Organic-Inorganic Interactions in Petroleum Systems - from Nanometer to Reservoir Scale

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Organic-inorganic interactions occur in conventional and unconventional petroleum systems. The controlling factor is the conversion of labile organic material at shallow depth, or alteration or biodegradation of oil or solid organic matter at greater depth. During such processes soluble organic compounds like acetic acid or carbon dioxide are generated which can lead to changes of the hydrogeochemical characteristics of the pore water, e.g., of pH. Such changes cause imbalances of the existing rock-fluid equilibrium, and may lead to dissolution and precipitation of minerals and thus to changes of the rock properties and to gas formation.

Organic-inorganic interactions occur at a broad range of scales ranging from the nanomater scale to the reservoir scale, and are involved in a variety of processes. Biogenic or H2S methane formation, or oil reservoir compartmentalization take place on the reservoir scale, whereas such interactions also occur in micro-environemnts in shale. However, all these processes have one factor in common: water.

Organic-inorganic interactions are thus basically hydrogeochemical processes, or in other words: complex hydrogeochemical process chains. That means that the actual matrix for geochemical processes in sediments is water, which is ubiquitous in sedimentary basins where hydrocarbons form, accumulate and where they can be altered. Water occurs as a free aqueous solution in rock pores and fractures, as a surface-coating water film around mineral grains (so-called irreducible water), as part of multi-component gases, or bound to/into hydrated minerals. As such, the aqueous microsphere in the subsurface is the reactor in which a seemingly limitless number of geochemical processes may take place, either microbially-mediated or abiotically, at a broad range of temperatures. Water is thus either a reactant or a reaction product in organic-inorganic interactions, but importantly aqueous solutions in sediments are the matrix for diffusive and/or advective mass transport.

This keynote focusses on the basics of organic-inorganic interactions, how the processes can be unravelled in a qualitative and quantitative manner, and will present selected examples to demonstrate the need for interdisciplinary work.