Formation of hydrocarbon accumulations: Noble gas chronometry

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Radiogenic noble gases, (NG), $^{4}He^{*}$, $^{21}Ne^{*}$ and $^{40}Ar^{*}$, are produced in rocks by the decay of the parent isotopes, U, Th, K, and associating nuclear reactions and partially migrate into pore waters. During hydrocarbon (HC) production NG partition into HC phases, in where their abundances are high and therefore "frozen". This allows Time between ground water Recharge and HC Production (TRP) to be estimated.

Applying $^{4}He^{*}/^{40}Ar_{AIR}$ chronometer to data presented in [1], the average TRPs of HC fields, situated in different geological settings, *i.e.*, ancient plates, young plates, and mobile belts, approach 400, 175 and 40 Ma, respectively; these time intervals are comparable with the mean age of HC-bearing rocks in these settings, thus presenting evidence on chronology of HC production processes.

High contributions of radiogenic NG could result in too long TRPs, indicating external sources of NG. Thus, TRP ≈ 1.5 Ga, obtained for samples from some HC fields in Alberta, Canada, greatly exceed the stratigraphic ages of the reservoir rocks, below 400 Ma; this was interpreted [2] as indication of radiogenic NG flux from the crystalline basement.

Rather short TRPs for samples with low contributions of $^{4}He^{*}$ can be translated into the CH_4 production rates. Thus, RP ≈ 20 Kyr, including ground water migration time as well as time of methane generation and uplift, was derived for samples from the Chonan gas field, Kanto district, Japan [3]. Multiplying the $^{4}He^{*}$ production rate in rocks (having average upper-crust U and Th concentrations), 6.3×10^{-13} cc STP ^{4}He g^{-1} $year^{-1}$, on the observed ratio of CH_4 / $^{4}He^{*} \approx 2 \times 10^{6}$ gives the CH_4 production ≥ 1.2×10^{-6} cc CH_4/(g of organic bearing rock × year), in accord with independent estimates.

Radiogenic NG chronometers allow estimate the formation time scale; an interval ≈ 10 Ma, was derived for samples with (almost) identical ratios of $^{21}Ne^{*}/^{21}Ne_{AIR}$ and $^{40}Ar^{*}/^{40}Ar_{AIR}$ in different segments of the Magnus oilfield [4]. These and other examples show validity of NG time scales extracted from HC.

[1] Prasolov (1990) *The isotope geochemistry and origin of natural gases*. Nedra, Leningrad, pp. 283 (in Russian). [2] Hiyagon and Kennedy (1992) *GCA* **56**, 1569-1589. [3] Wakita et al. (1990) *Appl. Geochem*. **5**, 263-268. [4] Ballentine et al. (1996) *GCA* **60**, 831-849.