

# Naturally occurring radionuclides at a geothermal facility in the North German Bassin

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II. EU-NORM Symposium, Prague, Czech Republic, 17<sup>th</sup> to 20<sup>th</sup> June 2014

| Verantwortung für Mensch und Umwelt | ■ ■ ■ ■ ■ ■ ■ ■



Bundesamt für Strahlenschutz

# Introduction

→ Annex VI of EU-BSS - industrial sectors involving NORM

among others

## - Geothermal energy production

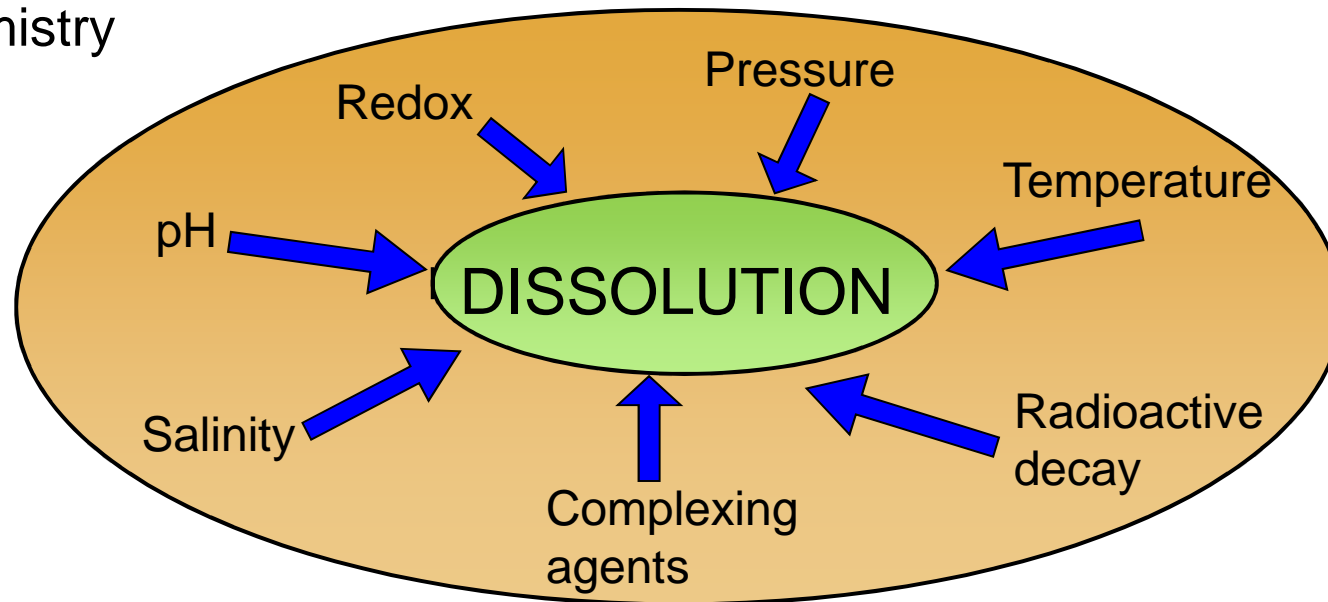
→ Distinction between deep (heat exchange) and close to surface facilities (heat pump)

→ The generation of NORM is strictly bound to a transfer of matter.  
Using heat pumps or earth tubes for energy production only an exchange of heat occurs.

→ From the geochemical point of view, a close look what happens at hydrothermal or petrothermal (Enhanced Geothermal System) facilities is necessary.

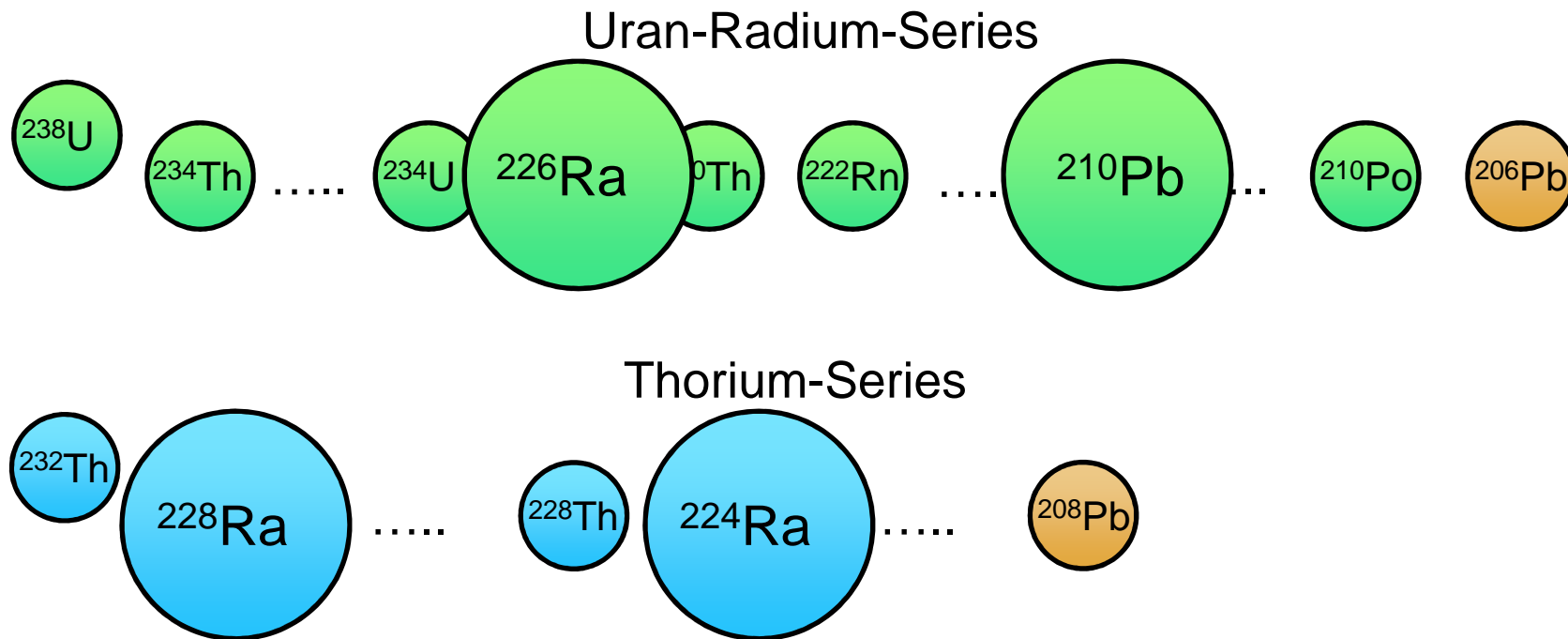
# Radionuclides in deep thermal waters

Geochemistry



- Thermal waters contain dissolved naturally occurring radionuclides
- $C_{RN}$  (Water) not in secular equilibrium
- high C only with high TDS

# Relevant radionuclides



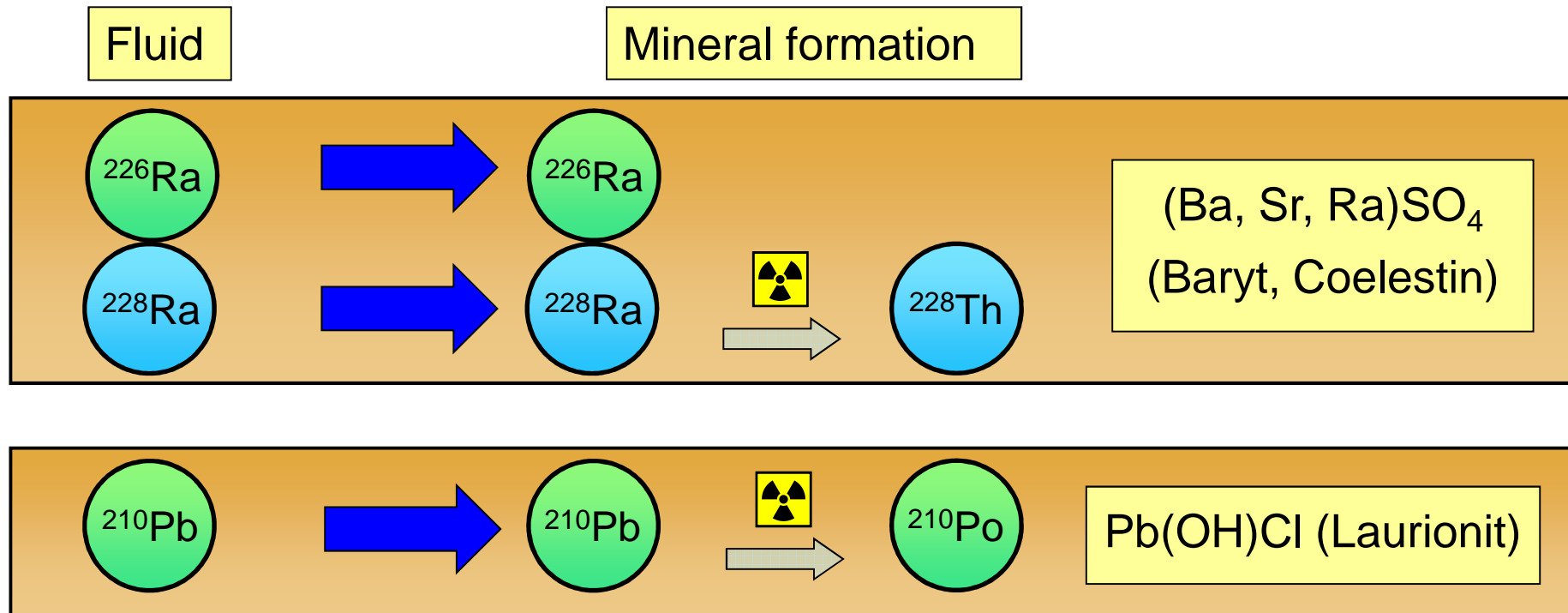
- Primordial radionuclides are wide spread in rocks and sediments.
- Depending on the rock age, the decay chains should show secular equilibrium.

# Filter residues and scale

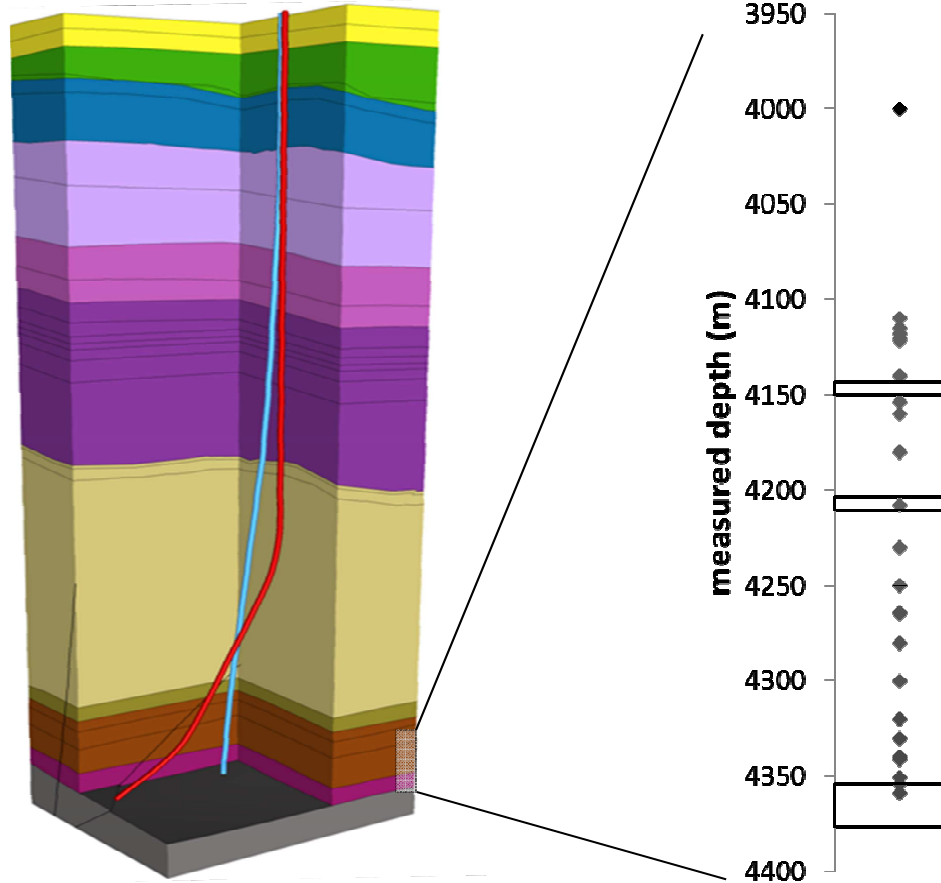
$\Delta T, p \rightarrow$  mineral formation

$\rightarrow$  accumulation in plant equipment (scale)

$\rightarrow$  particles in fluid (need for filtering)



# Groß Schönebeck site – operated by GFZ



# Measurement program

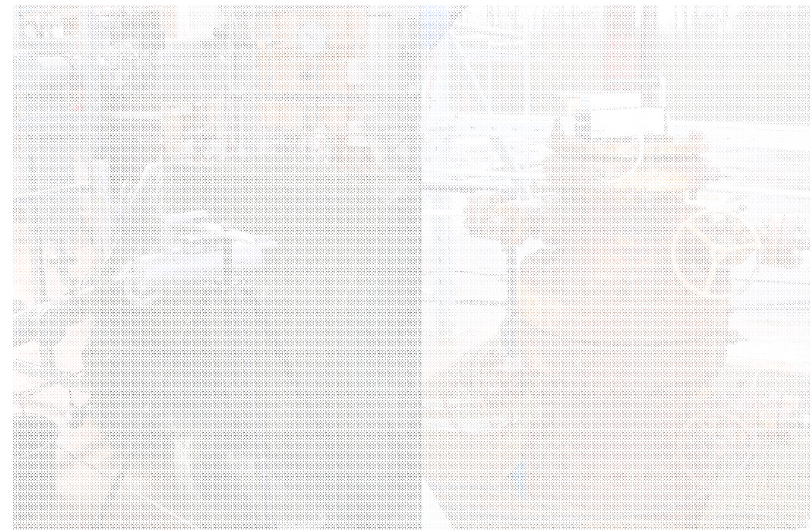


## Gamma-ray spectrometry

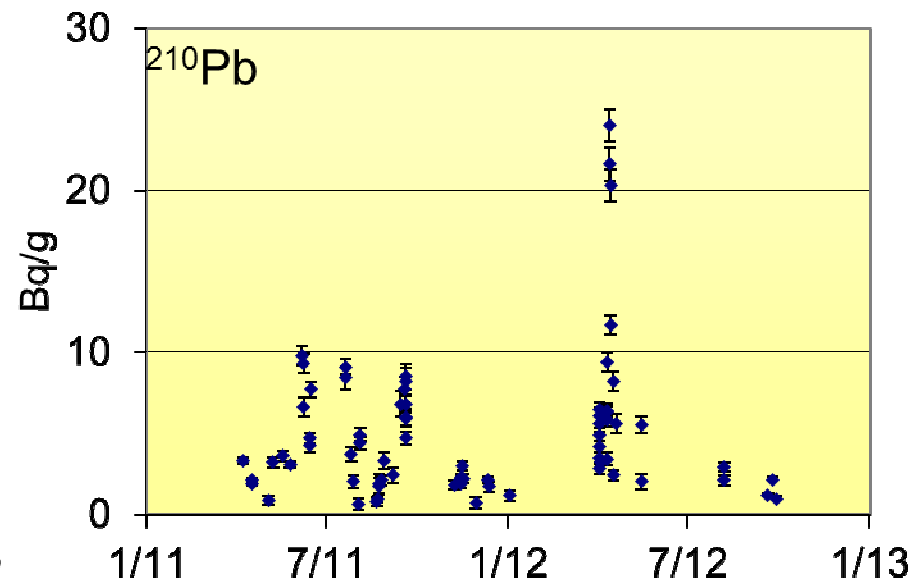
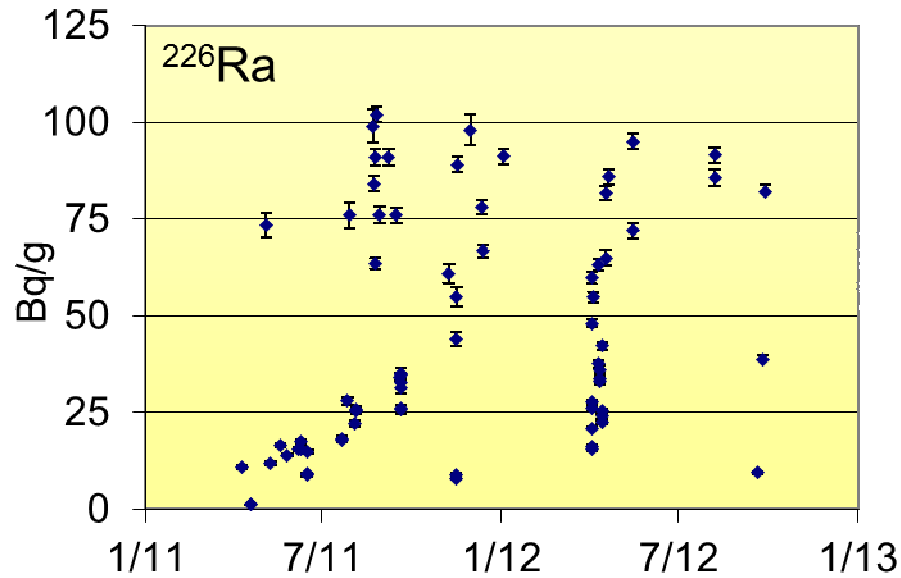
- Cuttings
- Filter residues
- Thermal water

## In-situ measurements

- Ambient dose rate (ODL)
- Personal dosimetry
- TLD measurements



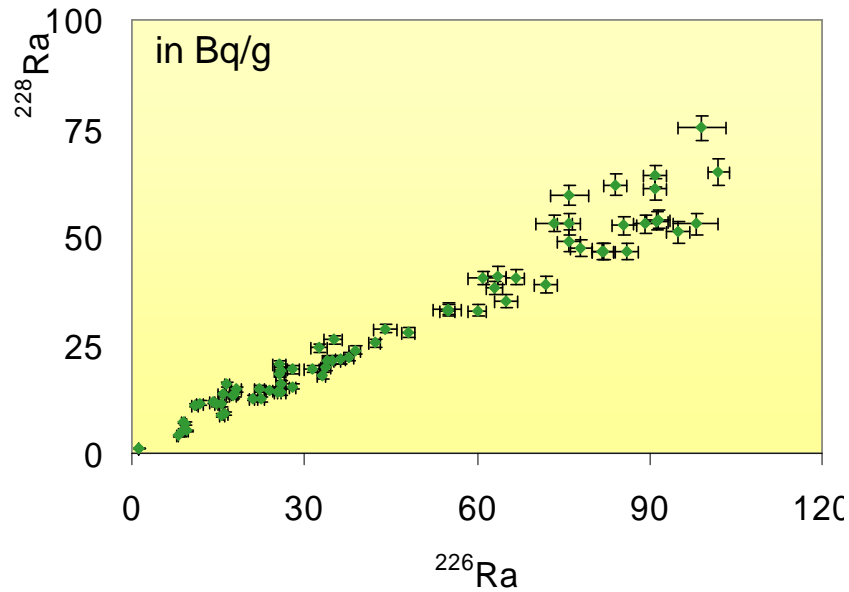
# Filter residues I



- relevant radionuclides  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$  and  $^{210}\text{Pb}$
- 2-3 orders of magnitude
- no time dependency
- $^{238}\text{U} \ll 1\text{Bq/g}$



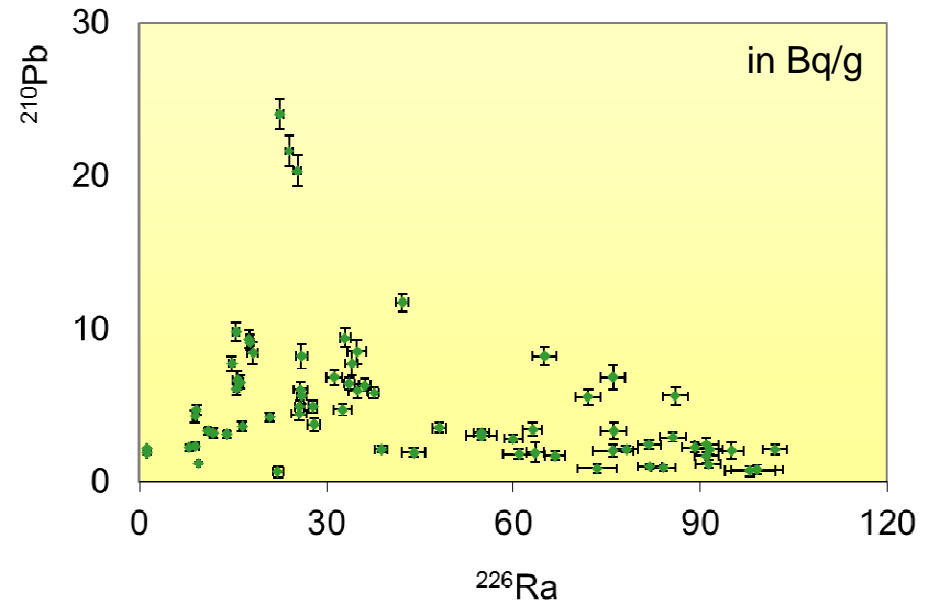
# Filter residues II



$^{226}\text{Ra}$  vs.  $^{228}\text{Ra}$

systematic relation

→ **identical** chemical process

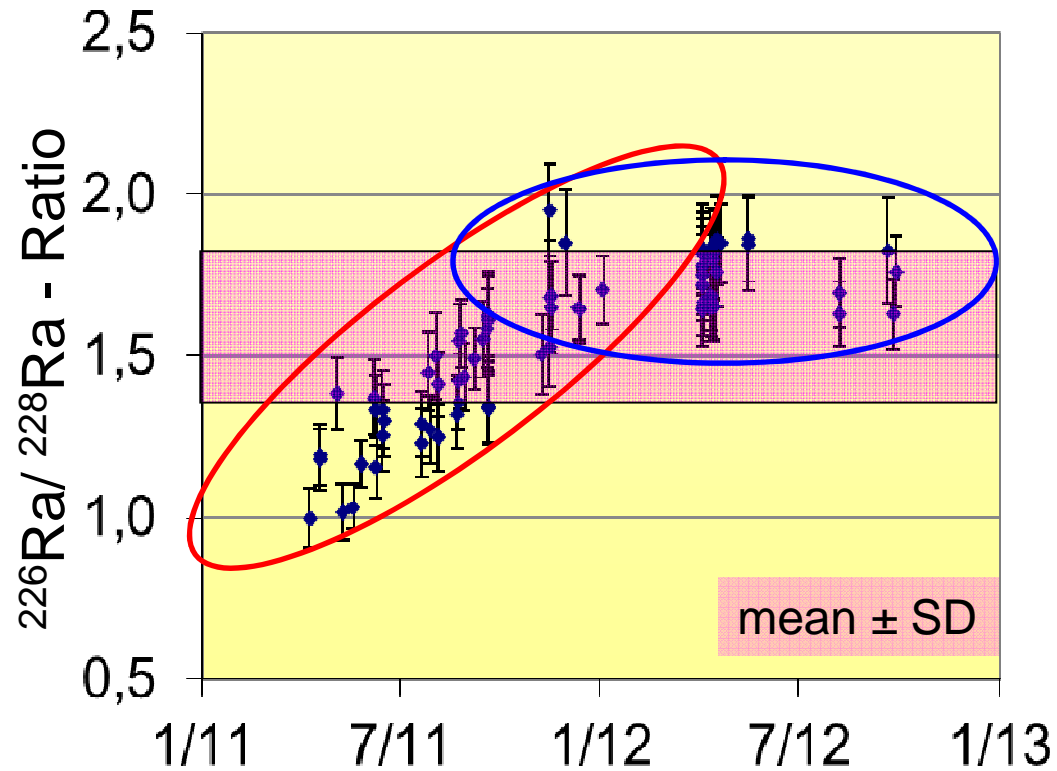


$^{226}\text{Ra}$  vs.  $^{210}\text{Pb}$

non-equilibrium

→ **different** chemical processes

# Filter residues III

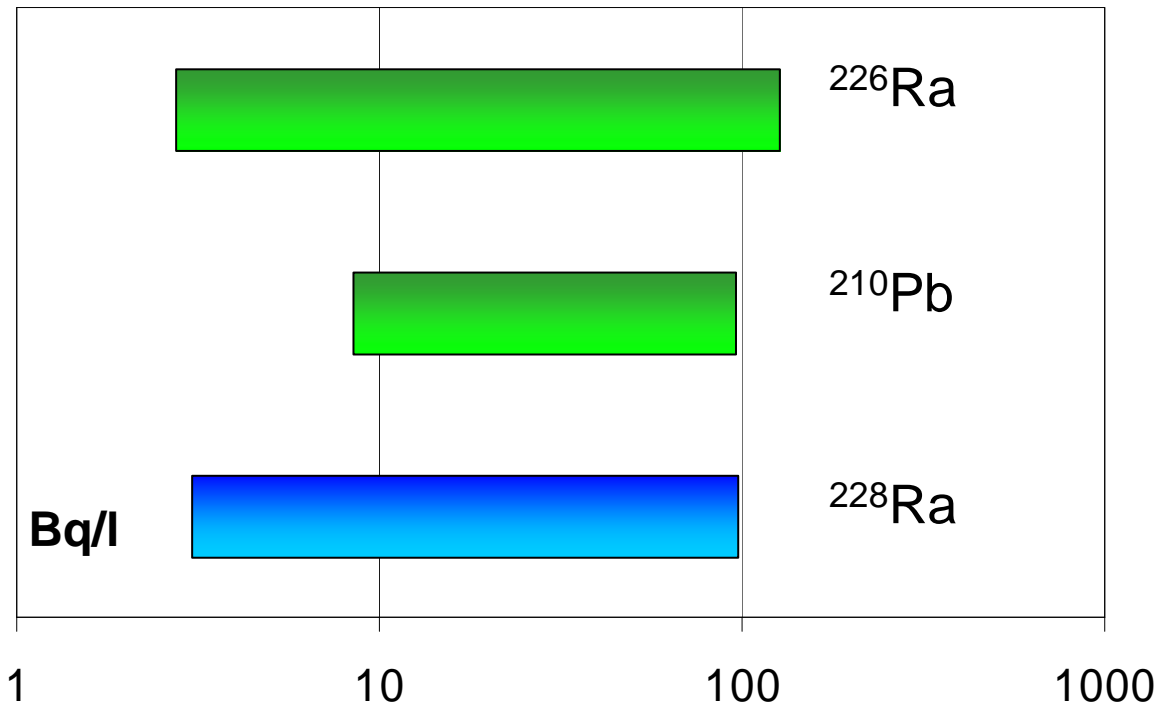


$^{226}\text{Ra}/^{228}\text{Ra}$ -Ratio

Transient till end of 2011

- different flow regime
- continuously clogging of bore hole
- varying contribution of water supplying aquifers

# Thermal waters (2009 – 2012), analysis with time delay



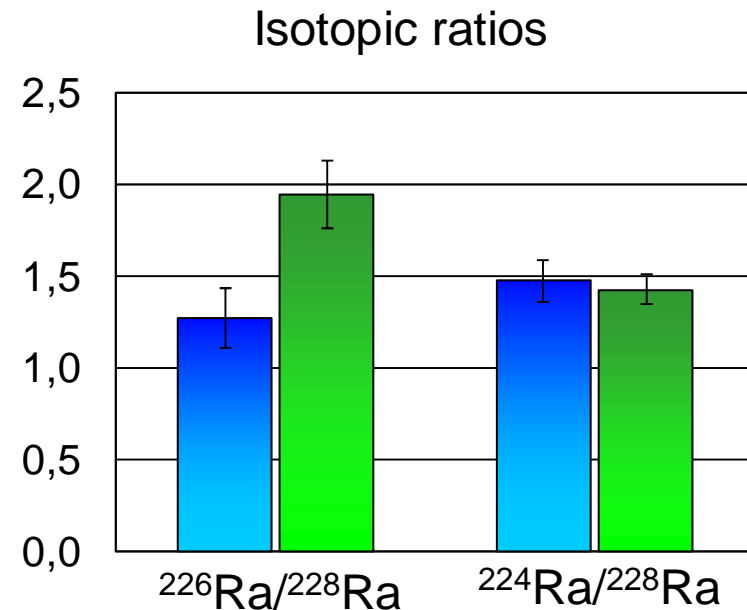
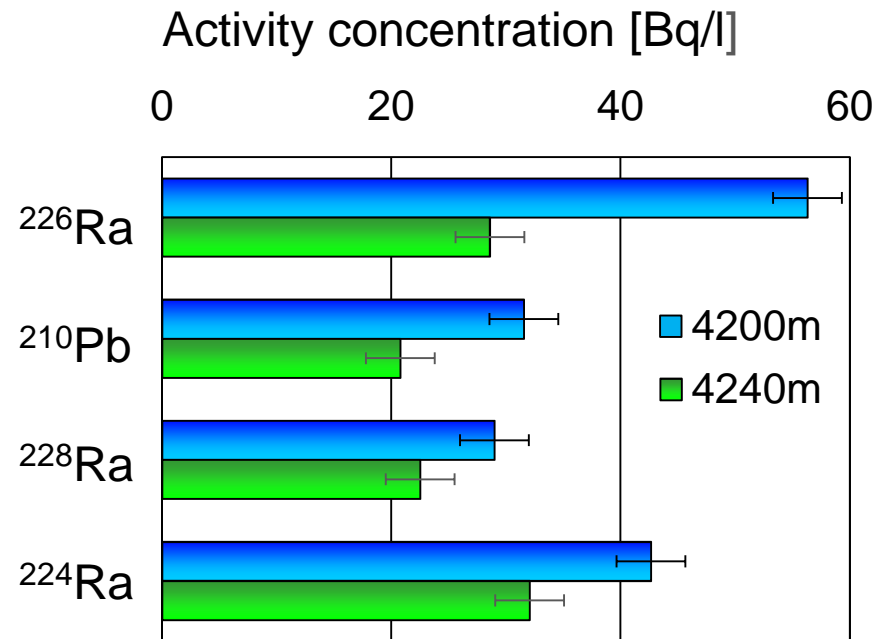
Drinking water survey (Bq/l)	
$^{226}\text{Ra}$	0,38
$^{210}\text{Pb}$	0,27
$^{228}\text{Ra}$	0,21

→ Spread over three orders of magnitude

→ C ( $^{224}\text{Ra}$ ,  $^{228}\text{Th}$ ) depending on time delay between sampling and measurement

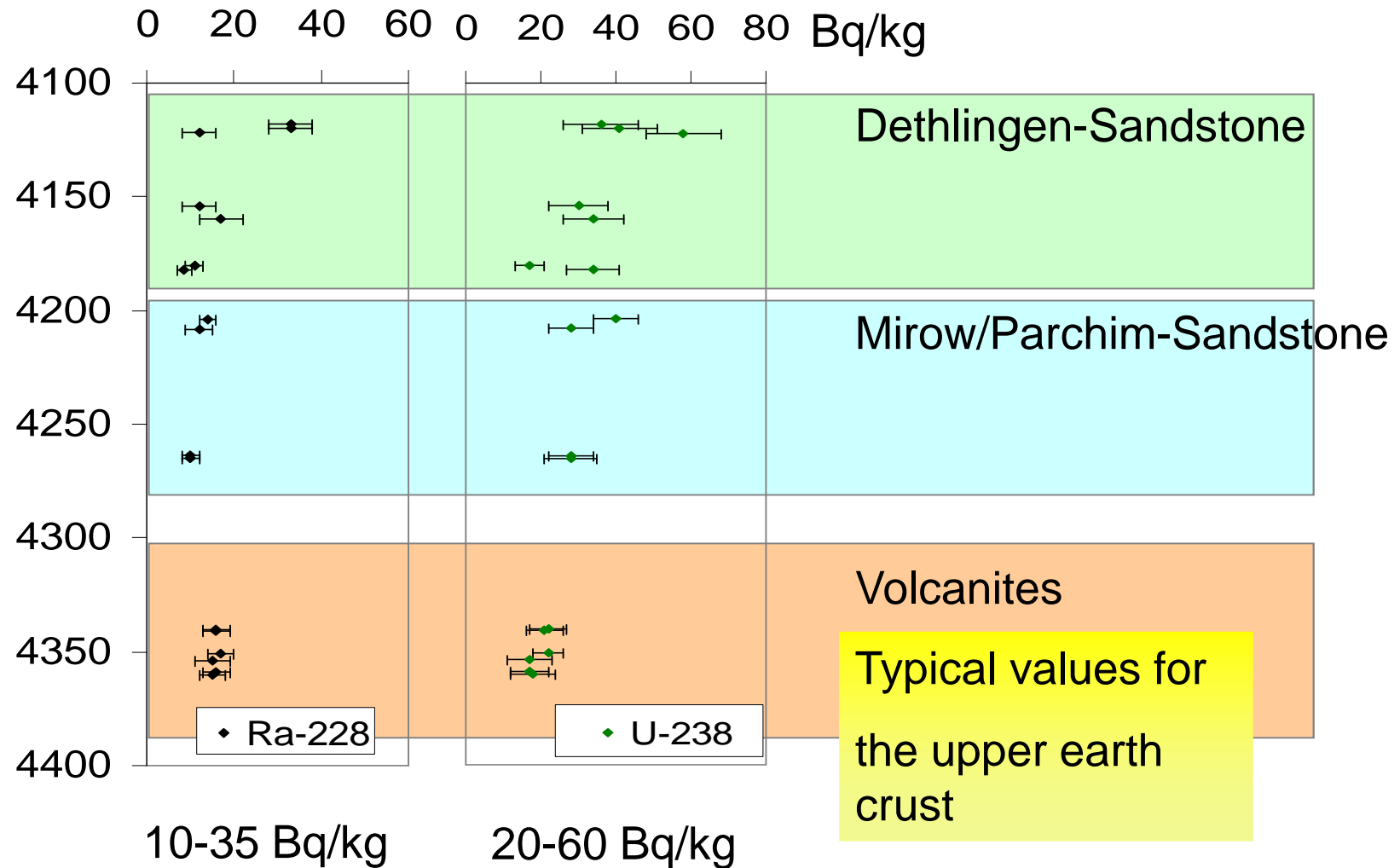
$^{224}\text{Ra}$  decays,  $^{228}\text{Th}$  grows in

# Thermal waters (2014), analysis without time delay

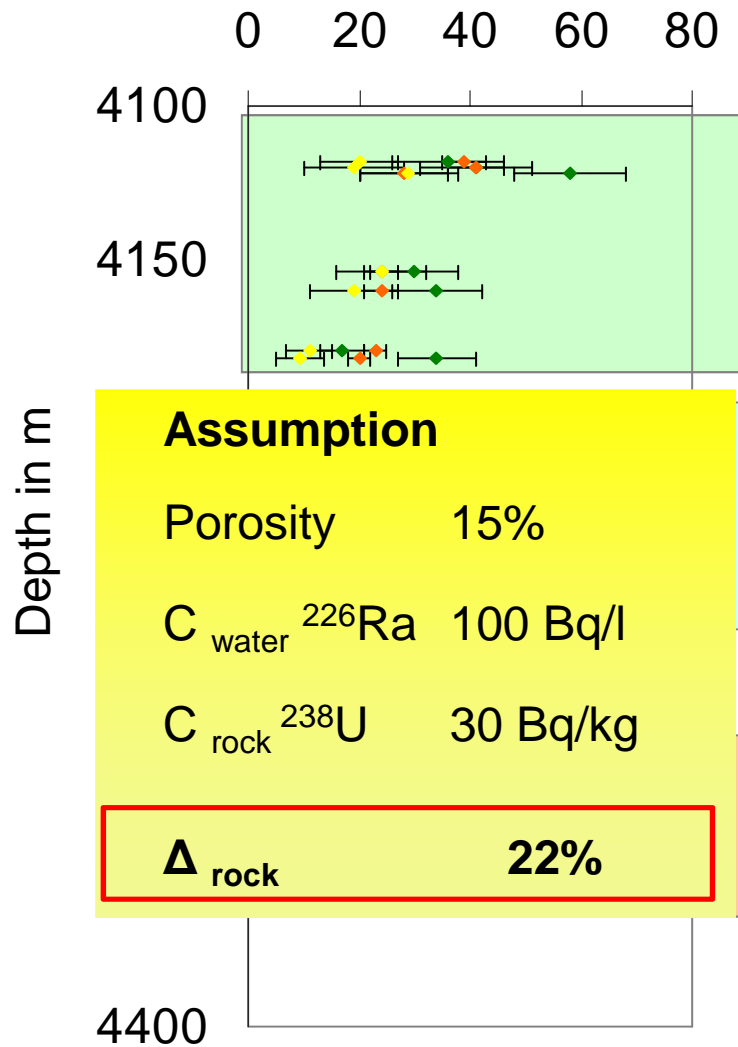


- $^{226}\text{Ra}/^{228}\text{Ra}$  differs in the two depths → different aquifers / host rock
- $^{224}\text{Ra}/^{228}\text{Ra}$  in both depths is constant
- The activity concentration of Radium in brine must somehow be fed by the host rock

# Cuttings



# Cuttings



Uran-Radium Series

# Summary

Depending on the geochemical conditions in brines high specific activities of some 10 Bq/l for  $^{226}\text{Ra}$ ,  $^{228}\text{Ra}$  and  $^{210}\text{Pb}$  can occur. A key factor seems to be a high chloride concentration leading to soluble chloro-complexes.

Due to thermodynamically changes in temperature and / or pressure, high salinities favour the mineral formation of laurionite and Ra-bearing barite. Consequently NORM occurs more frequent in geothermal facilities using high saline waters.

A detailed interpretation of analytical data lead to the detection of flow disturbances and, quite surprisingly, of a disequilibrium in the Uran-Radium series in sandstone formations.



Thank you for your attention!