Czech University of Life Sciences Prague

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The key controls of thallium isotopic fractionation in soil

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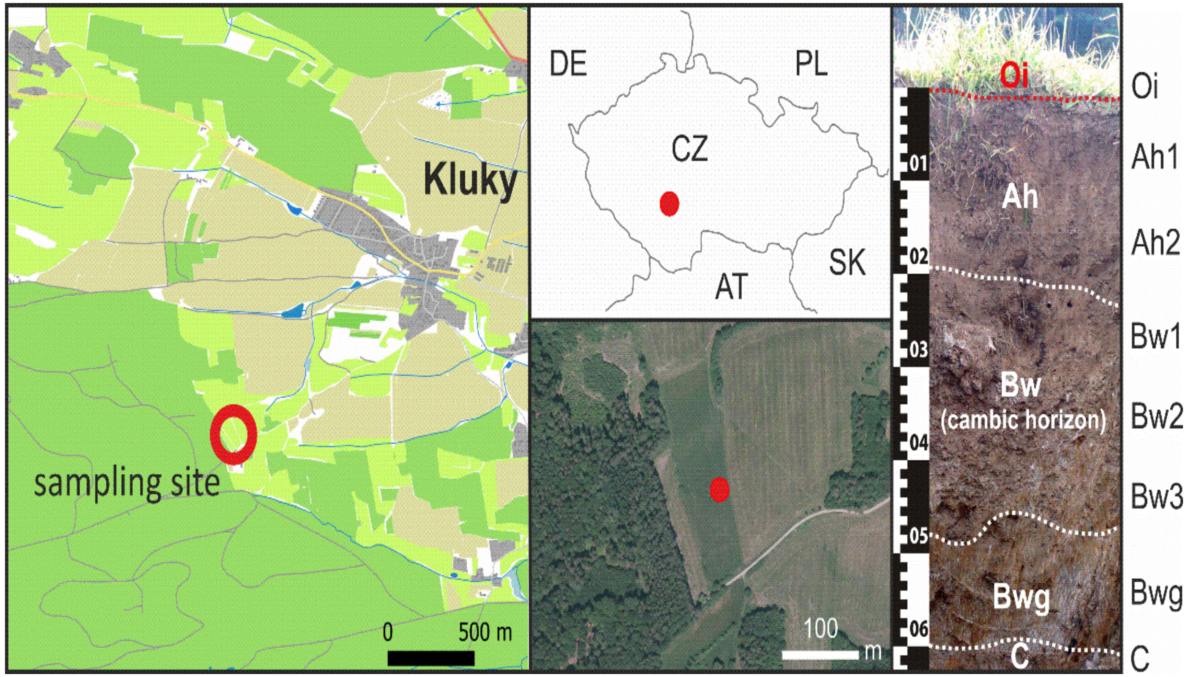
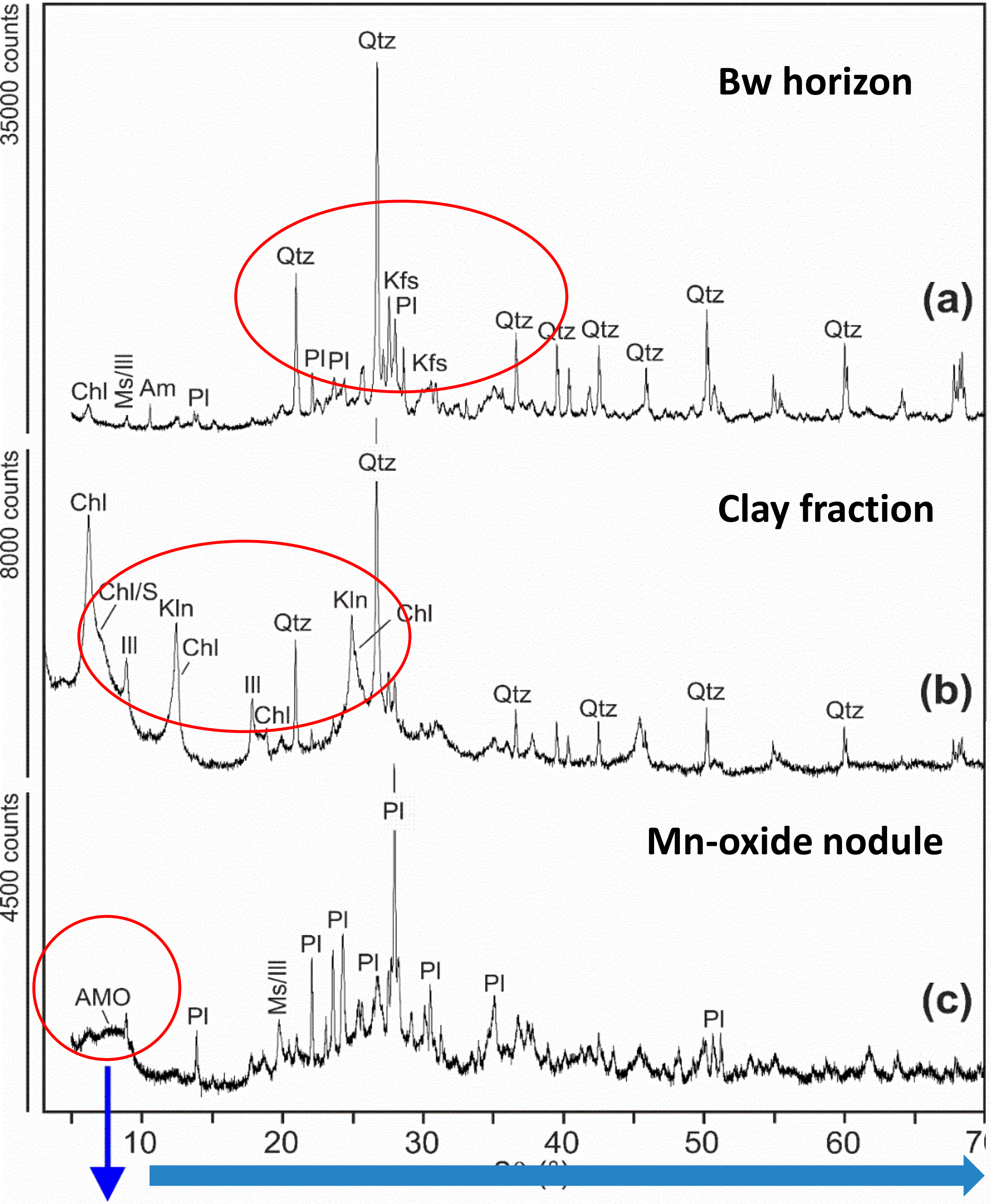
Our study

- Thallium (Tl) geochemistry is complex
- Variations of stable Tl isotopes (^{205}Tl and ^{203}Tl) can indicate specific chemical processes or alterations of Tl in soil
- To investigate the key geochemical and mineralogical factors that could affect the fractionation of stable Tl isotopes in soil.
- A set of soil samples enriched in geogenic Tl and selected Tl-containing minerals from the Czech Republic.

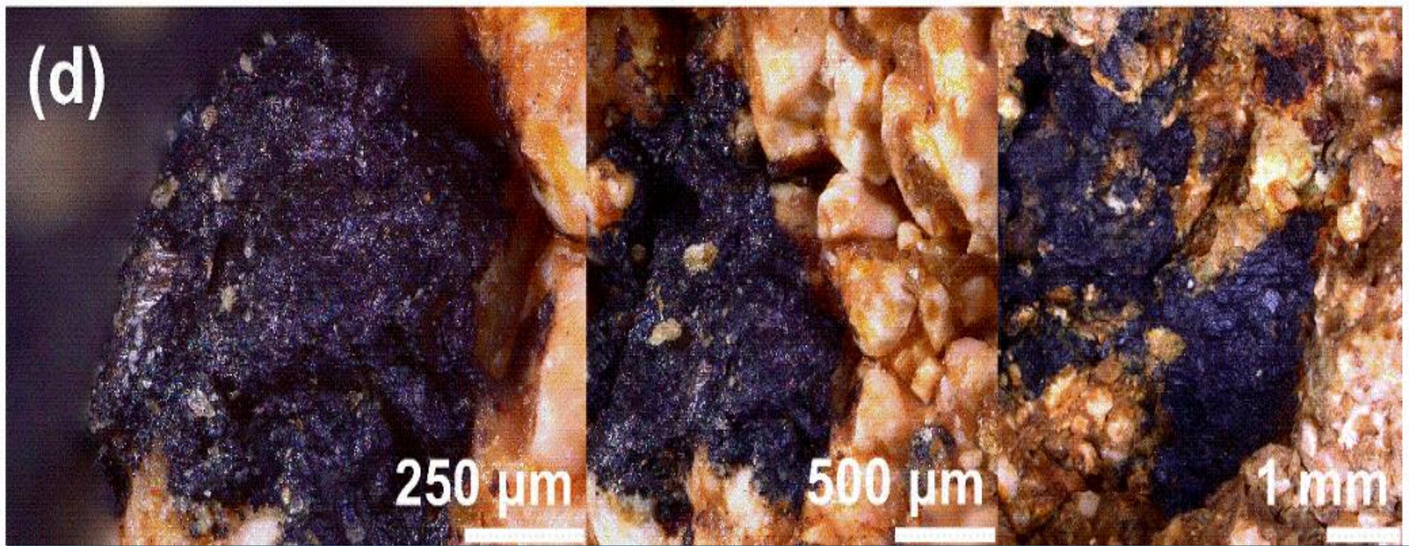


Results

X-ray diffraction patterns of the bulk soil sample.



Optical micrographs of Mn-oxide-rich nodules.



Total (Tl_{tot}) and exchangeable (Tl_{exch}) concentrations and Tl isotopic signatures ($\varepsilon^{205}Tl$) in the studied soil and selected Tl-containing samples.

Sample/ Soil Horizon	Depth (cm)	Tl_{TOT} (mg/kg)	Tl_{exch} (mg/kg)	$\varepsilon^{205}Tl \pm 0.7$
Oi	1–0	0.62 ± 0.14	–	+1.96
Ah1	0–10	1.29 ± 0.06	0.02	+1.25
Ah2	10–20	1.32 ± 0.02	0.05	+4.03
Bw1	20–30	1.51 ± 0.14	0.04	+3.72
Bw2	30–40	1.83 ± 0.02	0.04	+3.48
Bw3	40–50	2.65 ± 0.28	0.03	+2.69
Bwg	50–60	2.95 ± 0.16	0.04	+0.02
C	60–	1.99 ± 0.10	0.04	+1.52
Bedrock/granite		1.34 ± 0.08	–	+1.60
K-feldspar		2.12 ± 0.12	–	+1.39
Soil clay		3.35 ± 0.20	–	+4.57
Mn-oxide nodules		–	–	+14.4*
Mn-oxide nodules		4.98 ± 0.40	–	(+8.17)
AGV-2		0.27 ± 0.02	–	−3.10

- Peak in the middle zone -> alteration of soil Tl, redox-driven Tl cycling
- ^{205}Tl enrichment -> due to Mn-oxide and illite

- Preferential leaching of lighter Tl isotopes and sorption by pedogenic phases
- Isotope ratios similar to bedrock -> Lithogenic

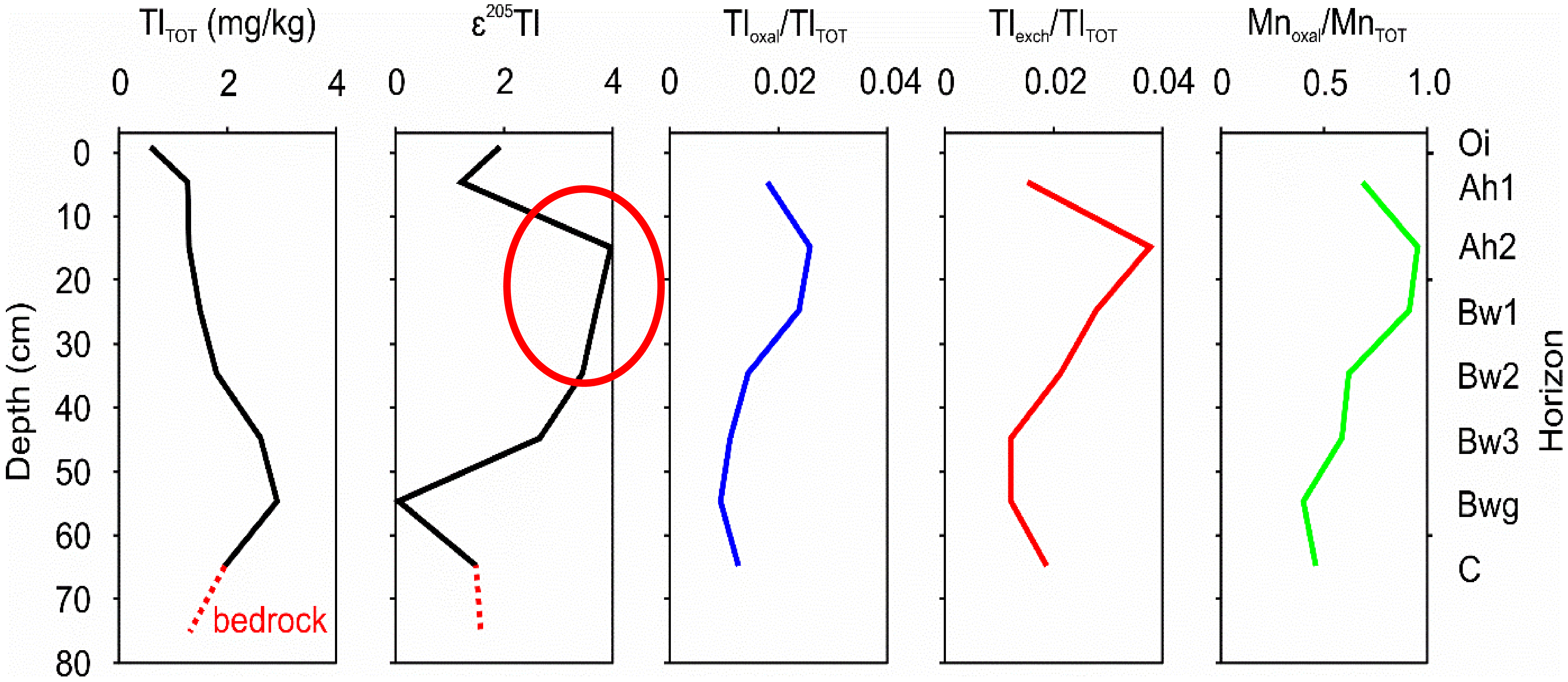
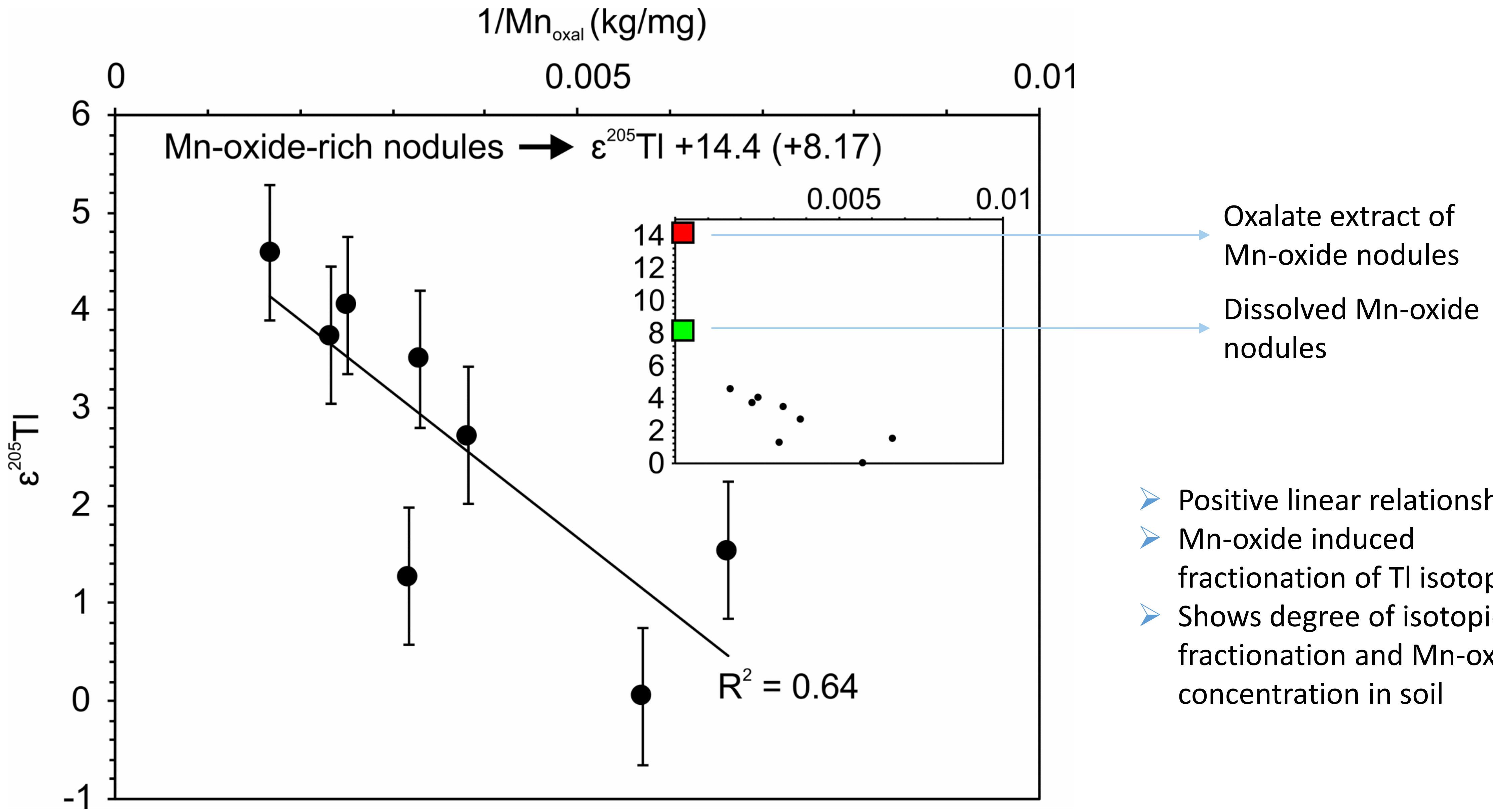


Figure: Vertical evolution of total Tl concentrations (Tl_{TOT}), Tl isotopic signatures ($\varepsilon^{205}Tl$) and the proportions of oxalate-extractable and exchangeable Tl or Mn fractions relative to total metal concentrations in the studied soil profile.



- Positive linear relationship
- Mn-oxide induced fractionation of Tl isotopes
- Shows degree of isotopic fractionation and Mn-oxide concentration in soil

Figure: Tl isotopic signatures of the soil horizons and the separated soil clay as a function of inverse oxalate-extractable Mn concentrations.

Conclusion

- Tl can be used as proxy to understand different soil processes.

- ^{205}Tl enrichment in the soil is partly due to ->

  - specific clay phases (illite), as inferred from the redoximorphic nature of the tested soil samples

  -systematic (redox-driven) Mn-oxide degradation and Tl cycling -> key control

- This study depicts similar results to our study on samples from Buus, Switzerland, where a similar trend in stable Tl isotopes can be seen (Vaněk et al., 2020 Geoderma).

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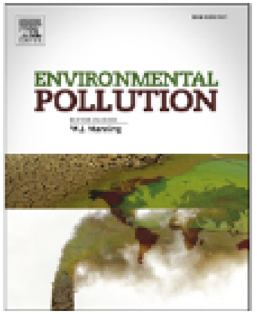

Thallium isotopic fractionation in soil: the key controls☆

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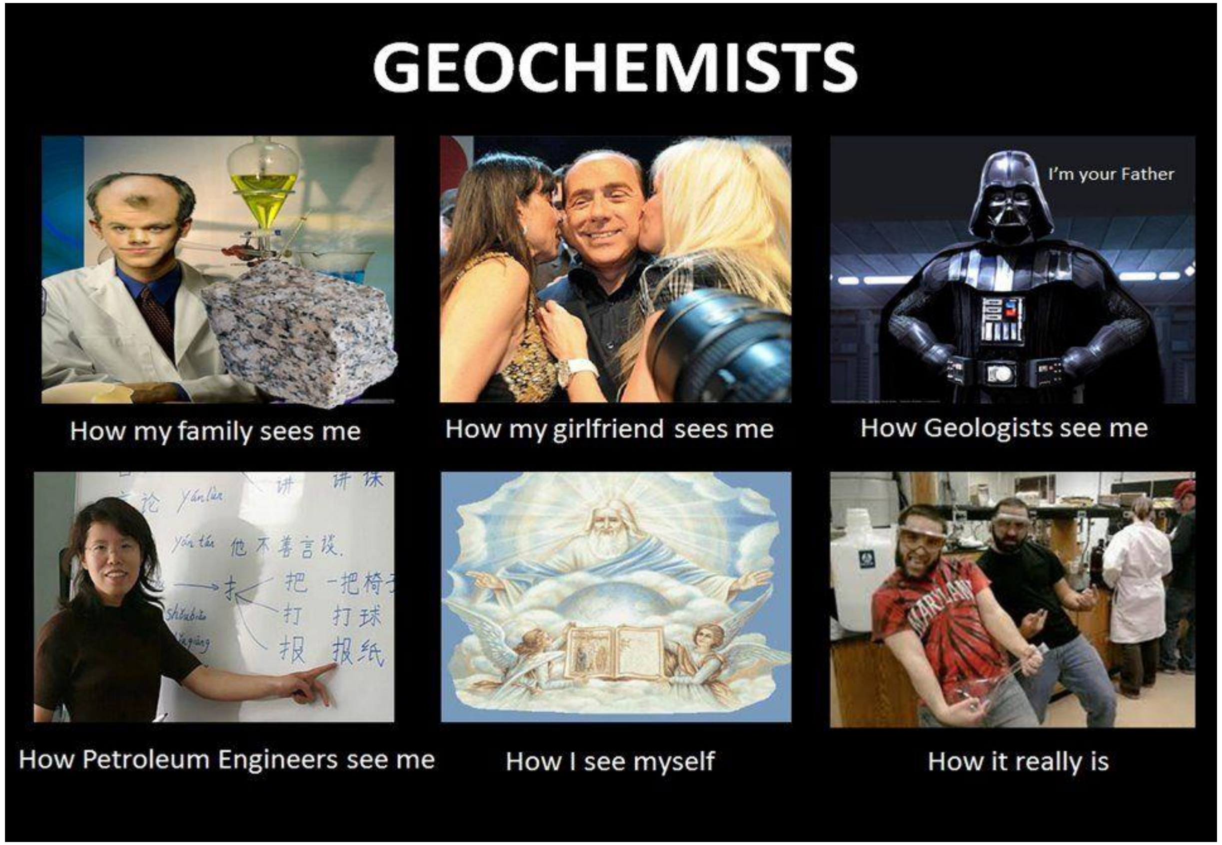
Thank you for your attention!



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