly shales. The lignite sample has a Rock-Eval hydrogen index (HI) of 481 mgHC/gTOC and a mean vitrinite reflectance of 0.36 %Rr. The total amount of expelled oil generated in the sequential HP experiments is 259 mg/g TOCorig. This expelled waxy oil contains abundant high-molecular-weight n-alkanes and an extremely high pristane/phytane ratio of 6.5. These attributes are typical of crude oils generated from coals as observed in some onshore and shallow offshore accumulations of the Niger Delta. The overlying coaly shale has a lower HI of 191 mg/gTOC and a mean vitrinite reflectance of 0.40 %Rr. The total amount of expelled oil generated in the sequential HP experiments is only 15 mg/g TOCorig. This oil contains n-alkanes that gradually decrease in content from n-C16 to n-C36 with a pristane/phytane ratio of 2.6 suggesting a more marine source as observed in some shallow water and onshore/shelf oil accumulations in the Niger Delta. Generated gas from these two samples also shows notable differences. Total hydrocarbon gas yields range from 25 mg/g TOCorig for the lignite to 34 mg/g TOCorig for the coaly shale. The δ13C of the methane generated at 355 °C for 72hours is -39.5‰ for the lignite and -35.0‰ for the coaly shale. These results suggest that the coals and shales within the Agbada Formation can be responsible for Niger Delta oils with terrigenous and marine characteristics; secondly, paralic source rocks can change from terrigenous to marine organic matter over narrow stratigraphic intervals (2meters) and thirdly, the oil expulsion efficiency of coals can be significantly greater than that of associated coaly shales, as previously thought.