



Emissions from mine tailings: spatially- and temporally-resolved life cycle assessment

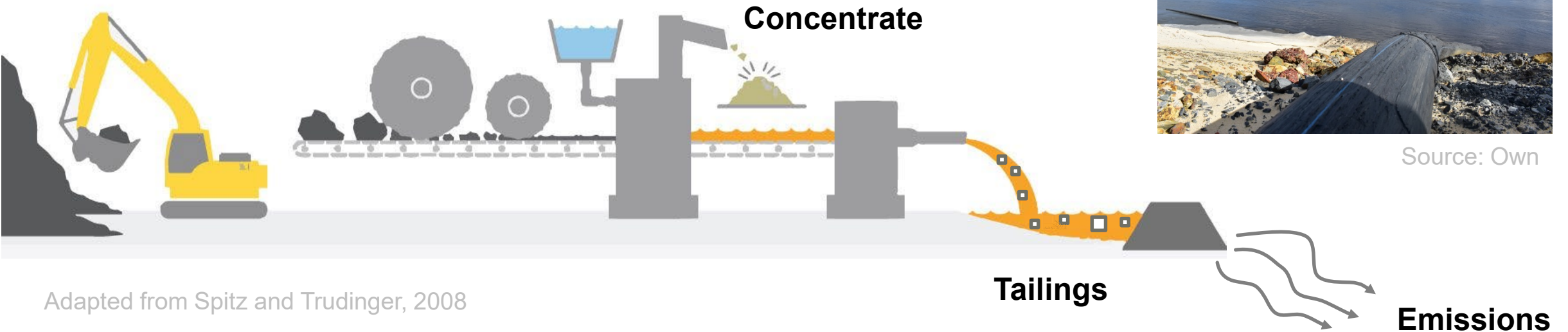
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How do we quantify tailings emissions?



Legacy pollution (Lottermoser, 2010):

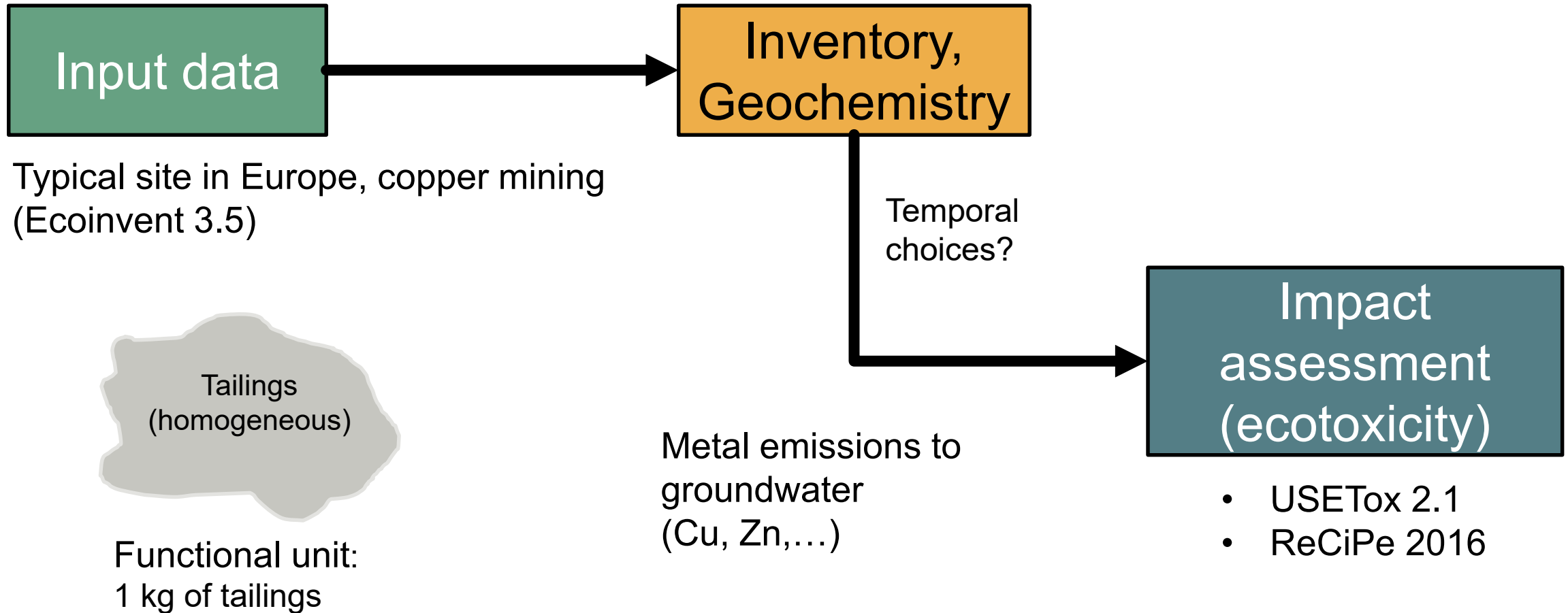
- Long-term emissions like 'landfill' (i.e., mine drainage)
- Structure stability

New models needed to estimate tailings emissions

- Geochemical model as a tool to assess long term prediction (Dijkstra, 2018)
- Tailings dataset is available in Ecoinvent, differentiated by metal type and country-level
 - Averaged concentrations, no physical & chemical interactions
- Temporal perspectives matter when dealing with long-term heavy metal emissions (Bakas, 2015)
- ❖ However, different tailings have different compositions (mineralogy)
 - Deposits origin and technology-dependent
 - Minerals can act as buffers or enhance metal releases

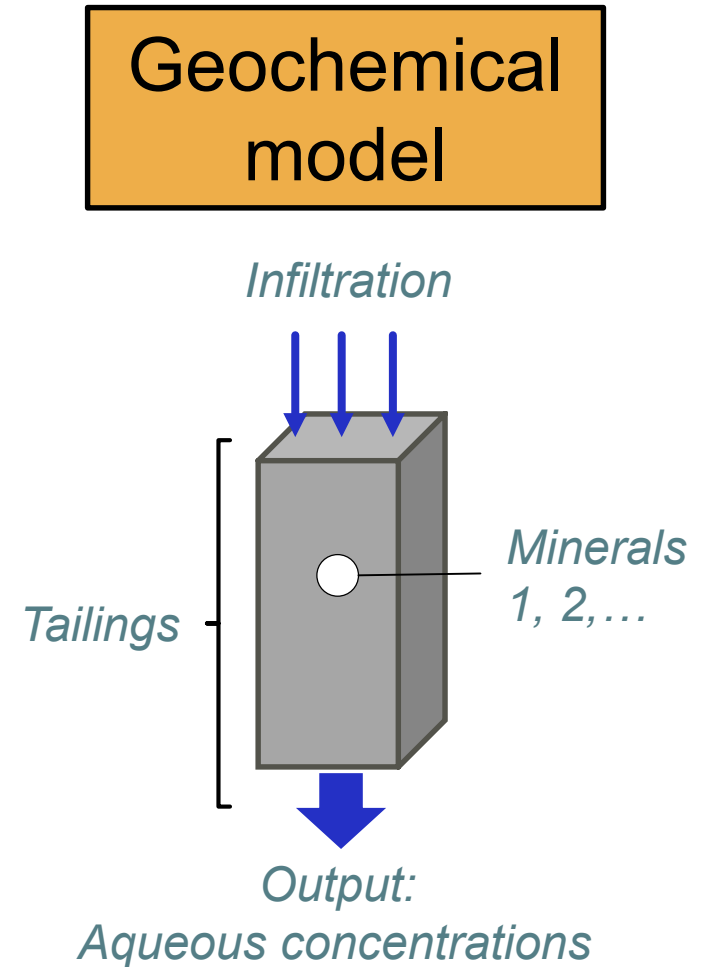
The necessity to consider site-specific factors

Case studies

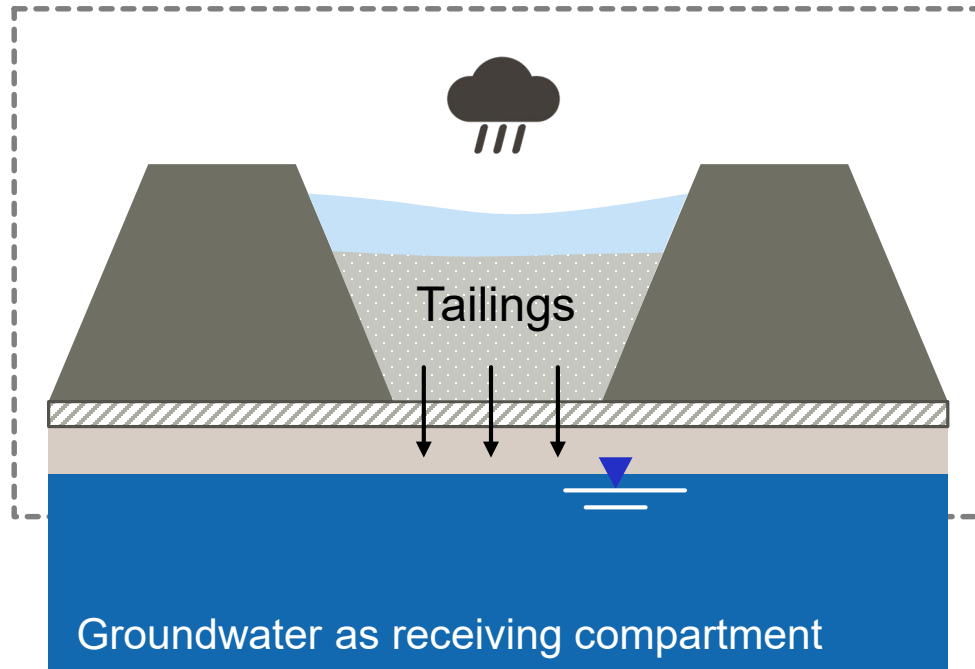


Inventory (release) modelling

- Geochemical approach:
 - Integrating factors (mineralogy, climate conditions) that contribute to heavy-metals release over time
 - Complexation and dissolution/ precipitation of minerals
 - Making use of comprehensive geochemical database 'PHREEQC' and 'Wateq4f' (Parkhurst, 2013; Nordstrom, 2002)



Parameterization and outputs



Site-specificity

Parameters

- Homogeneous tailings composition
- Water composition
- Matrix infiltration rate (PR)

Mineralogy

Buffers:

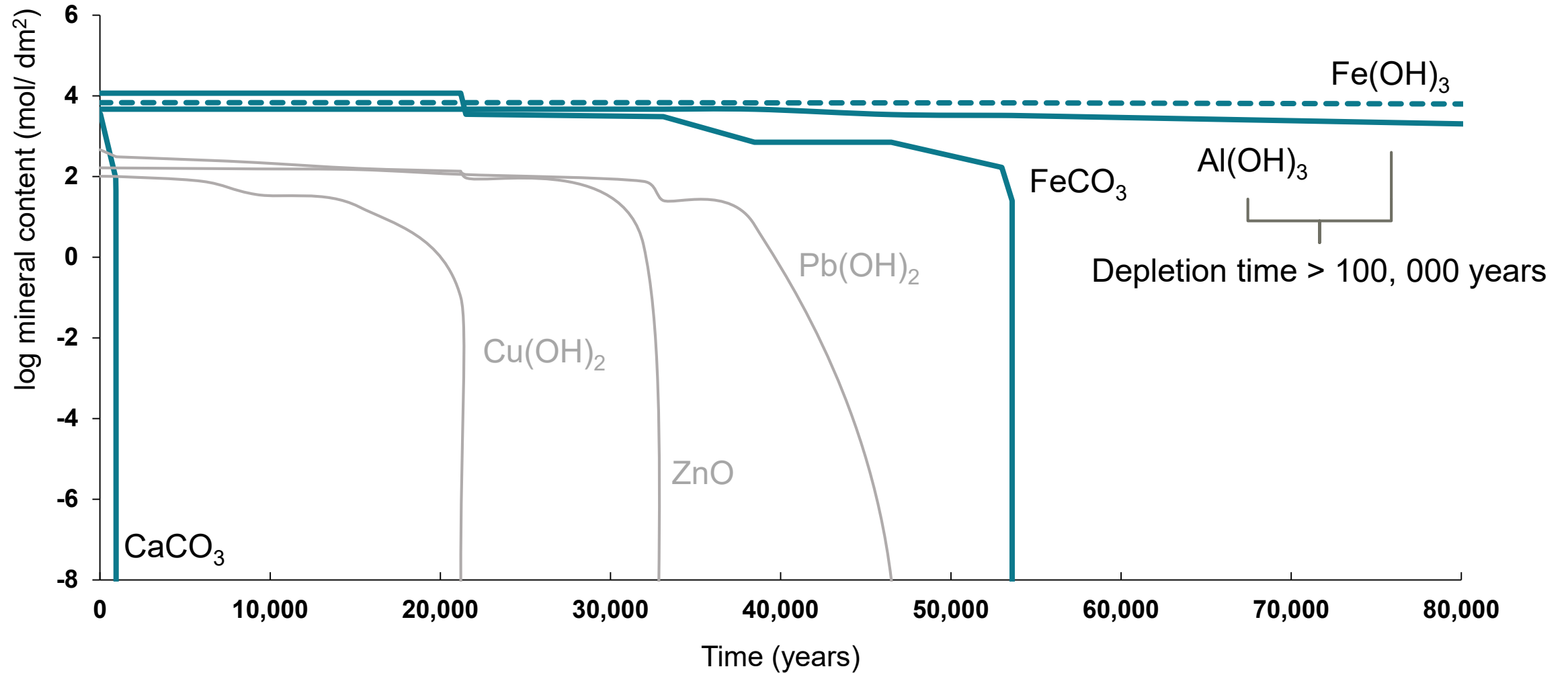
- Calcite
- Siderite
- Ferrihydrite
- Gibbsite

Simulation

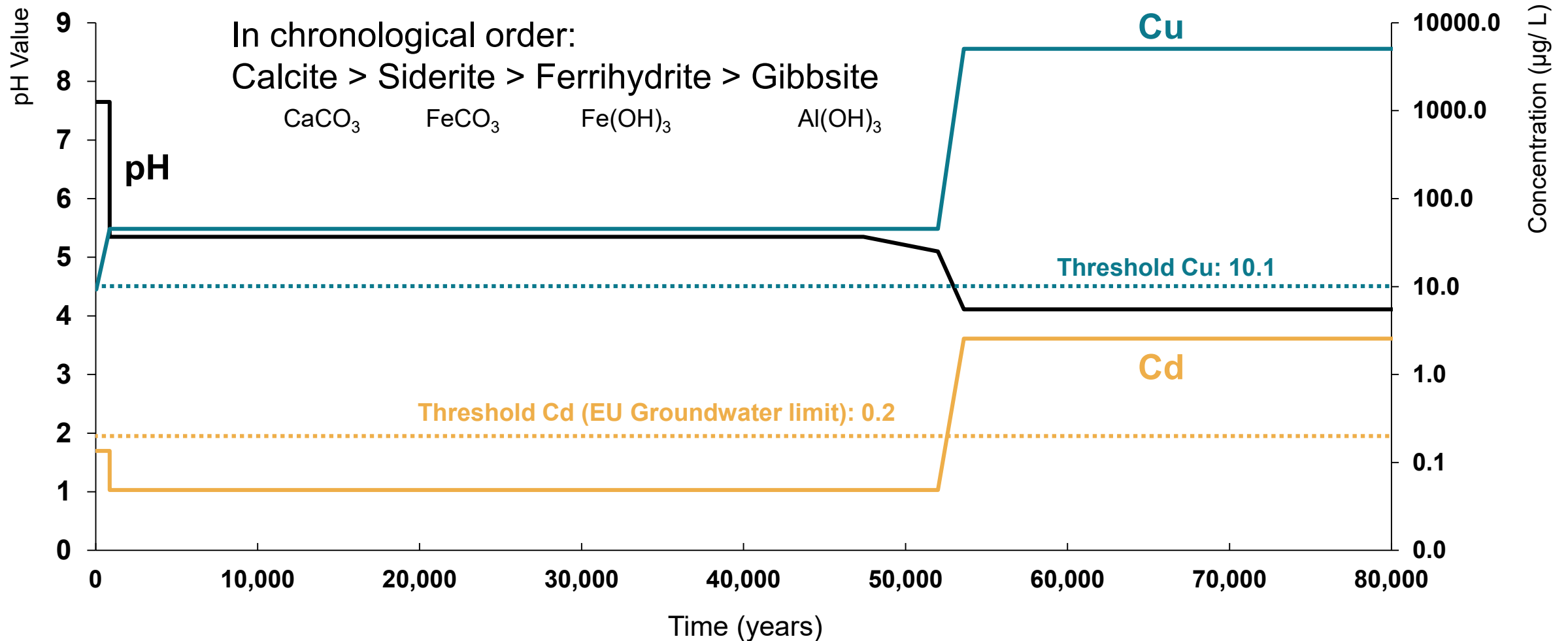
- Leached mass of species over time ($M_{x, total}$)

$$M_{x, total} = \sum_{t=t_0}^{t_1} PR \cdot t_{timestep} \cdot (C_x(t))$$

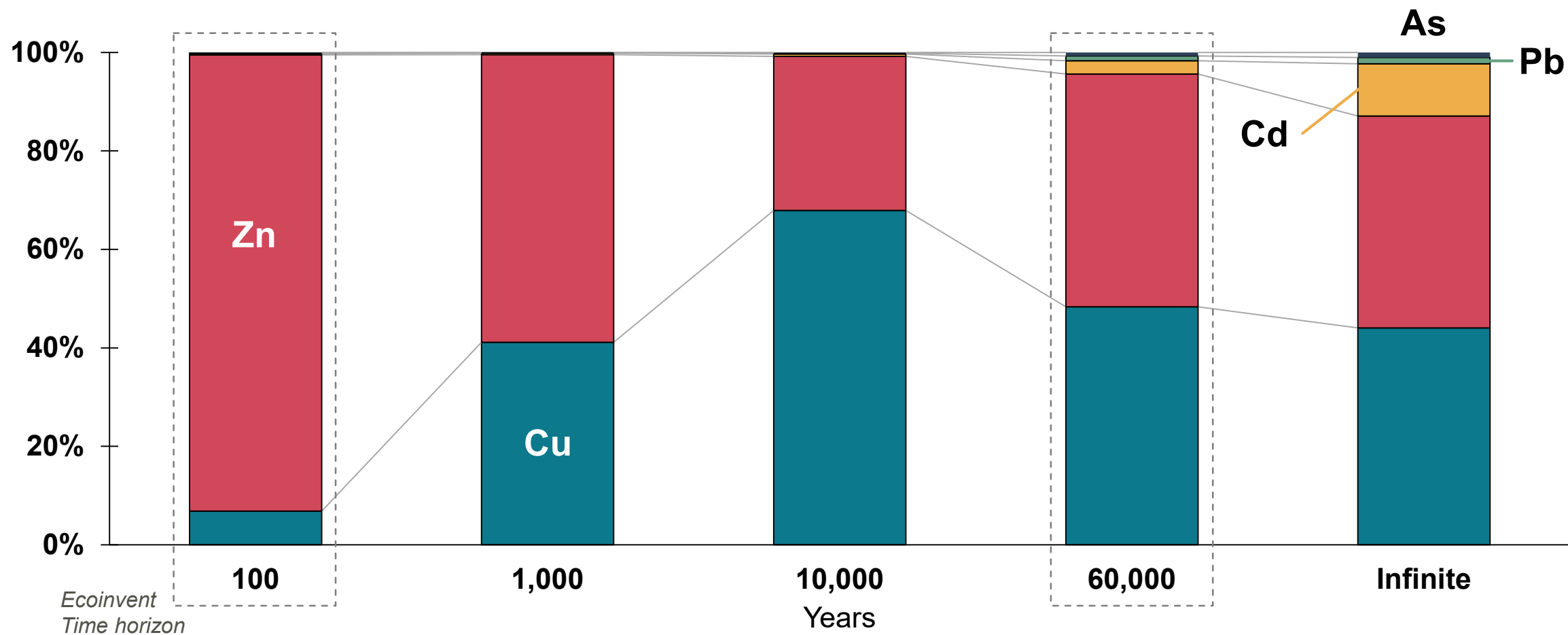
Dissolution of minerals and major buffers over time



Concentrations of leachate vs. groundwater limit



Forward-looking LCA (USETox, freshwater ecotoxicity)

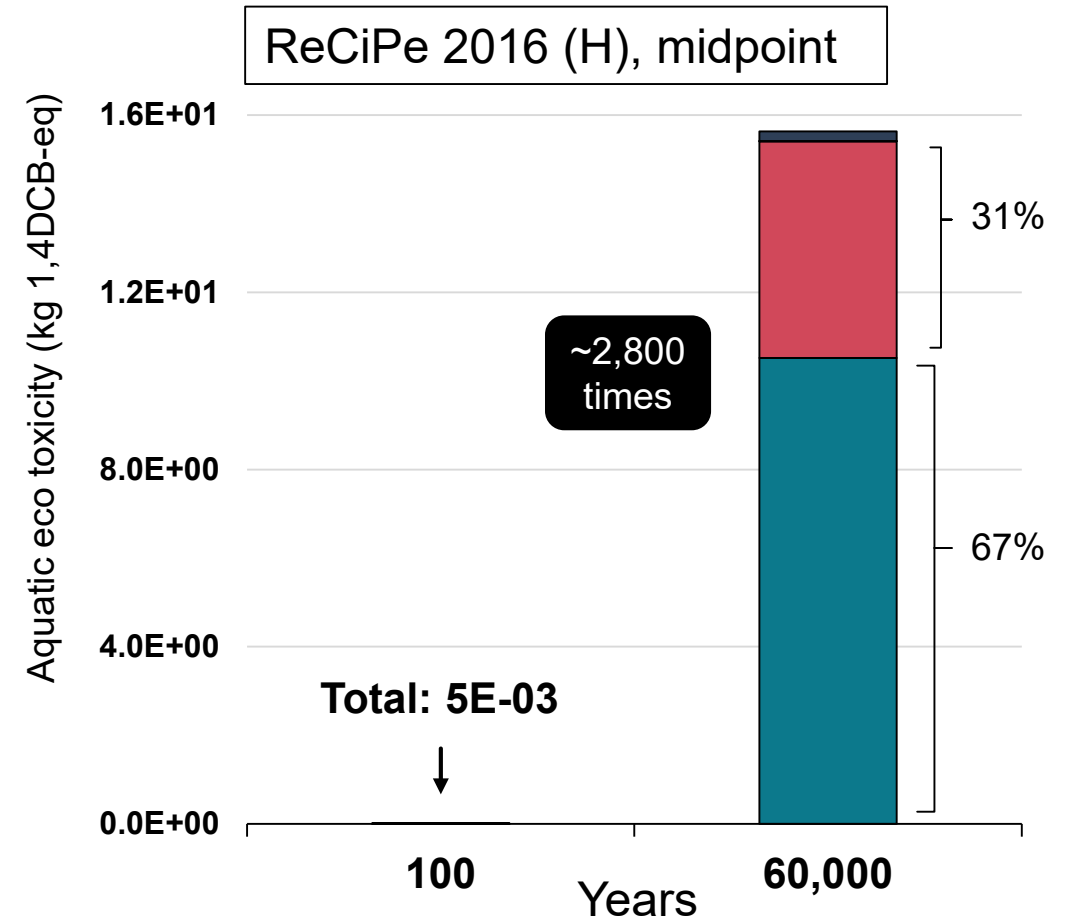
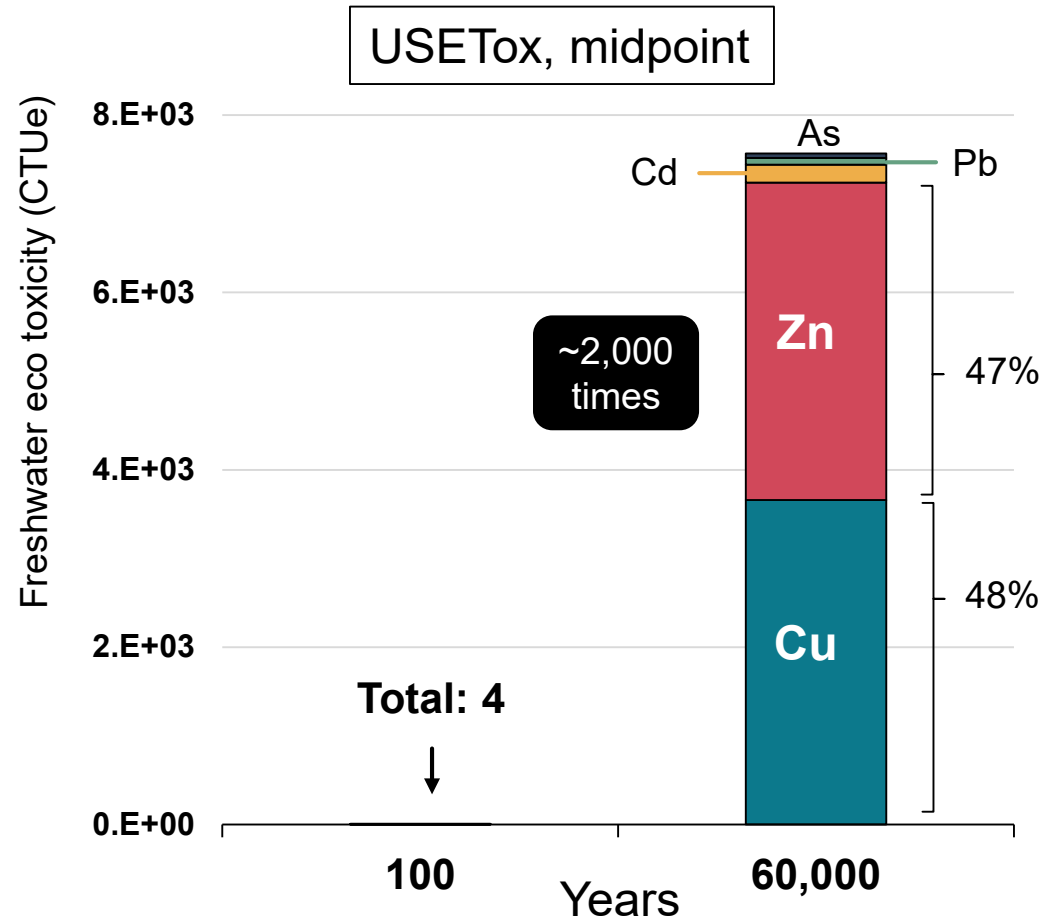


in CTUe

4	638	5001	7570	8312
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Choice of LCIA methods

FU: 1 kg tailings, after 100 years and 60,000 years



Comparison of transfer coefficients after 100 years

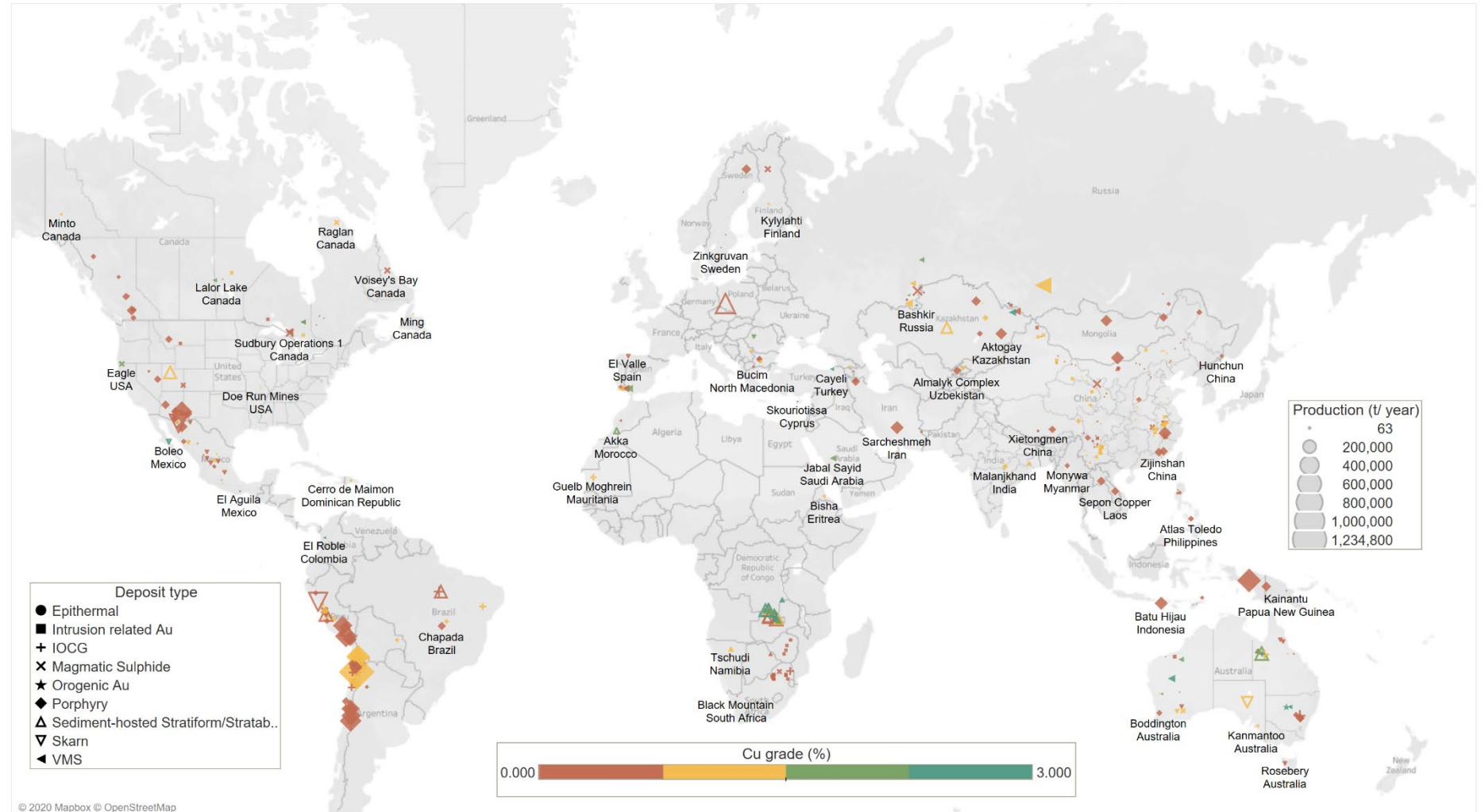
Species	Simulated (this study)	Ratio	Ecoinvent (current database)
Cd	3.5×10^{-9}	0.3	1.4×10^{-8}
Cu	4.5×10^{-6}	15	3.0×10^{-7}
Zn	2.2×10^{-5}	23	9.7×10^{-7}

- Differences due to consideration of thermodynamics and mineralogy inputs
- For simulated case, Cu and Zn have been completely leached out after 60,000 years

Outlook: Towards global assessment

An opportunity to improve consistency of tailings emissions

LCA of metal production



Data compiled from: USGS Minerals Resources; S&P Market Intelligence; Mudd et. al 2018; Companies' reports)

Conclusion

- The approach parameterizes the model of tailings emissions
- Geochemistry and infiltration rate control releases of heavy metals
- Possibility to include different time horizons in tailings inventory
- Choice of time horizon affects the overall LCA results

Acknowledgment



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Kindly send your questions
via live chats 😊 Thanks



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