



Natural K_2O , Th, and U concentration in bedrocks of major geological units in Hesse (Germany).

Special Session: Radon and Geology

Annemarie Militzer, Rouwen Lehné, Thomas Reischmann, H.-Dieter Nesbor
Department G4 Geology of Commodities, Mineralogy, Geochemistry



Für eine lebenswerte Zukunft

Motivation

- New radiation protection law
- Necessity to define radon-prone areas



Source: Wikipedia

Radiation exposure



[mSv/a] mean annual radiation exposure in Germany

Motivation

- New radiation protection law
- Necessity to define radon-prone areas

→ Hessian radon strategy

- Soil gas measurements as base for subsequent maps

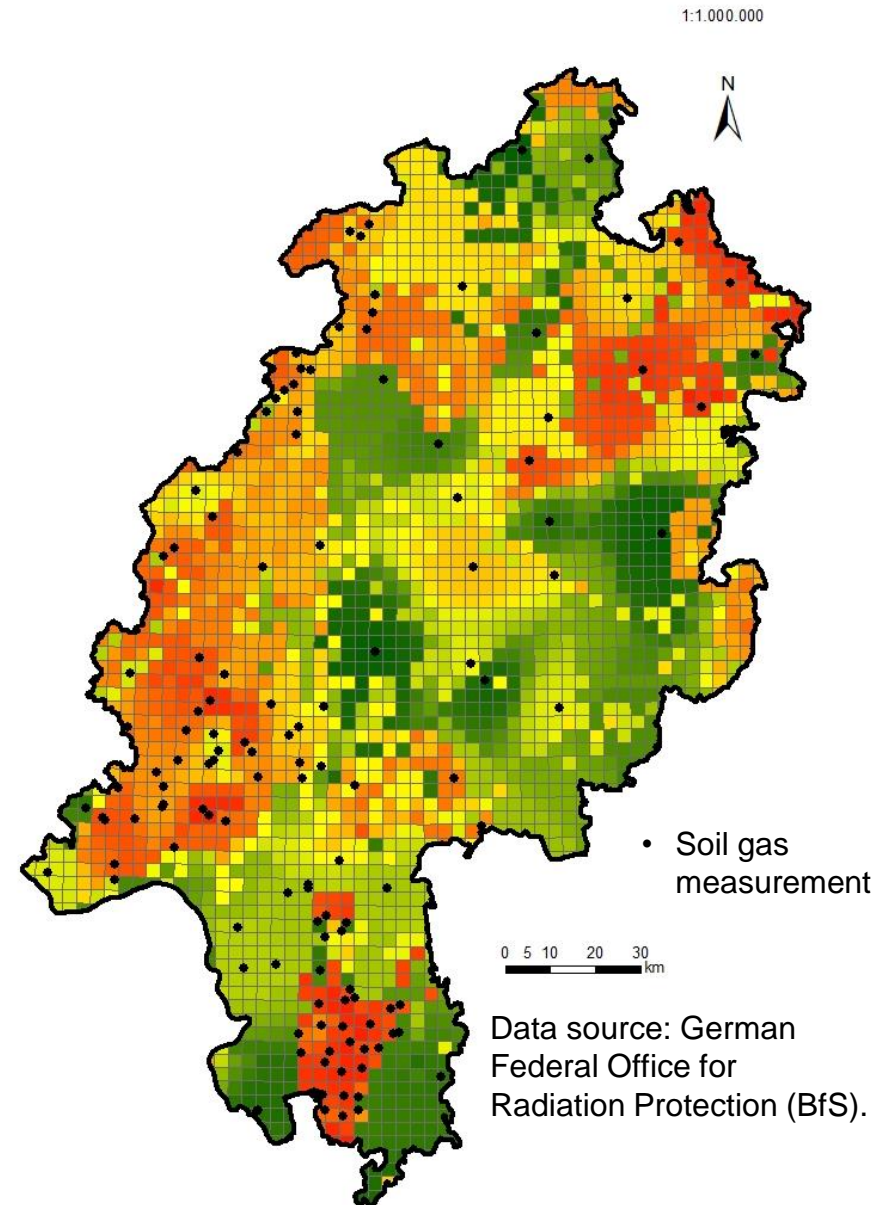


Source: Wikipedia

Rn soil gas map

- Rn soil gas distribution on current map mimics geological units
- Hypothesis: radon soil gas correlates (roughly) with rock type

→ organization into major geological units according to their rock types and stratigraphic situation



Radioactive decay of natural elements

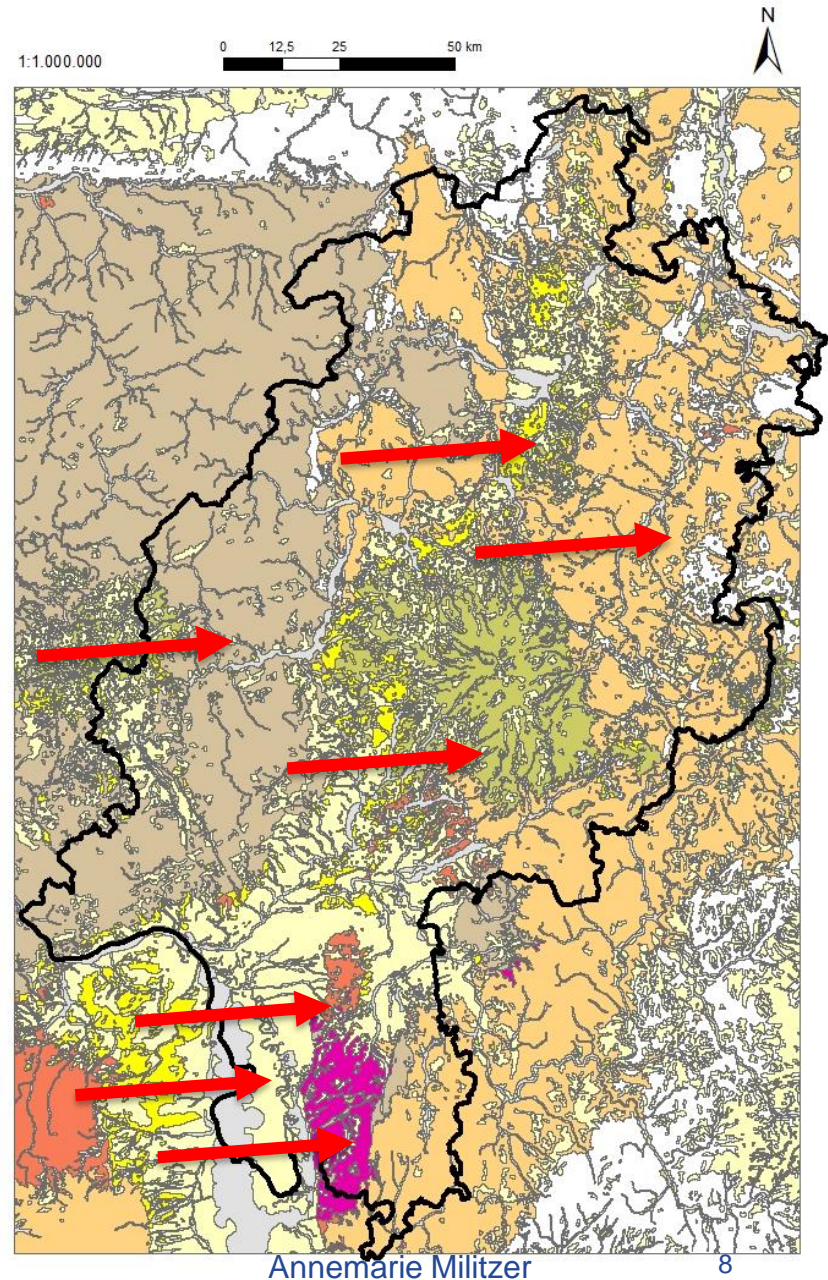
- $^{238}\text{U} \rightarrow \dots ^{222}\text{Rn} (3,8\text{d}) \rightarrow \dots ^{206}\text{Pb}$
 - $^{232}\text{Th} \rightarrow \dots ^{220}\text{Rn} (55,6\text{s}) \rightarrow \dots ^{208}\text{Pb}$
 - $^{235}\text{U} \rightarrow \dots ^{219}\text{Rn} (3,9\text{s}) \rightarrow \dots ^{207}\text{Pb}$
- } >60% of natural radiation exposure
- ^{223}Rn , ^{218}Rn and ^{217}Rn because of short half-life irrelevant in radiological aspects
 - $^{40}\text{K} (1,27 \times 10^9\text{a}) \rightarrow ^{40}\text{Ca}$ bzw. ^{40}Ar (~10% of terrestrial radiation)
 - Components of minerals such as
 - feldspar, zircon, monazite, titanite, allanite, clay minerals and uranium ore

K₂O, Th and U fingerprint of different rock types

Rock type	K ₂ O	Th	U
Gabbro/Basalt	low to moderate	low	low
Diorite	variable	moderate	low to moderate
Granite/Rhyolite	high	high	moderate to high
Sandstone	moderate	variable	variable (to high)
Marl	low to moderate		variable to high
Amphibolite	low to moderate	low	low
Quartzite	low	low	low

Hessian Radon strategy → Major structural units

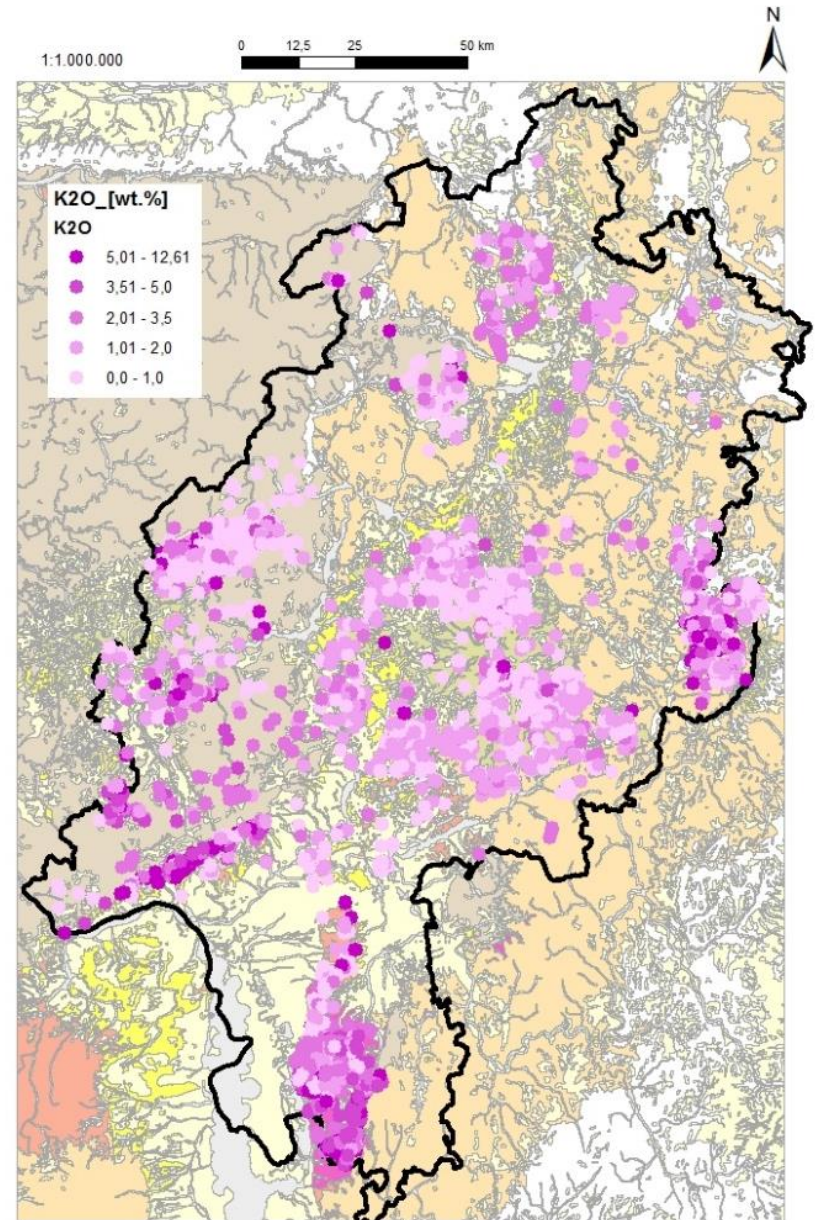
- Crystalline basement (granites and gneiss)
- Rhenohercynian (metasediments and –volcanics of Devonian/Carboniferous)
- Rotliegend (sedimentary and igneous)
- Bunter Sandstone
- Tertiary volcanics (mainly basalts, few evolved)
- Tertiary sediments
- Quaternary sediments (Upper Rhine Graben)



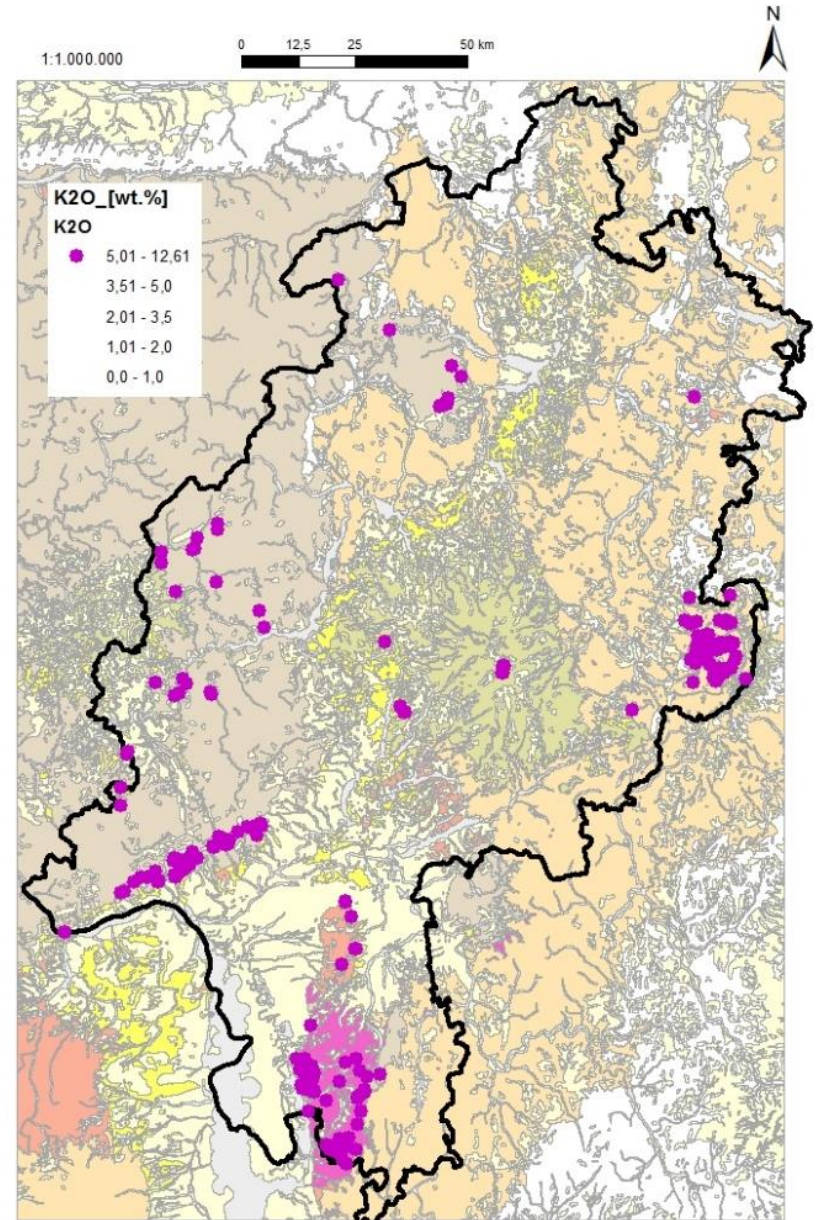
Geochemical database

- Includes a vast number of geochemical analyses that are linked to samples from quarries, drill cores, small outcrops as well as surface samples.
- In most cases radon has a migration distance of a few meters. Therefore, we focus on the geochemical composition of surface samples or from a depth of max. 10m.

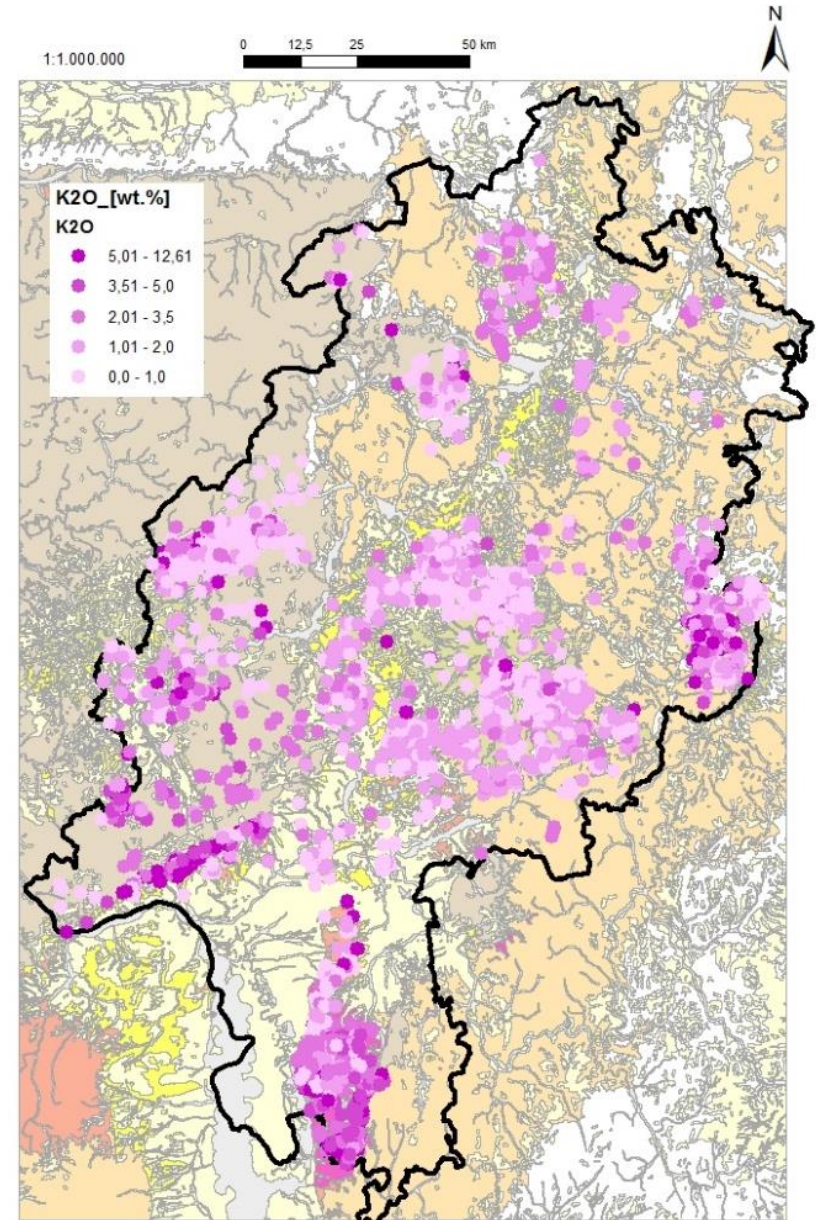
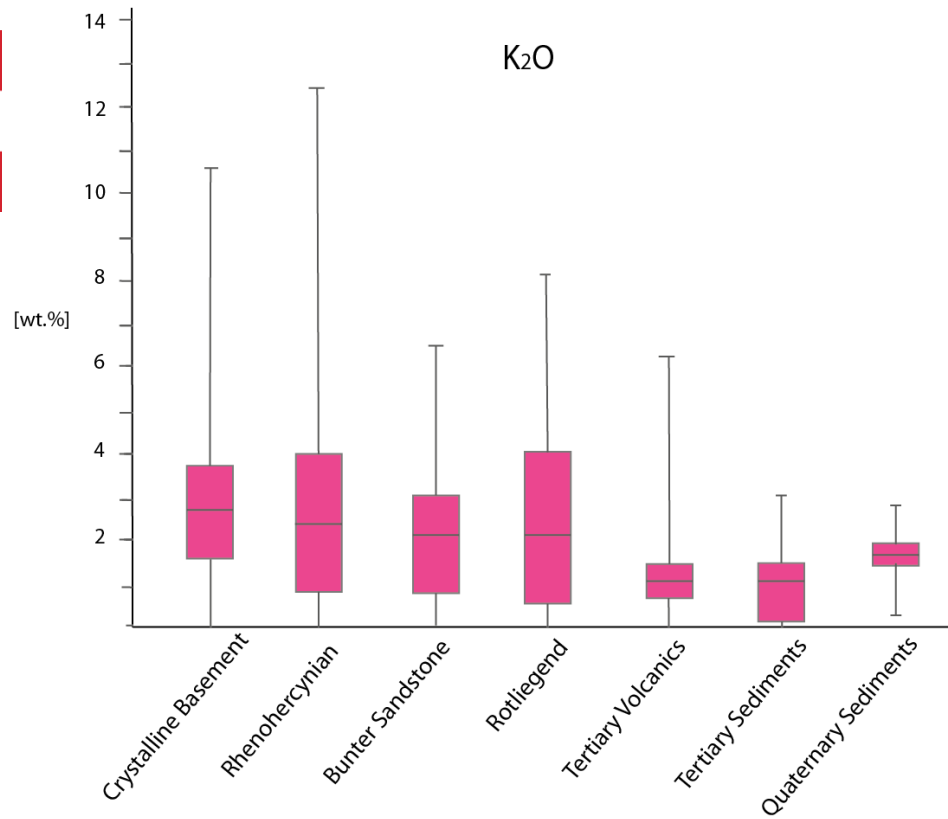
K₂O contents



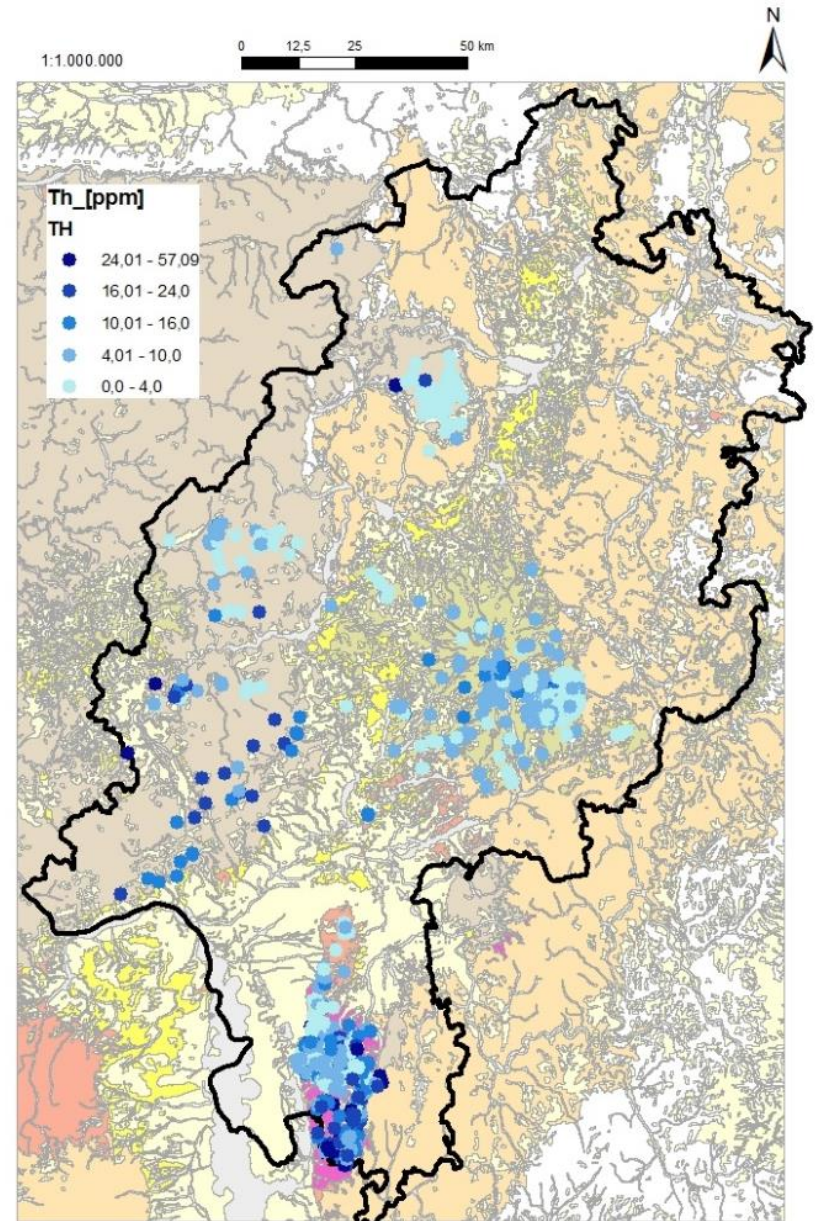
K₂O max contents



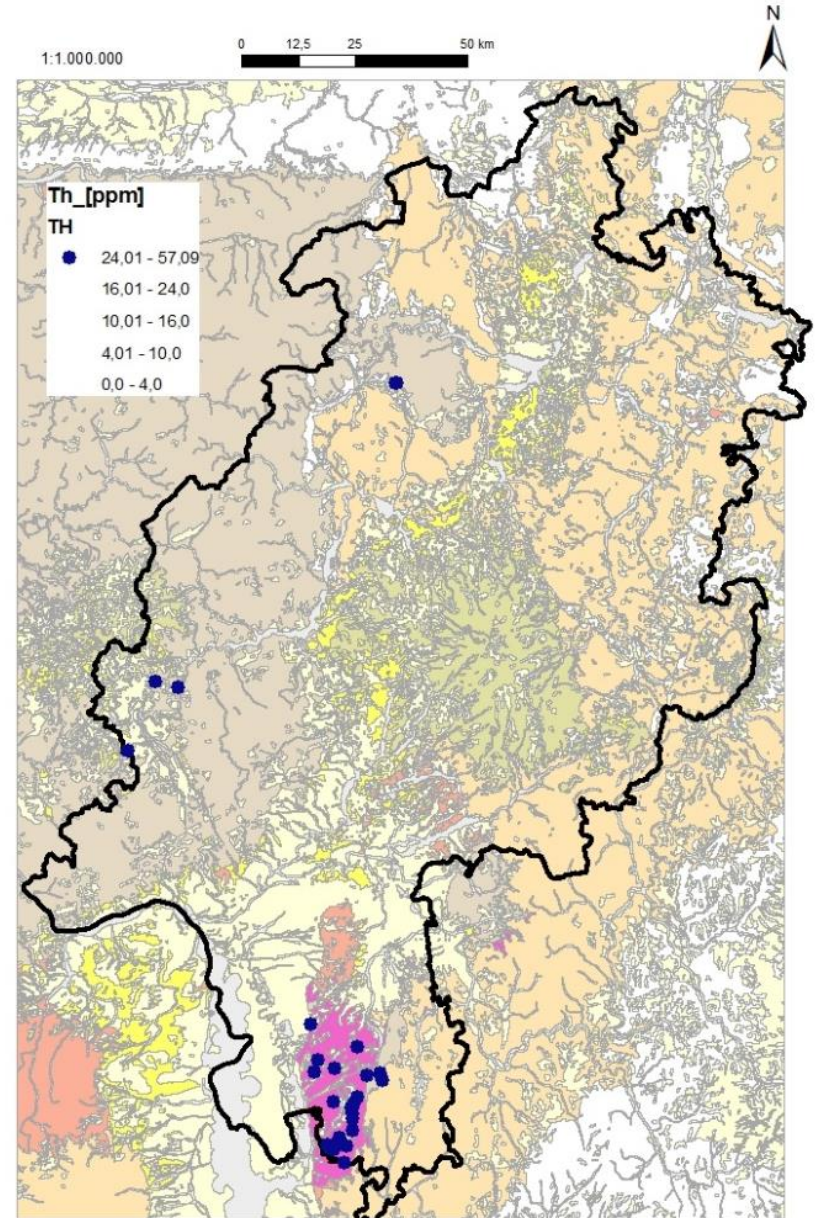
K₂O contents in structural units



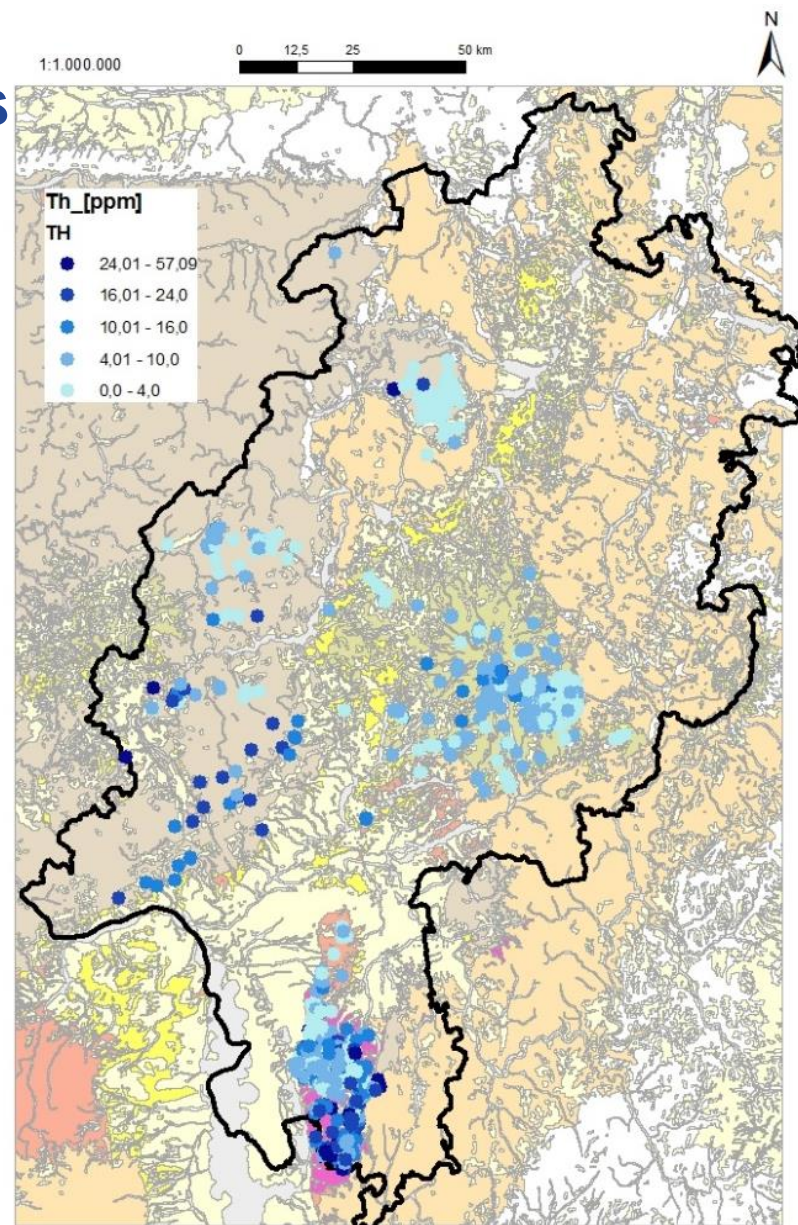
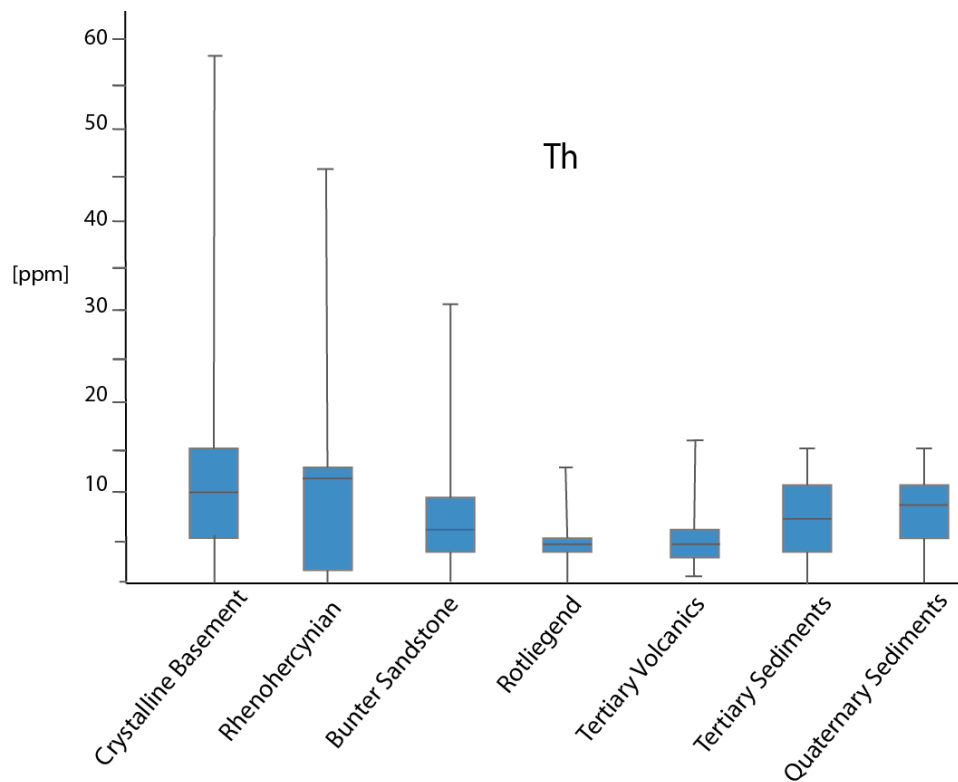
Th contents



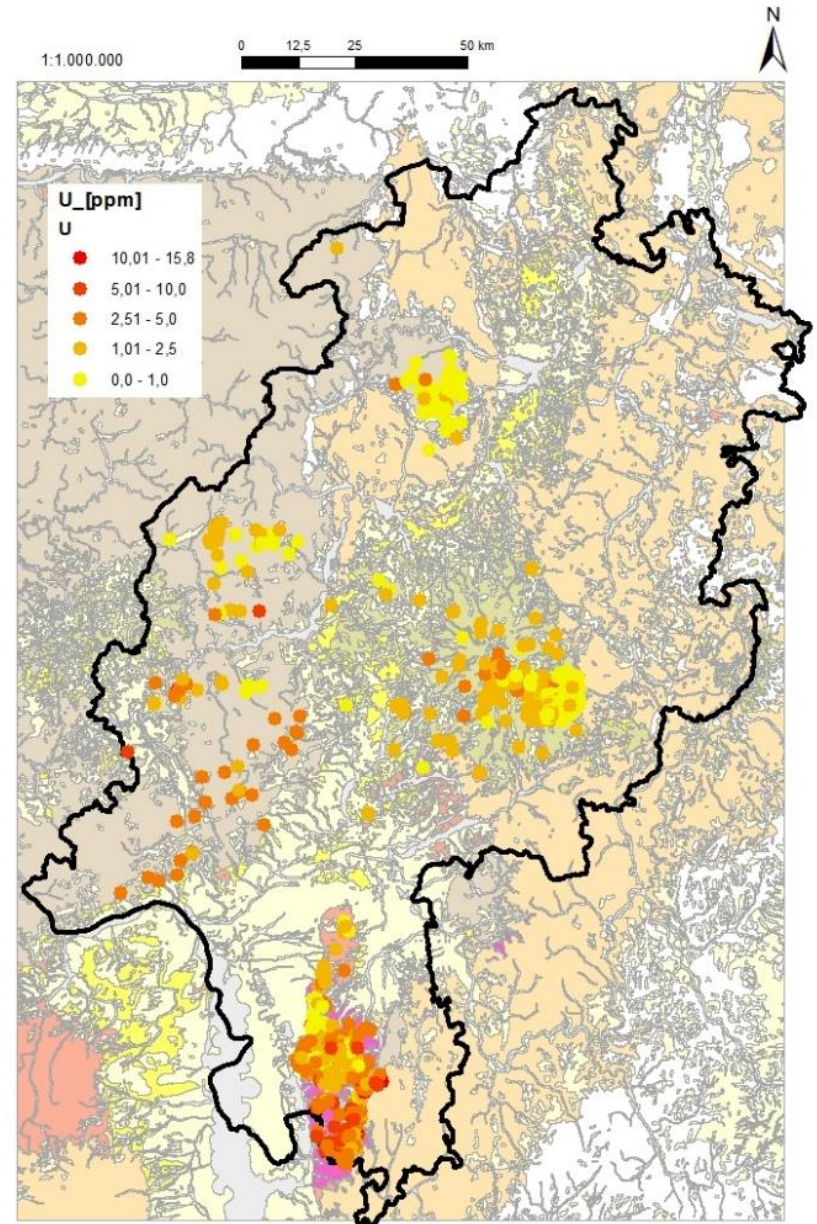
Th max contents



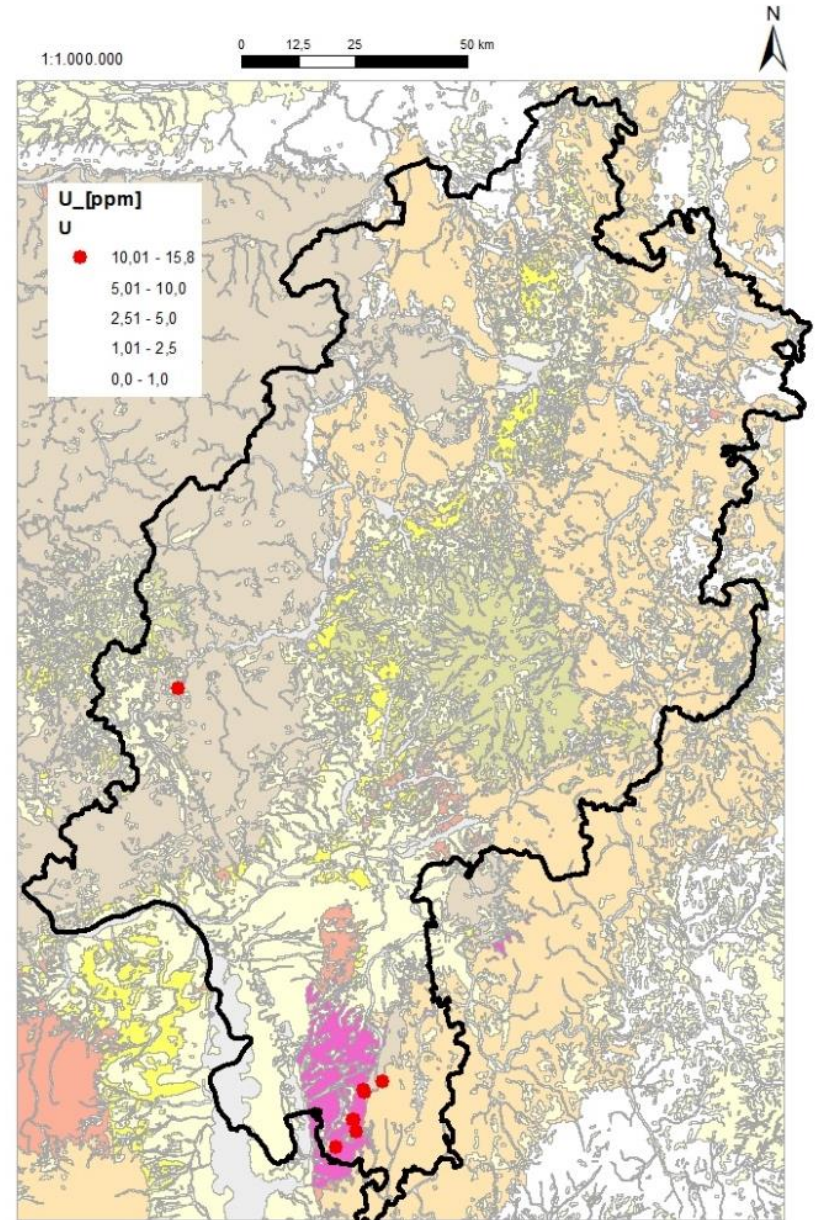
Th contents in structural units



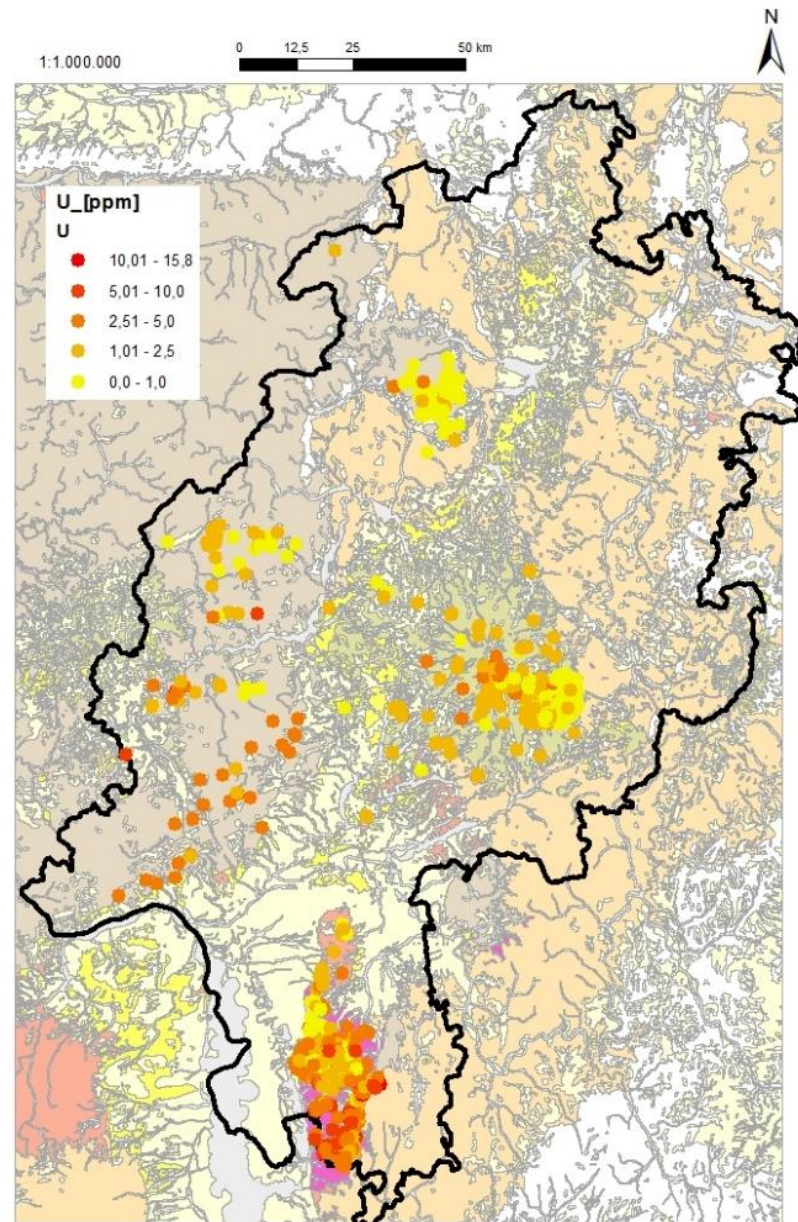
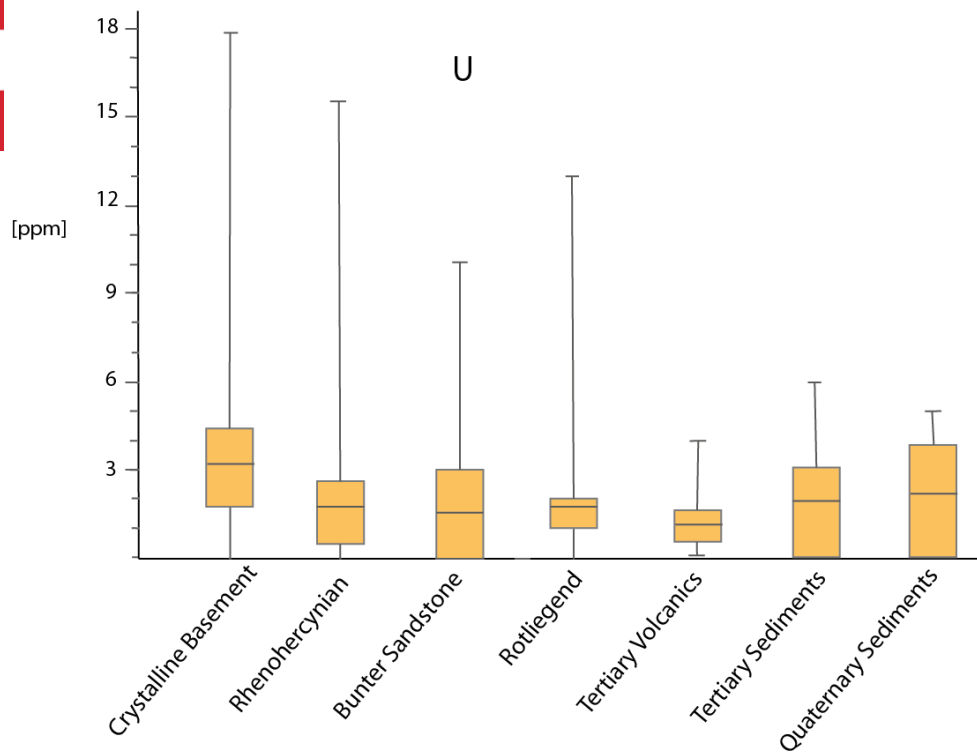
U contents



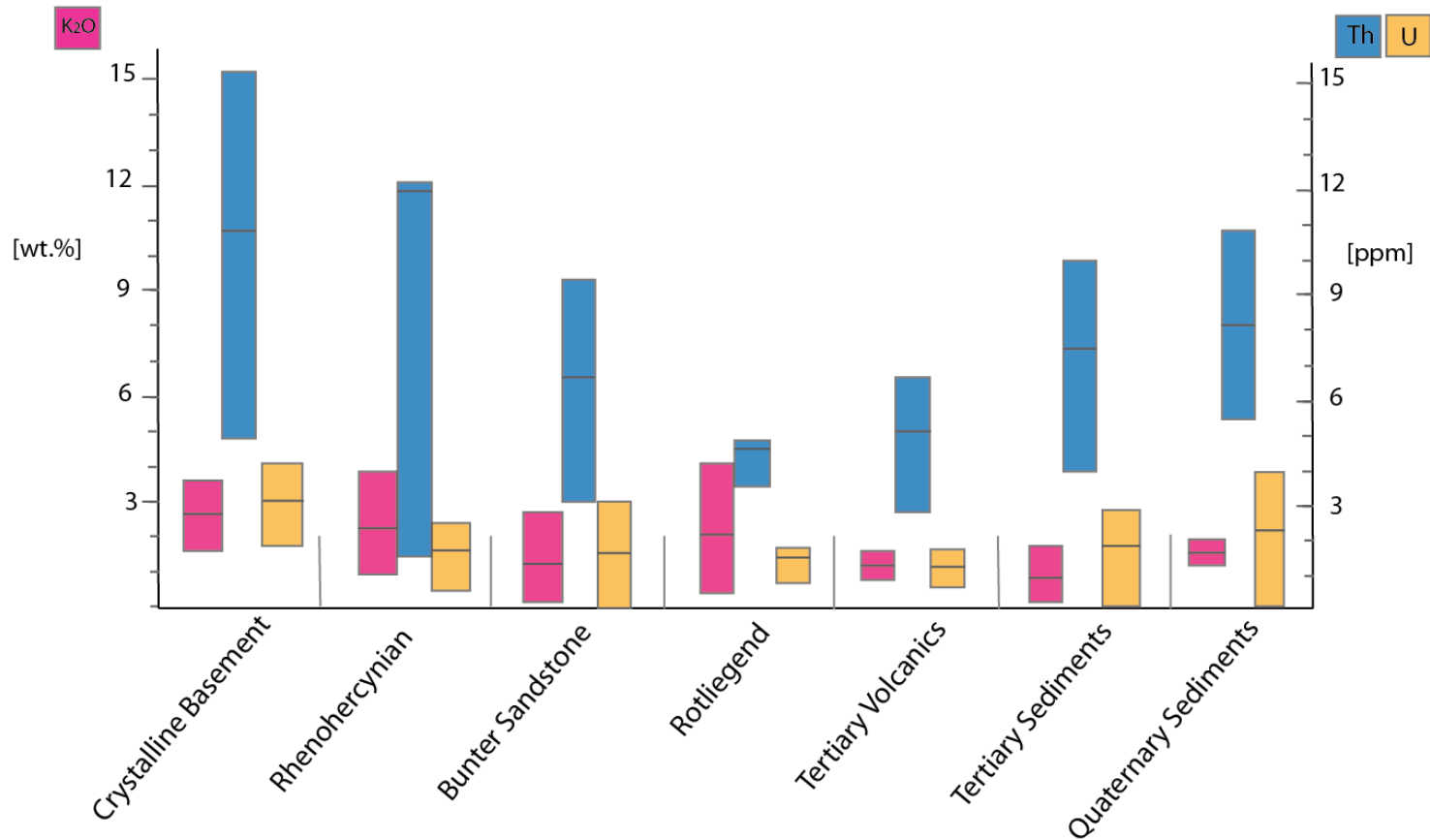
U max contents



U contents in structural units



Compilation geochemistry



Conclusions

- K_2O , Th and U content is significantly governed by rock type and varies accordingly in major structural units
- Still insufficient or missing data for Bunter Sandstone, Tertiary and Quaternary sediments
- Highest K_2O content in differentiated igneous rocks such as granites, phonolites, (meta-) rhyolites etc.
- Highest Th and U values are bound to crystalline basement and appear locally in Rhenohercynian and Bunter Sandstone (Mesozoic)
- K_2O , Th and U mean content in sedimentary rocks can be surprisingly high, dependent on source rock and clay content

Next steps

- Completion of geochemical analyses, especially of „missing“ lithotypes, to achieve a Hessian map for radiogenic potential of bedrocks
- Soil gas measurements
 - in structural units
 - along major faults between structural units
- Evaluation of bedrock composition (K_2O , Th, U) in comparison with Rn-content in soil gas

Thank you for your attention!

Questions?

annemarie.militzer@hlnug.hessen.de