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Improved characterisation of kerogen in organic-poor shales using fluorescence microscopy: an example from the Chad Basin, NE Nigeria

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Very large absolute amounts of buried organic matter can occur in thick sequences of relatively organic-poor shales. Because their total organic carbon (TOC) contents are low (0.3-1.0%), Rock-Eval pyrolysis analyses are influenced by mineral matrix adsorption effects, leading to the underestimation of hydrogen indices (HI), the common presumption of terrestrial Type III-IV kerogen, and a conclusion that no source potential is present. We present evidence that such shales can sometimes contain oil-prone organic matter (Type II kerogen) and that the critical factor controlling their source rock potential is then just their TOC. This is important from an exploration point of view because if the original level of organic matter preservation is adequate, and the main limiting factor is dilution, there is a much higher probability that such shales can pass locally (geographically or stratigraphically) into richer potential source rock facies within more condensed sections.

About 170 ditch cutting samples from the Cenomanian to Turonian Gongila and Fika formations in seven wells from the Chad Basin (NE Nigeria) have been studied for their bulk geochemistry and palynofacies. These homogeneous dark grey shales have TOC values of between 0.5 and 1.5 wt%. Marine amorphous organic matter (AOM), which is usually oil-prone when well preserved and immature (fluorescent), dominates the kerogen assemblage of all the samples (typically $>$90%). For such samples the normal global visual evaluation of AOM fluorescence is inappropriate and instead we have counted the relative frequency of 20 AOM categories (per 300 counts), defined by relative brightness and colour combinations under blue light excitation. The measured hydrogen indices (HI) of the samples are generally less than 50 (partly due

to maturity) and show no correlation with average colour and brightness values of the AOM autofluorescence.

A subset of the samples covering the full range of maturity values (Tmax 420-462˚C), have been subjected to elemental analysis. Atomic H/C ratios range from 0.77 to 1.28 (equivalent to HI values of up to around 430, typical of oil-prone Type IIorganic matter, in immature samples). Multiple regression analysis reveals a strong positive relationship between the atomic H/C ratios and the colour and brightness of AOM autofluorescence (adjusted $r^2 = 0.84$, n = 22). Fluorescence microscopy thus provides a much better assessment of the hydrocarbon potential of the organic matter, and the resulting ability to estimate the true HI values permits mass balance calculations of possible oil yields. The low TOC appears to be the only factor limiting the source rock quality of these shales. About 10% of the samples from the immature upper part of the Fika Formation do have TOC values greater than 2.0%, proving that there are potential source rocks in the basin. Some of the more mature Gongila Formation may also have had similar properties when immature.