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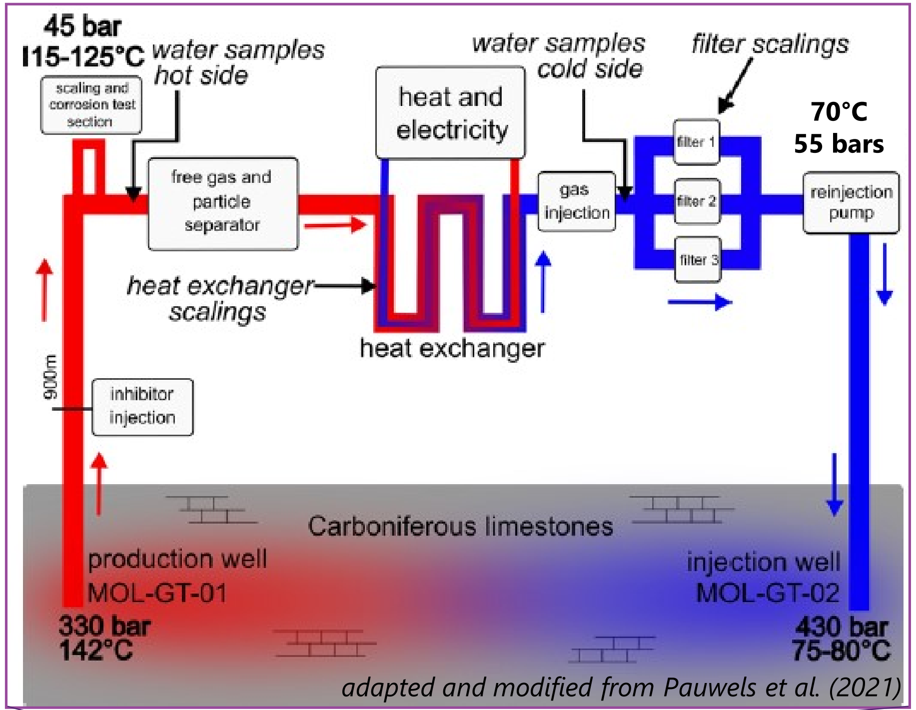
Characterization of natural and synthetic organic matter and naturally-occurring radionuclides (NORs) in the hypersaline brine of the Balmatt geothermal installation, Mol, Belgium

EGU 2023 – Vienna, Austria

Mineral scaling remains a major challenge in geothermal installations and in some cases accompanied by radioactivity

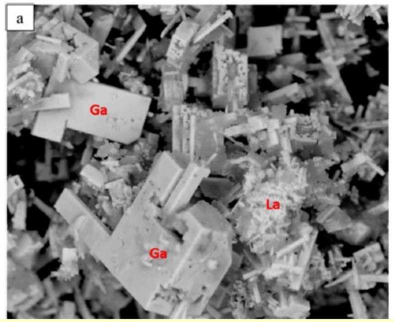
Balmatt geothermal installation, Mol, Belgium



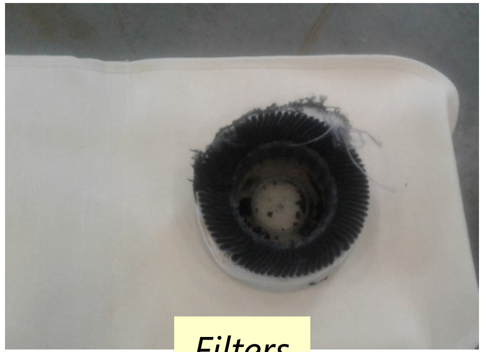
adapted and modified from Pauwels et al. (2021)

- Balmatt hypersaline brine (TDS ~165 g/L) *(Bos and Laenen, 2007)*
- Na(Ca)-Cl type brine *(Pauwels et al., 2022)*

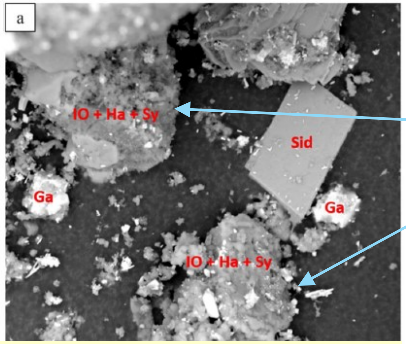
Heat exchanger



^{210}Po = 9160 ± 3743 Bq/g
^{210}Pb = 170 ± 40 Bq/g



Filters



^{210}Po = *below detection*
^{210}Pb = 250 ± 50 Bq/g

unknown organic phase acts as a matrix of the scales!

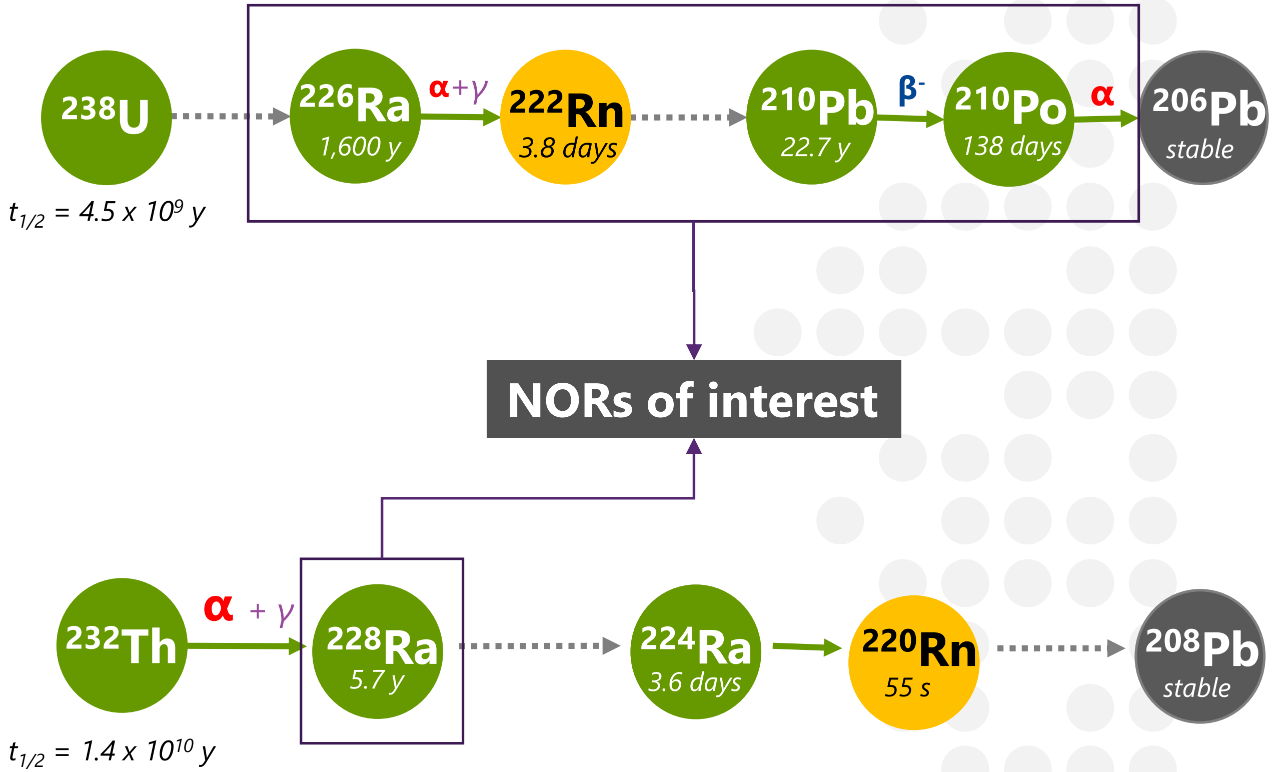
Pauwels et al. (2022)

Major scales: **galena (PbS), halite (NaCl), hematite? (Fe_2O_3)**
Minor: **laurionite (PbCl(OH)), and various carbonates**

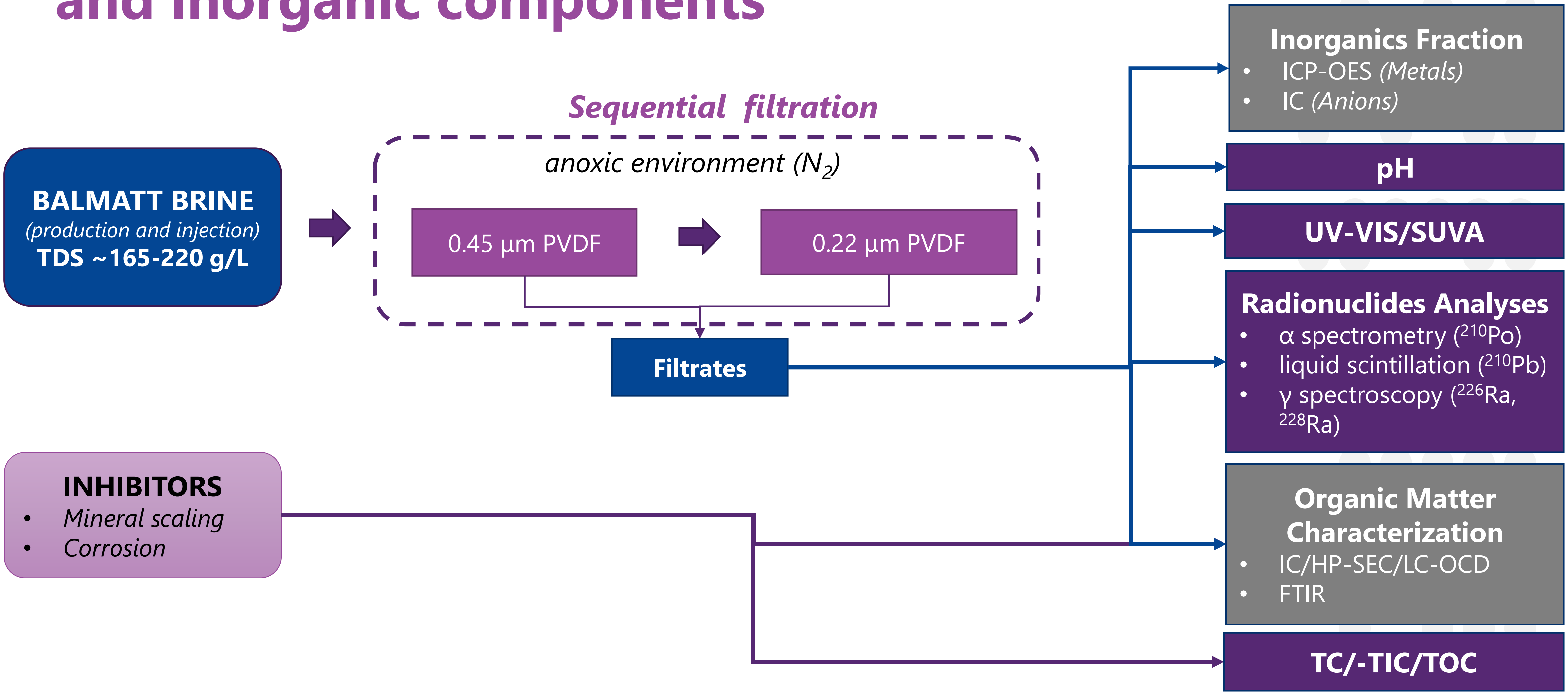
In order to understand the role of organic compounds in NORs fractionation, the 1st step is to characterize them in the brine

- To characterize the organic matter and to determine its concentration in the Balmatt geothermal fluids and in the chemical inhibitors

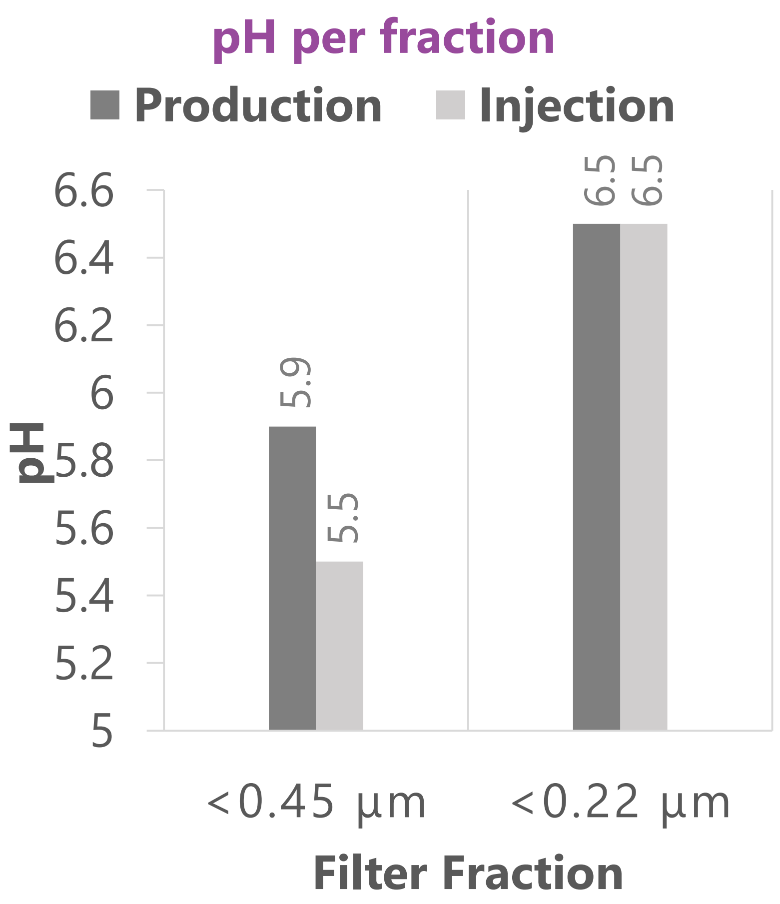
- To determine the activities of NORs (*i.e.* ^{226}Ra, ^{228}Ra, ^{210}Pb, and ^{210}Po) in the Balmatt geothermal fluids, and their association to organic compounds



Characterization methodologies of both organic and inorganic components



Higher pH values were measured in the smaller size fraction (<0.22 µm) of both production and injection fluids



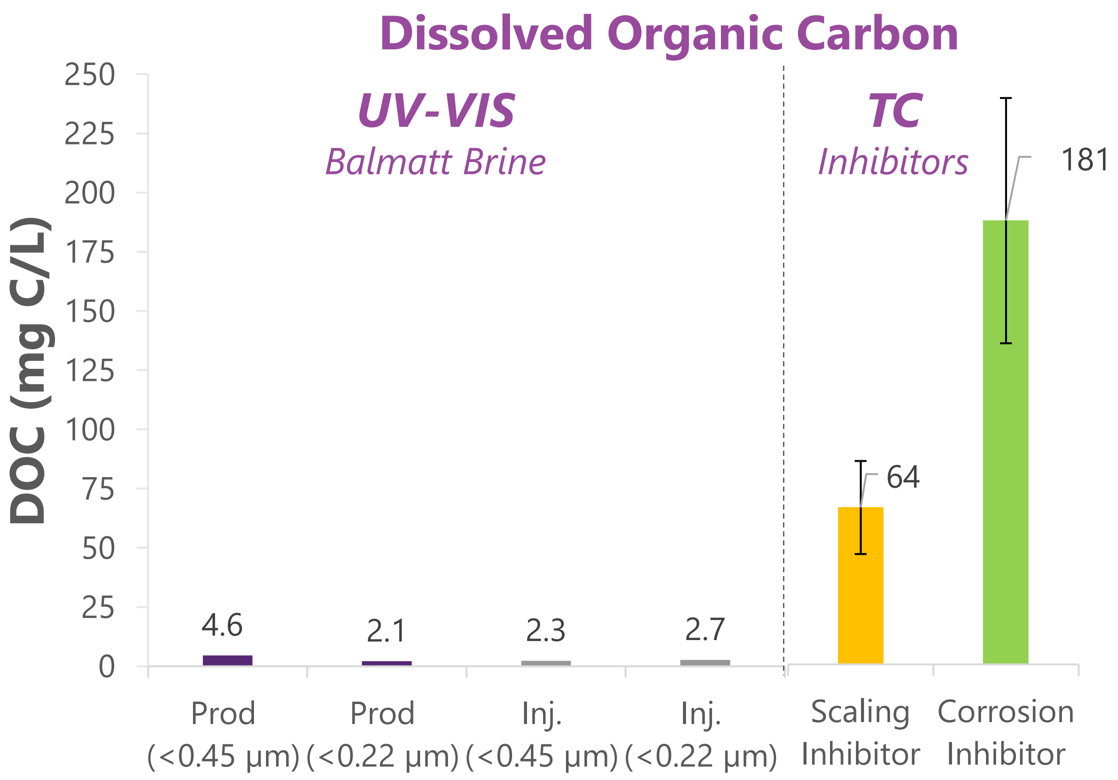
- Minimal pH difference in the larger size fractions (<0.45 µm) between production and injection fluids

Possible explanations:

  - *Injection fluids undergo an in-line filtration prior to sampling*
  - *High molecular weight organic acids being filtered out?*
  - *Changes in fluid composition during precipitation*
  - *Within uncertainty of pH measurements?*

- The pH of the <0.22 µm fractions of both the production and injection brines are the same

Low DOC concentrations (~5 mg C/L) were measured in the Balmatt brine, but higher DOC concentrations in the chemical inhibitors (64-181 mg C/L)



Specific UV Absorbance (SUVA)

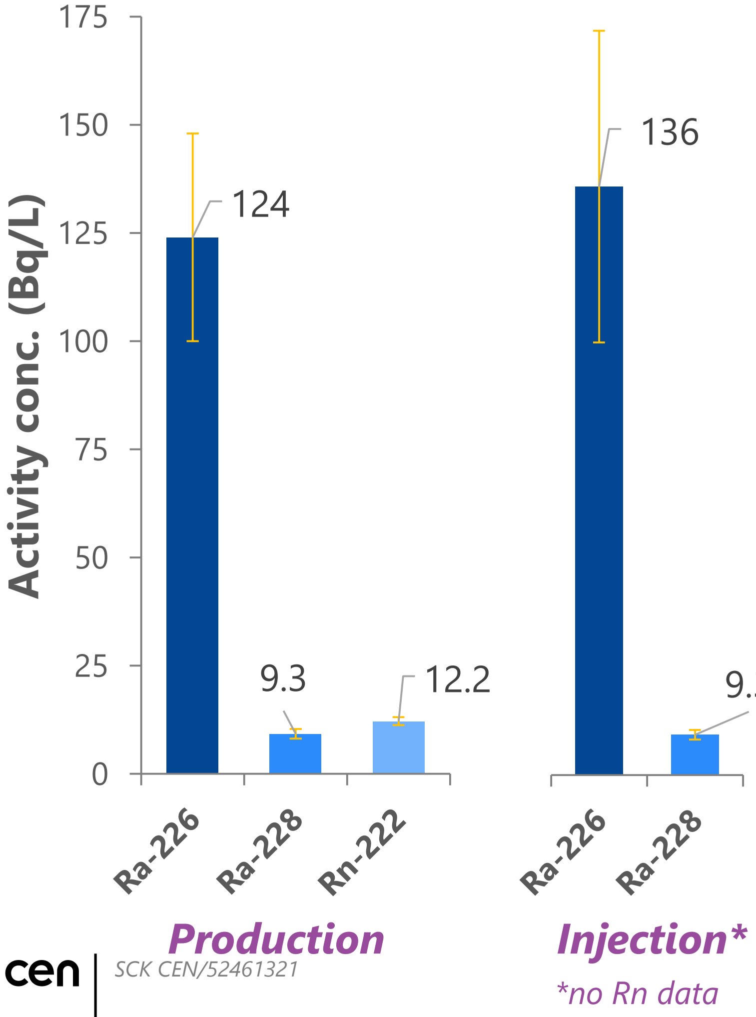
Sample	254 nm	280 nm
Prod. Brine	1	0.1
Inj. brine	1	0.5
Scaling inh.	10	10
Corrosion inh.	1600	800

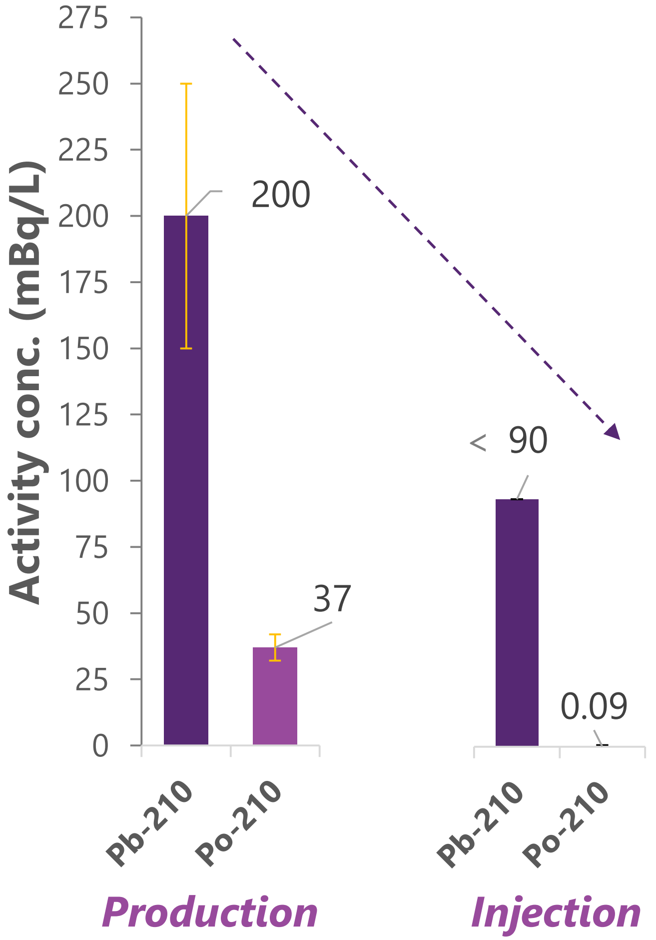
Possibly mainly hydrophilic groups SUVA <3 (Prod. Brine, Inj. brine)

Possibly mainly hydrophobic, aromatic groups SUVA >4 (Scaling inh., Corrosion inh.)

- DOC measurement was challenging due to high salinity
- DOC estimation using UV-VIS to be confirmed by other methods (i.e. LC-OCD)

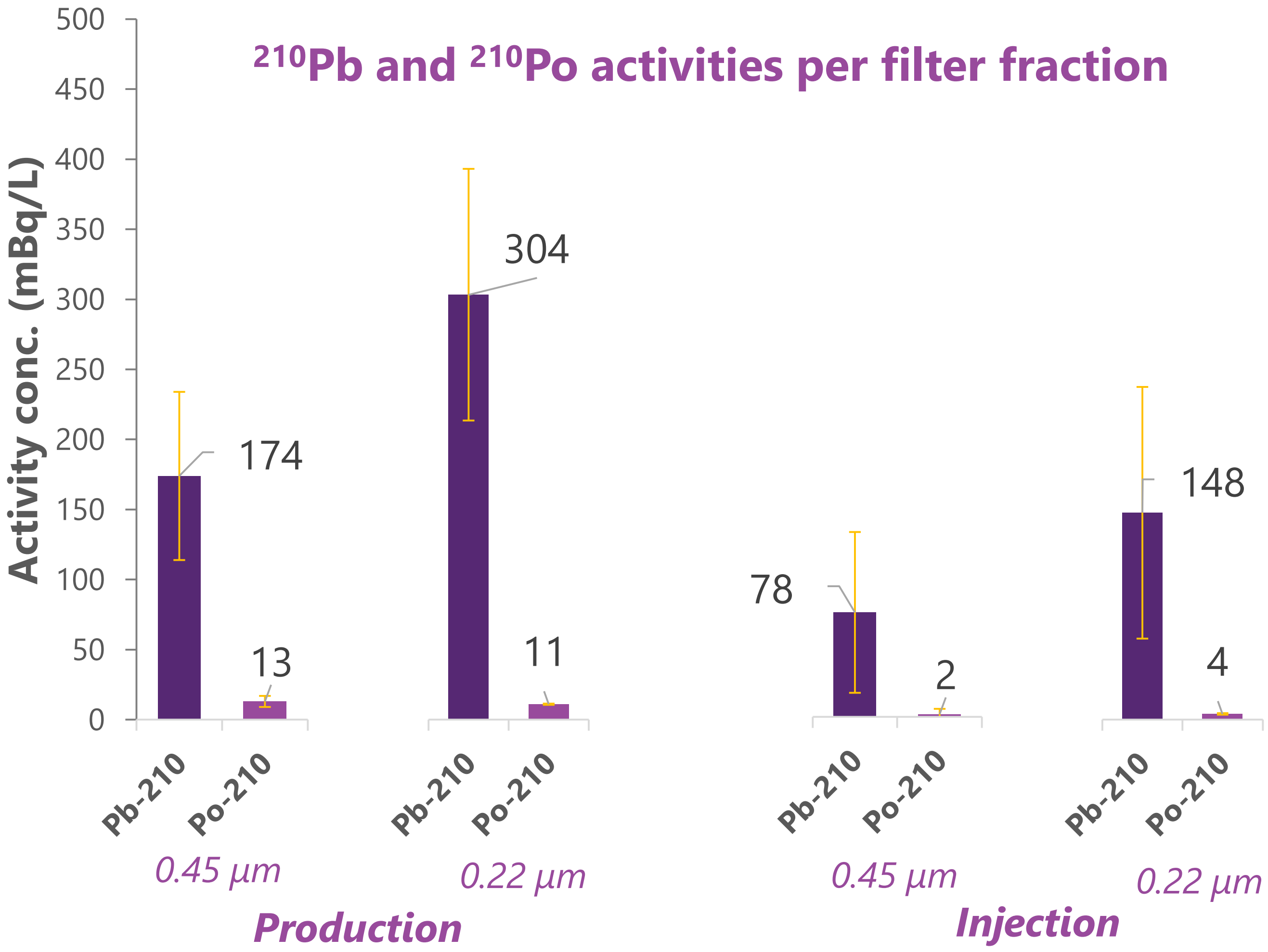
NORs in unfiltered samples: ^{226}Ra is dominant in both production and injection fluids, while higher ^{210}Pb and ^{210}Po activity concentrations were measured in the production brine





- ^{226}Ra and ^{228}Ra remain in solution and is highly mobile in brine
- Decrease in ^{210}Pb and ^{210}Po activity concentrations from production to injection may indicate precipitation of Pb minerals and co-precipitation of Po

^{210}Pb and ^{210}Po activity concentrations in the sequential filtrates show inconsistent results and high uncertainties



- Correlation of ^{210}Pb and ^{210}Po activity concentration to size fraction cannot be made due to high uncertainty
- Repeat filtration and analysis to be done in the next sampling campaign

Our preliminary results confirm that chemical inhibitors are additional sources of organic compounds and may play a role in NORs fractionation

- A minimal pH value difference in the larger filtrate fraction (<0.45 µm) may suggest the possible influence of colloids and/or high molecular weight acids(?)
- Led to more questions: *How to distinguish between natural and synthetic organic compounds and their influences in NORs fractionation?*
- Decrease of ^{210}Pb and ^{210}Po activity concentrations from production to injection suggests their precipitation/co-precipitation in mineral scales
- ^{226}Ra remains soluble and mobile in the brine and is the dominant radioisotope, while ^{210}Pb and ^{210}Po are present in low activity concentrations
- ^{210}Po enrichment up to 9,160 Bq/g is plausible despite the low activity concentrations in the brine, as it represents ~2.5% of the total available ^{210}Po during the 14-day filter utilization:

$$\left[\frac{37\ mBq}{L} \times \frac{1\ Bq}{1000\ mBq}\right] \times \left[\frac{30m^3}{h} \times \frac{1000\ L}{m^3}\right] \times \left[14\ days \times \frac{24\ h}{1\ day}\right] = 372{,}960\ Bq$$

^{210}Po in brine — *Volumetric flow rate* — *Filter utilization time* — ***Total available ^{210}Po***

We intend to complete the characterization including the rocks/mineral scales, and conduct complexation experiments in high temperature-high temperature autoclaves

NOM Leaching of reservoir rock samples

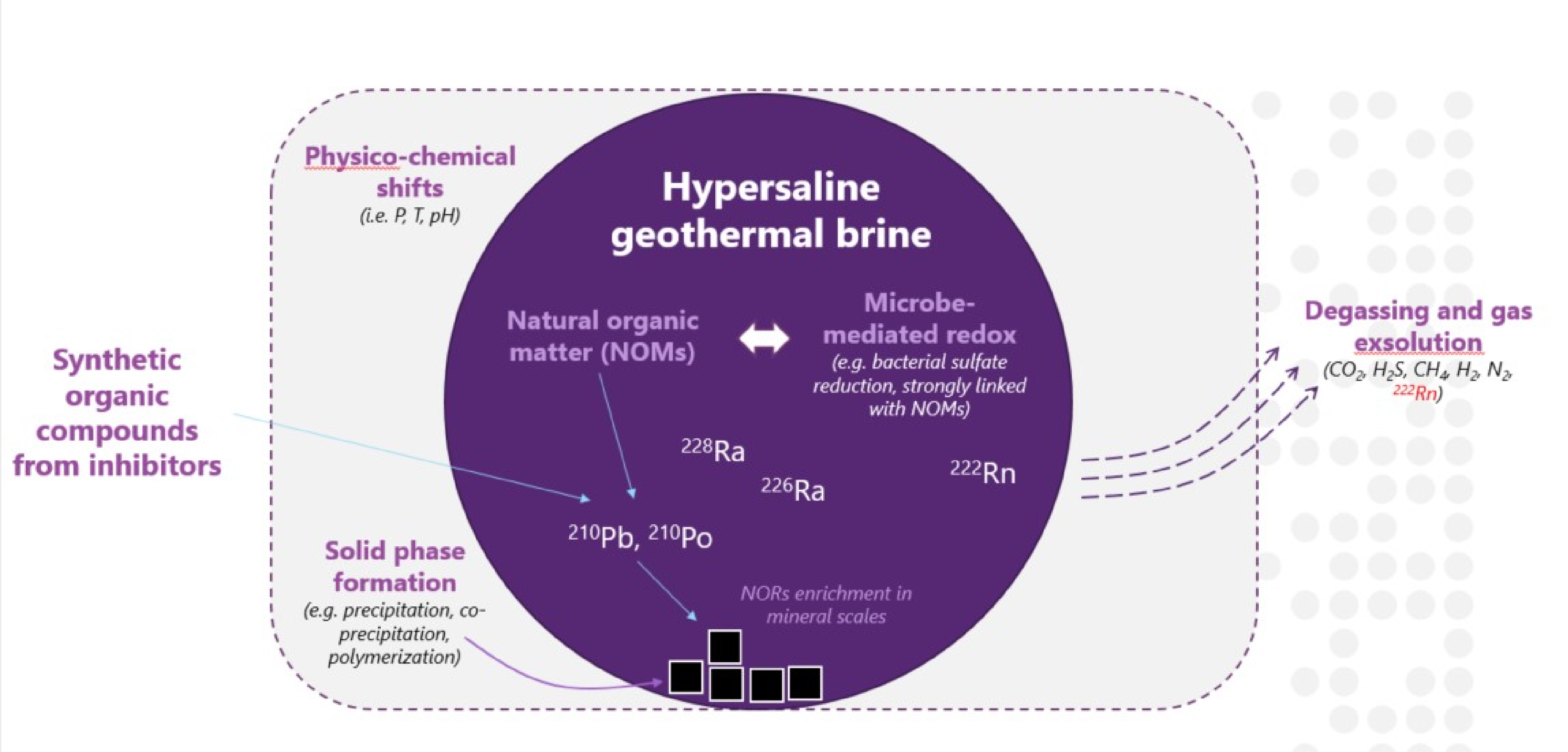
Thermal Stability/Degradation Tests of Inhibitors

Complexation and stability experiments of NORs analogues in presence of brine, metals, inhibitors and NOM

Determine and distinguish organic compounds from these various sources

Sheds light onto the mechanisms of NOR fractionation, mobility, and enrichment in mineral scales

Understanding the mechanisms of NORs enrichment in the mineral scales of geothermal installations is important to ensure sustainability of energy production, and for human health and environmental protection.



Thank you for listening

SCK CEN
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Foundation of Public Utility

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