Is abiotic methane generation important in petroleum systems?

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Evidence of pure abiotic methane has been shown in hydrothermal vents on oceanic ridges, and in gas seeps associated with ophiolites and hyperalcaline springs. It is always associated with H_2, and sometimes CO. The $\delta^{13}C$ of CH_4 are always heavy, and may reach values as high as +5 per mil. A Rayleigh distillation may be modeled, with an associated heavy carbon source for CH_4 ($\delta^{13}C$=-4). In petroleum systems associated with volcanism, the $\delta^{13}C$ patterns of hydrocarbon gases may present inversions ($\delta^{13}C$ of $CH_4 > \delta^{13}C$ of C_2H_6). These patterns may present a trend to a purely thermogenic organic gas. The model of mixing of a low maturity wet gas with a high maturity dry gas is tested through mixing diagrams, and cannot fit the data. We suggest that, associated to the usual organic hydrocarbon generation, inorganic chemical reactions change the chemical and isotopic compositions of the accumulated hydrocarbons. The question of the proportion of abiotic extra amount of hydrocarbon is addressed, and it appears that with mass balance calculation combining noble gas isotopic ratios and hydrocarbons, it is possible to quantify the global proportion of extra-hydrocarbon generated through abiotic reactions. This proportion is generally minor in petroleum systems, but around 100% when associated with ultrabasic rocks. In summary, these chemical reactions are proven to be important in terms of hydrocarbon quality (GOR, gas composition), but it does not add any significant potential for conventional hydrocarbon reserves. The relative importance of abiotic methane associated with basic/utrabasic rocks has to be more precisely assessed.

Phase changes initiated by natural radioactivity in crystalline rocks and their implications

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Investigation of strongly radioactive primary minerals (monazite and rarely uraninite) in granites, migmatites and paragneisses of the Moldanubian area (Bohemian massif) revealed some effects of radioactivity which are little known yet. Aureoles which extend ca. 20 µm from the monazite surface formed, consisting mainly of clay minerals, often containing sulphides and/or Fe-hydroxides. In some cases zonation is observable: 1. sulphides (pyrrhotite, pyrite) in the outermost zone where reductive effect of beta radiation prevails, 2. Fe-hydroxides or even Fe-sulphate (formed, no doubt, from the sulphides) near the surface of radioactive grain where oxidation by alpha particles is dominant, 3. sulphide intimately intergrown with the monazite or uraninite. In extreme cases, monazite was finally replaced by a complicated H_2O-bearing phosphate.

The halos of secondary phases are formed mainly around radioactive inclusions in feldspars or cordierite and even in quartz. Migration of matter in a volume much greater than the visibly affected close vicinity of the radioactive grain must have occurred. The transport of elements is explained mainly with migration of fluid inclusions via dissolution/recrystallization of host minerals. Mechanisms how the radioactive grain could “attract” fluids include its acting as a point heat source, and mechanical tension in damaged crystals, supporting formation of microcracks. Calculations show that during long periods, steep temperature gradients sometimes form even in the vicinity of small and relatively little radioactive grains. However, it is also probable that radioactive heat production in rocks is overestimated due to neglecting of endothermic chemical processes (mainly dissolution).

The frequent association of monazite with H_2O-bearing secondary phases may significantly contribute to resetting of inherited monazite ages at metamorphism and partial melting.