GENERATION VERSUS EXPULSION DRIVEN MODIFICATIONS IN PETROLEUM COMPOSITION AND THE IMPACT ON MATURITY PARAMETERS

M. Stockhausen[1], L. Di Paolo[2], R. Galimberti[2], U. Berner[3], M. Erdmann[3], R. Elias[4], F. Gelin[4], L. Schwark[1]

[1]Kiel University, Germany; [2]Eni S.p.A., Italy; [3]Statoil, Norway; [4]Total, France

Reservoir charging history, as well as petroleum composition and quality are highly affected by expulsion and migration, which are essentially controlled by the source-rock/reservoir properties and nature of the organic matter (OM). Thus, studying expulsion and migration effects is essential to obtain a comprehensive picture, from generation to reservoir charge, and aiming towards calibration and improvement of modelling calculations.

However, investigation of these critical processes until now is still hampered by inappropriate methodologies in lab-scaled simulation. Addressing this issue, the Organic Geochemistry Unit at Kiel University has developed the "EXPULSINATOR"-device in cooperation with Eni S.p.A. The EXPULSINATOR facilitates semi-open hydrous pyrolysis of an intact source rock (i.e. with unaltered mineral matrix and kerogen network) under near-natural lithostatic and hydrostatic pressure regimes (Stockhausen et al., 2013). It has been applied to a variety of generation, migration and expulsion studies, proving its applicability for laboratory simulation of oil and gas generation and release upon subsidence or alternatively upon uplift events. Previous EXPULSINATOR studies demonstrated a systematic, though highly variable expulsion behaviour in dependence of source rock character, which controlled the lithological or petrophysical properties and the kerogen type (Stockhausen et al., 2013, 2016). However, geo- and biomarker maturity ratios in some cases exhibited unexpected behaviour, demonstrating gaps in our knowledge concerning the sensitive interplay of generation, decomposition and conversion affecting these parameters.

We here discuss six EXPULSINATOR experiments performed with very different pressure (**p**) and temperature (**T**) programs, using an immature (Rr=0.45%) source rock (kerogen type I/II). Differences in product amount and composition observed in the experiments enable distinguishing effects triggered by generation on the one hand, and migration/expulsion on the other hand. Figure 1 depicts the different programs used in these experiments:

(I): Here we focussed on the lithostatic **p** effect by keeping **T** and hydrostatic **p** constant and modulating lithostatic **p** only. (I-a) and (I-b) differ in pyrolysis **T** (330 vs. 360 °C).

(II): Aiming towards catagenesis simulation, **p** and **T** were increased stepwise in these experiments, simulating a maximum depth of 3 km. Recovered products can be assigned to a specific **p** and **T** regime due to the stepwise program setup. Experiment II-b featured a shift between generation (**T** and hydrostatic **p** controlled) and lithostatic **p** stages, facilitating investigation of **p** triggered expulsion effects.

(III): A catagenesis simulation mimicking natural conditions was approached in these ramp-wise experiments. **T** and **p** were increased in parallel, simulating a depth of 2.67 km (III-a), and 3 km (III-b), respectively. Following an isothermal phase of 24 h, uplift of the source rock has been simulated by decreasing **p** and **T**.

Rock matrix deformation on micrometre-scale, recorded in experiments II-b and III, revealed a connection between compression-expansion movements of the source rock and expulsion events. Simple parameters, like the Pristane/nC_{17} ratio at the same calculated maturity level reached different values in these experiments indicating an expulsion driven control. In the EXPULSINATOR the immediate product removal following their expulsion from the rock matrix reduces their time for isomerization at a given **T**. This will affect isomerization based parameters in a different way to cracking depended maturity ratios. We observed such effects for ratios calculated from relative abundance of alkylated naphthalenes or phenanthrenes, which were not in compliance with maturity progress and differed from those based on side-chain cracking of aromatic steroids. In addition to effects of isomerization time a fractionation of methyl-phenanthrenes was observed in experimental uplift simulation and attributed to geochromatography effects controlled by rock matrix alteration.

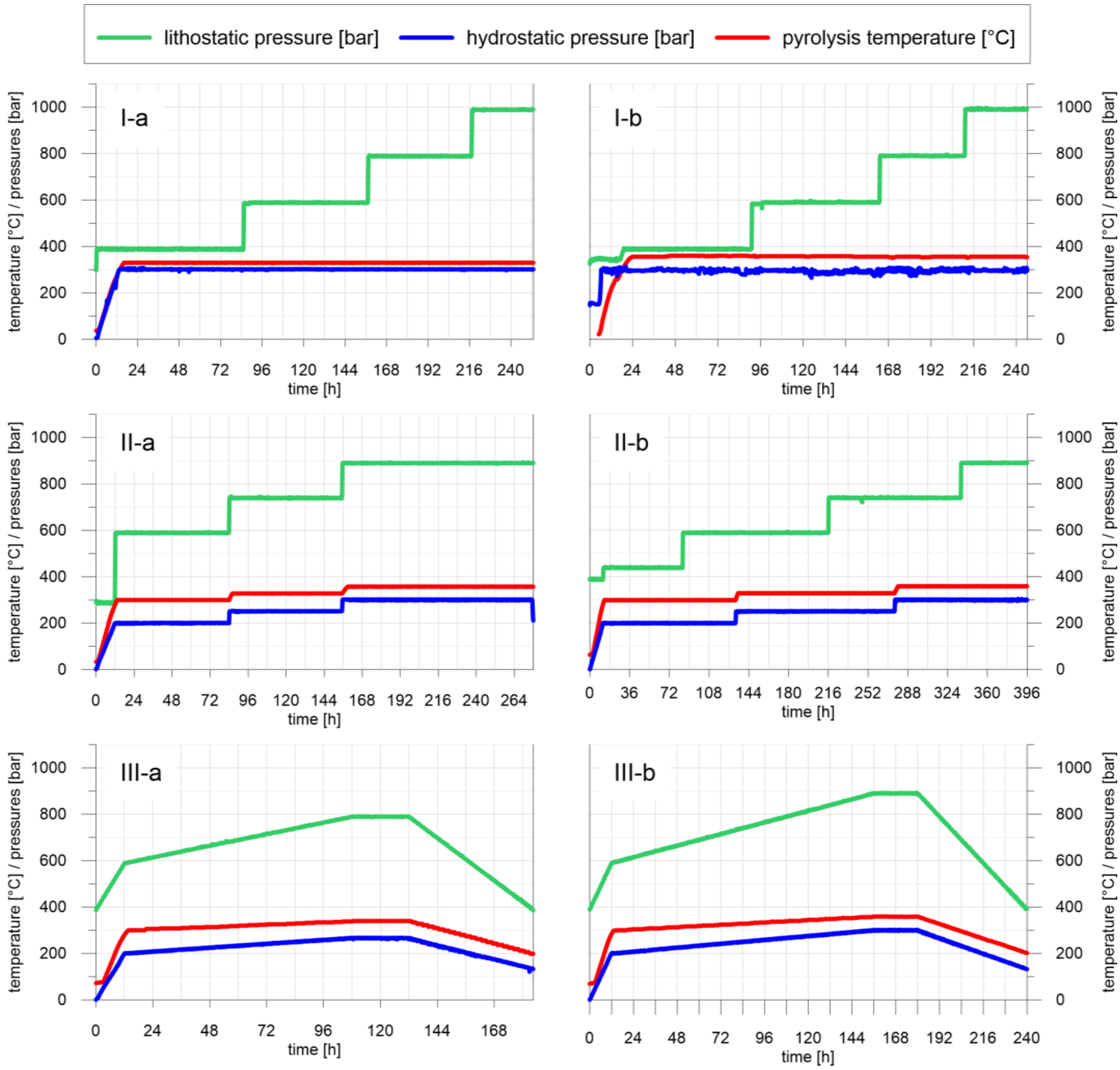

Figure 1 *Pressure and temperature programs of Expulsinator experiments. (I) Effect of lithostatic pressure on expulsion; (II) Stepwise catagenesis experiments; (III) Ramp-wise catagenesis experiments.*

References

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