

APPLICATION OF MOLECULAR MARKERS TO PETROLEUM MATURITY ASSESSMENT

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The maturity of an incremental petroleum charge effectively represents the temperature at which it is expelled from its source rock and is commonly expressed in vitrinite reflectance equivalents or more effectively as an equivalent expulsion temperature. As petroleum is expelled over a range of temperature the concept of maturity is very limiting as all oils (for example) actually represent an aggregate mixture of a range of petroleum with distinct maturities with different components contributed at different times. This is further complicated by the unfavourable concentration-maturity systematics of many common molecular maturity parameter sub components. Thus Wilhelms and Larter (2004) described petroleum accumulations in terms of mixtures that derive from several different components charged from source rocks at different temperatures with no single maturity value ascribable to an oil accumulation. They showed in particular that biomarker based parameters are very poor at assessing average maturity but are good at tracking the early oil charge while gasoline range compounds best track late charge maturity. The introduction of routine quantitative analysis of hydrocarbons and non-hydrocarbon paves the way for development of more rational maturity assessment procedures acknowledging the impact of oil charge mixing on net oil composition.

We present quantitative hydrocarbon and non-hydrocarbon composition data from a suite of single source related oils at various maturity levels assessed by analysis of drainage area maturation levels. The molecular maturity parameters based on the steranes and hopanes attain their equilibrium end-points prior to the main oil generation window and are therefore of limited use through the oil window (Fig. 1a). The use of biomarkers at the early maturity stage of petroleum generation is supported by the fact that they are at their most abundant in early mature fluids (Fig. 1b). Thus with increasing maturity, the fluid composition receives an increasing contribution from later generated biomarker depleted petroleum phases which effectively dilutes the biomarkers. In contrast aromatic compounds such as phenanthrene and dibenzothiophene show little change in concentration through the oil window (Fig. 1c). The employment of molecular maturity parameters based on aromatic hydrocarbons are thus likely to be most reliable in mixed charge oil situations although an exception to this is shown by

the behaviour of aromatic steroid hydrocarbons (shown for $C_{26}+C_{27}$ triaromatic steroids) which follow a similar trend to the saturated hydrocarbon biomarkers (cf. 1b).

The composition of fluids in the reservoir represents an integration of the many fluid phases that have completed the journey to the reservoir. Thus the charged oils represent a mixture best described by a maturity spectrum rather than a single maturity. To define a maturity spectrum for a petroleum accumulation containing many phases that derive from early mature biomarker rich phase and increasing contributions from biomarker depleted fluids requires an assessment of the quantitative evolution of several hydrocarbon and non-hydrocarbon compound suites. We describe how the maturity spectrum of a crude oil can be derived using quantitative molecular data and illustrate the potential of the maturity spectrum approach.

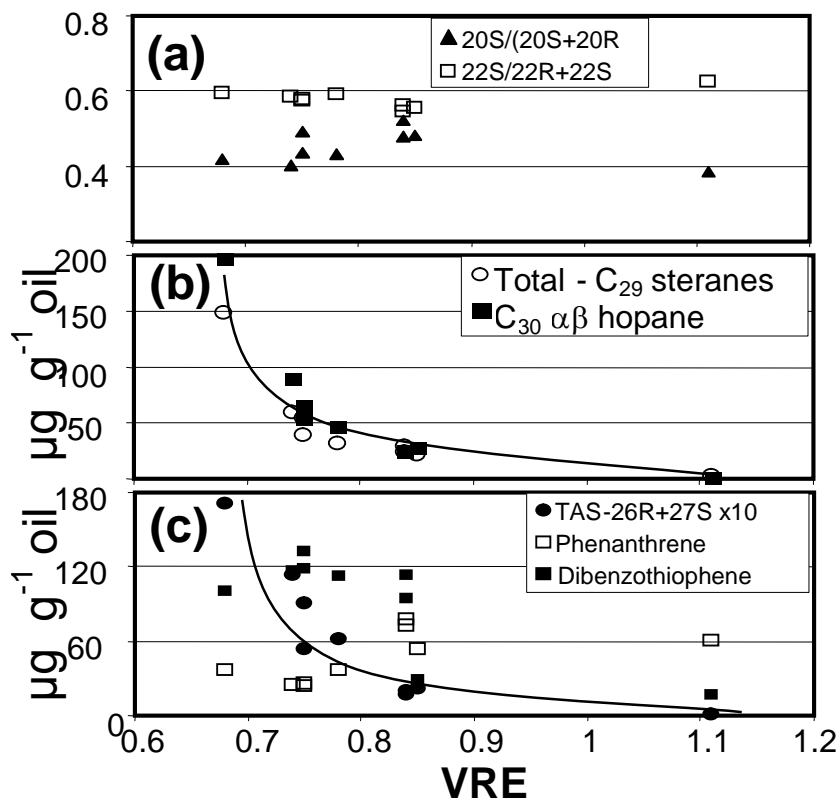


Figure 1. Plot showing the variation in (a) biomarker molecular maturity parameters and variation in concentrations ($\mu\text{g g}^{-1}$ oil) of (b) biomarkers and (c) aromatic hydrocarbons as a function of maturity given by vitrinite reflectance equivalent (VRE). Curves are drawn to aid viewing of trends amongst the biomarker and the triaromatic steroid (TAS) hydrocarbon data.

REFERENCES

- Wilhelms, A. & Larter, S.R. (2004). Shaken but not always stirred. Impact of petroleum charge mixing on reservoir geochemistry. In: *Understanding Petroleum Reservoirs; towards an integrated Reservoir Engineering and Geochemical Approach*. Cubitt, J.M., England, W.A. & Larter, S.R. (eds). Geol. Soc. Lond. Spec. Publ. 237, 27-35.