Hydrous Pyrolysis Petroleum Yields from Lignites and Associated Shales in the Anambra Basin: Evidence for Marine Sourced Oils and Implications for the Niger Delta Petroleum Systems

Samuel O. Akande[1], Michael D. Lewan[2], Mark Pawlewicz[2], Sven Egenhoff[3], Olukayode Samuel[4], Olabisi A. Adekeye[1], and Olusola J. Ojo[1]

[1]Department of Geology, University of Ilorin, Ilorin, Nigeria.
[2]Organic Geochemistry, U.S.Geological Survey, Denver, CO.
[3]Department of GeoSciences, Colorado State University, Fort Collins, CO.
[4]Exploration Department, ExxonMobil, Lagos, Nigeria.

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 huminites (>70%) in the shales with highly fluorescing amorphous organic matter constituting most of the balance (~20%). 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 of original total organic carbon (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 carbonaceous shale has a lower HI of only 191 mg/gTOC, but a similar 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 and a pristane/phytane ratio of 2.6 suggesting a more marine source as observed in some shallow water and deepwater oil accumulations in the Niger Delta. These results suggest that the coals and shales within the thermally mature stratigraphic levels of the Agbada Formation can be responsible for Niger Delta oils with terrigenous and marine characteristics. Additionally, paralic source rocks can change from terrigenous to marine organic matter over narrow stratigraphic intervals (2 meters) and the oil expulsion efficiency of coals can be significantly greater than that of the interbedded carbonaceous shales as previously thought.