STABLE ISOTOPE-SPECIFIC HYDROCARBON GENERATION KINETICS OF ARCTIC SOURCE ROCKS

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The European Arctic is part of a frontier region of hydrocarbon exploration with a significant potential of undiscovered resources (Gautier et al., 2009). In this study we investigate coals and organic-rich shales of Paleozoic to Cenozoic age from outcrops on Spitsbergen. While most coals are considered to be gas-prone source rocks, previous organic geochemical studies showed that some arctic coals are hydrogen-rich and oil prone (Abdullah et al., 1988; Marshall et al., 2015). Knowledge of carbon isotope-specific kinetic parameters for the transformation of organic matter to hydrocarbons is important to evaluate hydrocarbon generation on a basin scale by numeric modelling. Isotope fractionation associated with hydrocarbon generation causes maturity related signatures in the stable isotope composition of generated oil and gas. These signatures can be used to correlate hydrocarbon accumulations with their source rocks and to estimate their maturity (Stahl, 1977; Berner & Faber, 1996).

To support an assessment of the hydrocarbon potential of sedimentary basins in the European Arctic, kinetic parameters were derived from non-isothermal, open-system pyrolysis experiments performed on different source rocks from Svalbard, including Paleozoic, Mesozoic and Cenozoic coals as well as Mesozoic shales. Pyrolysis temperatures ranged from 200 to 1200°C with heating rates from 0.1 to 5 °C/min.

The variations in carbon and hydrogen isotope signatures of hydrocarbons generated from these source rocks were determined by off-line GC-IRMS analysis on samples of the pyrolysis gas collected over discrete temperature intervals. Furthermore, based on previous work by Cramer et al. (2001), a new pyrolysis system was developed, which allows for on-line GC-IRMS analysis of the pyrolysis gas at higher sampling frequencies.

First results show that stable carbon isotope signatures of gas generated from the arctic coals and shales used in this study generally follow the expected trend of increasing $\delta^{13}C$ with increasing maturity. Although the bulk organic carbon $\delta^{13}C$ of -22 ‰ to -26 ‰ is in the typical range for coals, the isotope trends of gases generated from these arctic coals deviate from the trends reported for type III kerogen by Berner & Faber (1996) and show a systematic shift towards lower $\delta^{13}C$ values. Similarly, $\delta^{2}H$ of methane generated from the arctic coals shows the expected increase with increasing maturity, but all values are significantly lower than expected for coal-related gases (Schoell, 1980).

These observations indicate that correlation between source rock and gas based on the stable isotope signature can be difficult for arctic coals because especially at early maturity stages the signatures can resemble those of hydrocarbons generated from marine or lacustrine source rocks. Furthermore, maturity estimation based on gas isotope signatures for arctic coals should be derived from maturity relationships obtained for these specific source rocks rather than of those commonly used and derived from humic coals.

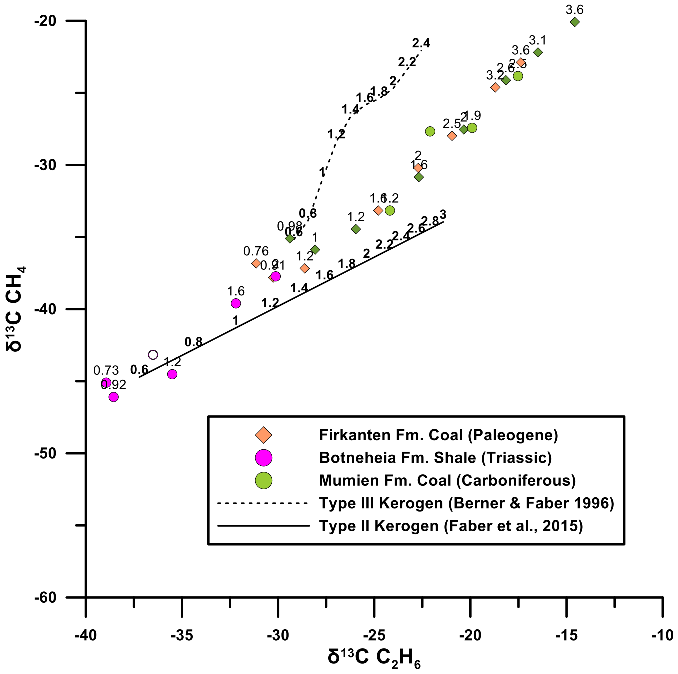

Figure 1 *Cross-plot of methane and ethane stable carbon isotope composition showing isotope signature for gas generated at different temperature (maturity) from two different coals and one shale from Spitsbergen. Numbers on trend lines and data points refer to vitrinite reflectance (VR %) and EASY%Ro calculated from pyrolysis temperature and time, respectively.*

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