Non-hydrocarbon compounds in oil and gas accumulations: Deep influx constrained by noble gases

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Recent oil and gas exploration demands deeper drilling and more complex targets. It is clear that fluids from a sedimentary basin cannot be considered isolated anymore from deeper fluids (metamorphic zones, continental basement, mantle). This induces negative consequences (occurrence of non hydrocarbon gases contaminating the hydrocarbon accumulations as carbon dioxide and nitrogen) and potential positive ones (high concentrations of helium as an economic resource, possible extra-generation of hydrocarbon gases through non organic processes). Different natural tracers allow us to quantify the importance of such deep fluids contaminants. Among them, the chemical and isotopic compositions of associated noble gases (from helium to xenon) give evidence, according to different oil fields, of mantle contributions from 0 to almost 100%. Very recent direct measurements of lead isotopes in associated liquid hydrocarbons confirm that mantle compounds may be associated both as inert gas molecules and heavy metals chemically associated with large organic molecules.

We present two examples of mantle-contaminated petroleum systems, where the noble gas chemical and isotopic patterns indicate a clear mantle contamination. Moreover, an excess of radiogenic ^{4}He is sometimes present, due to a leaching of crustal rocks through the migration of deeper carbon dioxide and/or nitrogen carrier gas, coming from deeper sources. This implies that the usual ^{3}He/^{4}He ratio, used commonly as an indicator of mantle contamination, may be useless, whereas the use of ^{3}He, associated with other gases (CH_4, CO_2, N_2, etc...), indicates clearly a mantle signature for CO_2 and N_2. The neon isotopes, as well as the pattern of fossil noble gas isotopes concentrations (^{3}He, ^{20}Ne, ^{36}Ar, ^{84}Kr, ^{132}Xe), normalized to air concentrations, give other proofs and quantifications of the importance of mantle fluid contamination. Associating these results with lead isotopes, with very different chemical properties (heavier component chemically associated with liquid molecules for lead, in contrast with light mobile and inert component as helium), should allow to better characterize the physical processes of mantle-fluid interactions in shallow sedimentary sequences.

U-Th-Ra fractionation in soil horizons of forested ecosystem (Strengbach catchment, France)

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The ^{238}U series nuclides (^{238}U, ^{234}U, ^{230}Th and ^{226}Ra) are recognized as tracers and chronometers of weathering processes. Using these tracers requires to understand the parameters and processes controlling their fractionation in soils surface horizons. In order to constrain these processes, the different compartments (soil profile, soil solutions and vegetation : wood, leaves, branchs and roots of beeches) of a experimental plot, situated in the Strengbach catchment (OHGE http://ohge.u-strasbg.fr, Vosges, France) have been sampled and analysed for major-trace elements and U-Th-Ra isotopes.

The shallower horizons of the soils have highest (^{226}Ra/^{230}Th) and lowest (^{230}Th/^{234} U) activity ratios (a.r.), respectively 1.41 and 1.12 compared to the other horizons of the soil profile. The analytical data of the different compartments of the vegetation suggest that the plants are characterized by very high (^{226}Ra/^{230}Th) ranging from 20 to 164 and low (^{230}Th/^{234} U) ranging from 0.84 to 0.97. Based on these results, we suggest that the geochemical signatures of the soils surface horizons (-40 cm) are influenced by litter recycling which could provide ^{226}Ra and ^{234}U excess in these horizons.

The (^{226}Ra/^{238}U) a.r. of the soil solutions (1.88-4.75) are higher hanthose of the corresponding soils (≈ 1.5). They decrease from the top of the profile to 30 cm depth and then increase weakly until 60 cm depth. The vegetation, which is responsible of both the litter recycling and the root uptake displays very high (^{226}Ra/^{238}U) ranging from 100 to 300. We propose that litter recycling influences the isotopic characteristics of the shallower soil solutions. The fractionation induced by root uptake, which mainly operate between 30 and 40 cm depth, could explain the lower (^{226}Ra/^{238}U) in soil solutions at these depths.

Therefore U series disequilibria allow to constrain the dynamics of a soil system. Moreover, the data point to the important role of the vegetation in controlling the geochemical/isotopical signatures of the soils surface horizons and soil solutions (-30 cm) by litter recycling and root uptake.

Reference

Chabaux *et al.* (2003), *Reviews in Mineralogy and Geochemistry* **52**, 533-569.