Project Proposal

Polar Petroleum Constituents in Exploration and Production

Executive Summary

Polar compounds including asphaltenes are key constituents of petroleum fluids, which have a profound influence on physical properties such as gravity and viscosity. Little is known about the mechanisms, by which polar compounds are generated from kerogen in the source rock, and the role that maturation may play with respect to their abundance and composition. Likewise, neither the fractionation of polar compounds between bitumen in the source and expelled oil during primary migration nor the interactions of polar compounds and minerals of the carrier rock that may influence fluid composition either by physical fractionation and / or chemical transformation (catalytic reactions) during secondary migration are well understood. Physical, chemical and biological alteration processes in petroleum reservoirs have a similar profound impact on the composition, properties and quality of crude oil (e.g. thermochemical sulfate reduction, biodegradation). However, the underlying mechanisms leading to the formation, transformation and enrichment of polar compounds in reservoirs are not even rudimentarily understood. From a filling history perspective, mixing of altered and pristine fluids considerably influences fluid compositional heterogeneity in reservoirs. Straightforward assessment of this heterogeneity is of outstanding importance for the correct assessment of reservoir continuity and compartmentalization.
Recent analytical developments including Fourier transform-ion cyclotron resonance-mass spectrometry (FT-ICR-MS) provide unprecedented insights into the compositional variability of polar compounds in petroleum fluids. Most importantly, these methods allow high sample throughput due to minimal sample preparation and short analysis time and thus are ideal to characterize organic matter/fluid heterogeneity at high spatial and temporal resolution. In this project we will use these methods to achieve a comprehensive understanding of source and reservoir controls on the formation, occurrence and distribution of polar compounds in petroleum fluids and to derive new parameters for routine exploration- and production-oriented reservoir assessment. We will analyze well-defined maturity sequences of petroleum source rocks to understand maturation-driven variability in fluid composition and properties. The influence of expulsion on polar compound abundance and composition will be assessed by comparing source rock data with those of corresponding reservoired oils from petroleum systems in which long lateral migration can be excluded. We will explore the utility of new geochemical tools based on polar compounds for the appraisal of primary and secondary controls on oil composition and its alteration from source to trap.

Goals:

- Develop a methodology for comprehensive characterization of polar compounds in chemically well-defined fractions of source rock bitumen, expelled oils and reservoir fluids by FT-ICR-MS using ESI, APPI and APCI in positive and negative ionization modes including new concepts for interpretation and visualization of analytical data sets
- Understand the processes controlling the formation of polar oil constituents in source and carrier rocks and their fractionation during expulsion
- Understand the processes controlling spatial and temporal heterogeneity of polar oil constituents in reservoir compartments (including mixing, abiotic and biotic alteration)
- Develop an integrated concept for the application of polar compound geochemistry to
    - to the appraisal of maturity- and migration-induced fluid heterogeneity in sedimentary basins (including mixing)
    - reservoir appraisal (exploration and production)

Samples:

- Source rocks and crude oils from Germany and Mexico
- Crude oils and reservoir cores from Haltenbanken and the Viking Graben, offshore Norway
- Use of well-documented case histories (routine geochemistry and basin modeling)

Deliverables:

- New approaches to determine bulk fluid properties (API, viscosity) from the molecular characterization of polar petroleum constituents
- Methodologies for the assessment of
    - maturity and migration using polar compound dynamics
    - reservoir scale processes using polar compound dynamics
- Database of analyzed source rocks, crude oils and reservoir cores

Costs:

- 50,000 € per participant per year*
- Project duration: 3 years
- Minimum number of participants: 4

*7% VAT not included

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