Microbial conversion of oil, coal and shales into methane – A future energy resource

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Since decades it is known from stable isotope studies that large amounts of biogenic methane are formed in oil reservoirs. The investigation of this biodegradation process and of its biogeochemical controls are of great economical and social importance for: (1) The understanding of reservoir biodegradation may be of great use for the exploration industry, and (2) a biotechnological stimulation of methane formation in reservoirs could provide new economical perspectives for hydrocarbon recovery. Even under optimal conditions, today not more than 30-40 % of the total oil in a reservoir are actually recovered. The conversion of at least parts of the non-recoverable oil, coal or shales via an appropriate biotechnological treatment into easily recoverable methane would provide an extensive and ecologically sound energy resource. Laboratory mesocosms and high pressure autoclaves with samples from different geosystems showed high methane production rates after the addition of different oils, coals or shales. Stable isotope probing (SIP) combined with fingerprinting of the microbial enrichments showed a large bacterial but limited archaeal diversity involved in degradation. For the characterization of degradation pathways metabolite spectra will be analysed, combined with the use of SIP. The variability of carbon and hydrogen isotopes of produced methane falls in a relative narrow range. Further we have analysed the isotope composition of methane in reservoirs and oil-contaminated aquifer to test whether the isotope composition of methane can be used as an indicator for methanogenesis. The variability of carbon and hydrogen isotope composition *in situ* was almost identical with those obtained with the enrichment cultures. This implies a common methanogenic degradation mechanism resulting in consistent patterns of hydrocarbon alteration. This will provide an exploration tool to identify and assess these microbial processes in different reservoir geosystems. Mass balance calculations showed that significant fractions (2-10%) of added coals or oils were converted to methane. Current studies focus on the identification of stimulating or inhibiting factors for scale-up and field studies on MEOR.

Fluid inclusions in stalagmites used as a quantitative thermometer in paleoclimate research

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We present a new approach to determine paleotemperatures (mean annual surface temperatures) based on fluid inclusion liquid-vapour homogenisation temperatures (T_h) in stalagmites. A precondition for these measurements is to stimulate the nucleation of a vapour bubble in the initially monophase inclusions by means of single ultra-short laser pulses [1]. The aim of our study is to explore the potential and the limitations of this new paleothermometer and to develop a reliable methodology for routine applications in paleoclimate research. Therefore, we have investigated recent fluid inclusions from the top part of actively growing stalagmites from various caves to compare our results with the present-day cave air temperatures.

The method makes specific demands on the selection, handling and preparation of the stalagmites to avoid artificially induced modifications of the original fluid densities by leakage or stretching of the inclusions. Additionally, the measured homogenisation temperatures $T_{h\ (obs)}$ need to be corrected for the effect of surface tension to determine the nominal homogenisation temperature $T_{h\ (nom)}$ [2] that is expected to be equal to the stalagmite formation temperature and therefore closely corresponds to the mean annual surface temperature outside the cave. Based on our present results we may expect an accuracy in paleotemperature determinantions within ±0.3 °C. The application of this thermometer is, however, restricted to climate zones and periods with mean annual surface temperatures higher than 9–11 °C. Inclusions formed below this temperature limit do not feature a stable liquid-vapour state and thus T_h cannot be measured.

[1] Krüger *et al.* (2007) *Eur J Mineral* **19**, 693–706. [2] Marti *et al.* (submitted)