ASSESSMENT OF ^{210}Pb-CONTAMINATION IN SOIL

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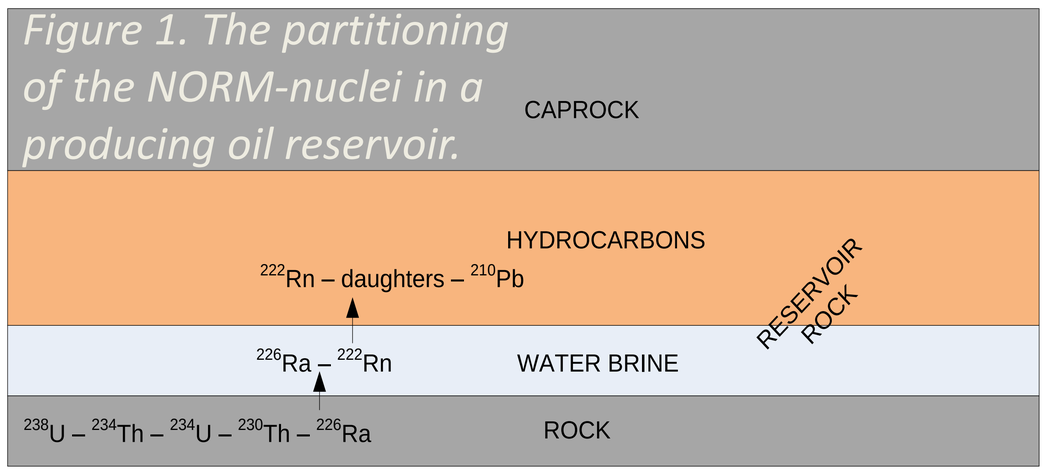
Introduction

Oil and gas may not only contain hydrocarbons, but also metallic components. Examples of such metals are mercury (Hg), vanadium (V), chromium (Cr), arsenic (As), and zinc (Zn). Radioactive components in the oil and the related aqueous brine are also usually present. Most rocks contain radioactive components (NORM) and radium (Ra) is the first element to be soluble in brine if the rock is oxidic. Radon (Rn) being a noble gas will prefer to stay in a non-polar environment like oil and gas, compared to the often very saline aqueous brine found in the oil reservoir. The noble gas diffuses into the non-polar phase. This is a rather slow process and the only isotope with sufficient half-life is ^{222}Rn. The daughters of ^{222}Rn all have too short half-lives to leave their environment until ^{210}Pb with 22.2 years half-life. This is illustrated in Figure 1 emphasizing the radioactive series from ^{238}U.

Figure 1. The partitioning of the NORM-nuclei in a producing oil reservoir.



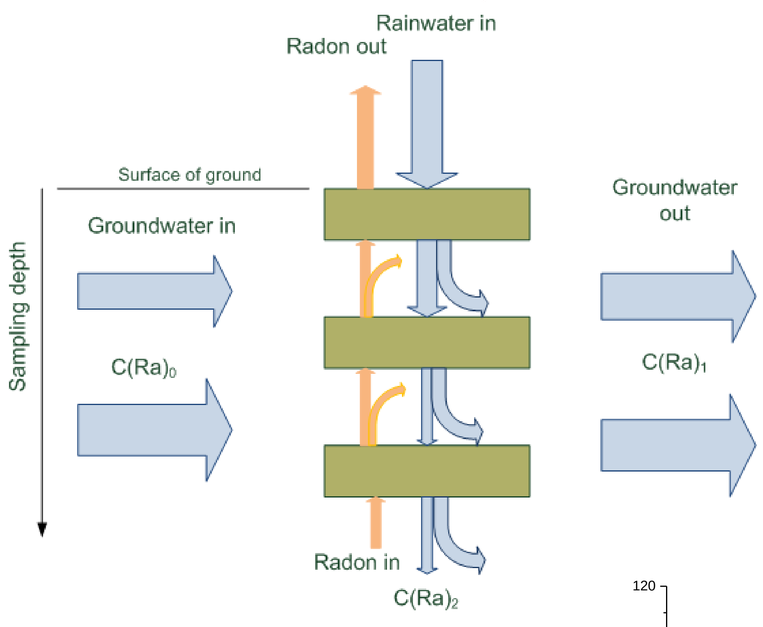
Schematic reaction models for how the ^{210}Pb is absorbed at corroded parts in a petroleum processing unit:
The FeS formed is amorphous and is usually given the stoichiometric formula FeS_x. (It is called "Black powder").

$$Fe(s) + H_2O(g) + CO_2(g) \rightarrow FeCO_3(s) + H_2(g)$$
$$FeCO_3(s) + H_2S(g) \rightarrow FeS(s) + H_2O(g) + CO_2(g)$$
$$FeS(s) + {}^{210}Pb^{2+} \rightarrow FeS \cdot {}^{210}Pb$$

There will always be traces of the gas components, H_2O, CO_2 and H_2S, in the hydrocarbon phases. The ^{210}Pb-atoms formed are all carrier free, so any lead atoms will stick to the most friendly environment, i.e. a sulfide.

Decommissioning of old oil-& gas-installations requires great attention to environmental issues. At a plant in Vats, Western Norway, dust from oil platforms has been shown to be emitted. The question was then:
Is the soil in the surroundings contaminated?

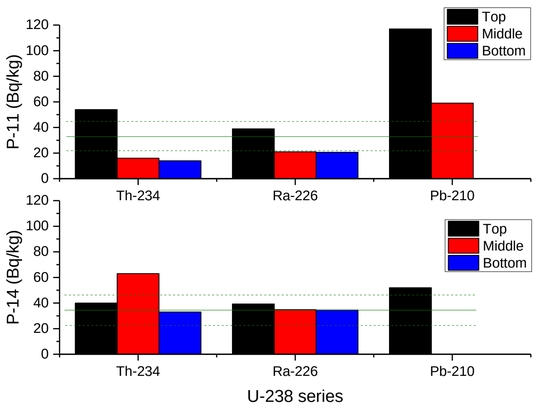
Model of NORM mobility:

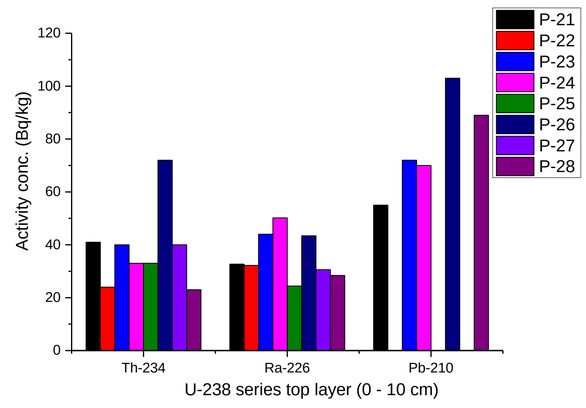


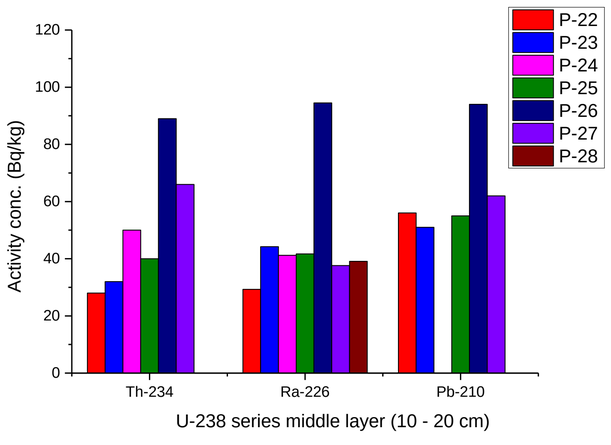
Method developed:

- Soil samples were taken from the area according to standard procedures in three layers of 100 mm.
- Analyses of NORM and toxic elements were performed by certified laboratories (ALS).
- Background were defined as the average level of NORM in the lowest layers. For the NORM nuclides, this turned out to be 34 ± 12 Bq/kg

Results:







Examples of results. A total of ca 70 sites were sampled and analyzed.

Conclusions:

- ^{210}Pb is shown to be >> average + 3·σ (70 Bq/kg) in the upper soil layer at several sites, and must have been added from outside. ^{210}Pb can therefore be used as a tracer for other heavy metals present in the oil phase.
- Concentrations of As, Hg, and Cr are higher than average in the area and decreases with distance from the decommissioning plant
- The highest concentrations were found in the upper soil layers
- As much as 1.3 kg Hg may have been discharged to the area, and probably much more to the sea.

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