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The Fate of Biogenic vs. Abiogenic Organic Matter during Thermal Maturation

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Organic compounds, especially in Archean rocks, usually raise the question whether their origin is biogenic or abiogenic as they might be an indicator for early life on Earth [1, 2]. However, they are biased by various parameters over geological time, e.g. changing temperature and pressure conditions, which may lead to a loss of important source information [3].

In our study we investigated the impact of thermal maturation on biogenic organic material (Green River Shale, Eocene) and compared it to the molecular traits of organic matter that we produced via aqueous Fischer-Tropsch type synthesis [4, 5] under hydrothermal conditions. The extractable and insoluble organic fractions were characterized by GC-MS analysis and Pyrolysis GC-MS, respectively. Hydrous pyrolysis of Green River Shale (GRS) kerogen in gold capsules for 2 h to 2400 h at 300°C allowed to assess the maturation behavior of several compounds used as life tracers and for the reconstruction of paleoenvironments (*n*-alkanes, pristane (Pr), phytane (Ph), gammacerane, steranes (St), hopanes (H), and cheilanthanes (Chei)). Lignite samples were maturated in parallel with the GRS kerogen to obtain exact vitrinite reflectance data at every sampling point.

Our experiment confirms the applicability of biomarker-based indices and ratios as maturity indicators (e.g. Chei/H; sterane and hopane isomerization indices). However, several biomarker ratios that are commonly used for paleoreconstructions (e.g. Pr/Ph, Pr/*n*-C_{17}, Ph/*n*-C_{18} and St/H) were considerably affected by differences in the thermal degradation behavior of the respective compounds. Short term experiments (48 h) performed at 400°C also revealed that biomarkers >C_{15} (especially steranes and hopanes) and 'biological' chain length preferences for n-alkanes vanished at vitrinite reflectances between 1.38 and 1.83% R_0. Beyond this point, no molecular distinction against abiotically formed Fischer-Tropsch type organic matter was possible.

Our data highlight that "thermal taphonomy" effects have to be carefully considered in the interpretation of biomarkers in ancient rocks and, potentially, extraterrestrial materials. The results also provide reference data for the discrimination of biogenic vs. abiogenic organic material in sedimentary rocks and will support the interpretation of data from the Mars Organics Molecule Analyzer (MOMA) that are expected early in the next decade.

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