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HOW TO GENERATE MORE RELIABLE DATA FOR THE LCA OF THE RAW MATERIAL SECTOR: THE IMPORTANCE OF INTERDISCIPLINARITY

LCM 2021 – MO.2.A. Life Cycle Approaches in the Raw Materials Sector II

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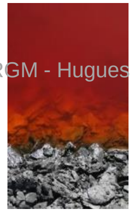
Introduction

Environmental issues associated to mining

Biodiversity losses - toxicity

Air emissions (PM,GHG, ..)

Water use and pollution



AMD Risk

Energy use

Land use

Solid wastes generation

Azapagic A (2004) Developing a framework for sustainable development indicators for the mining and minerals industry. J Clean Prod 12:639–662. https://doi.org/10.1016/S0959-6526(03)00075-1

Mining sector and its associated issues are poorly considered in LCI databases or specific scientific literature

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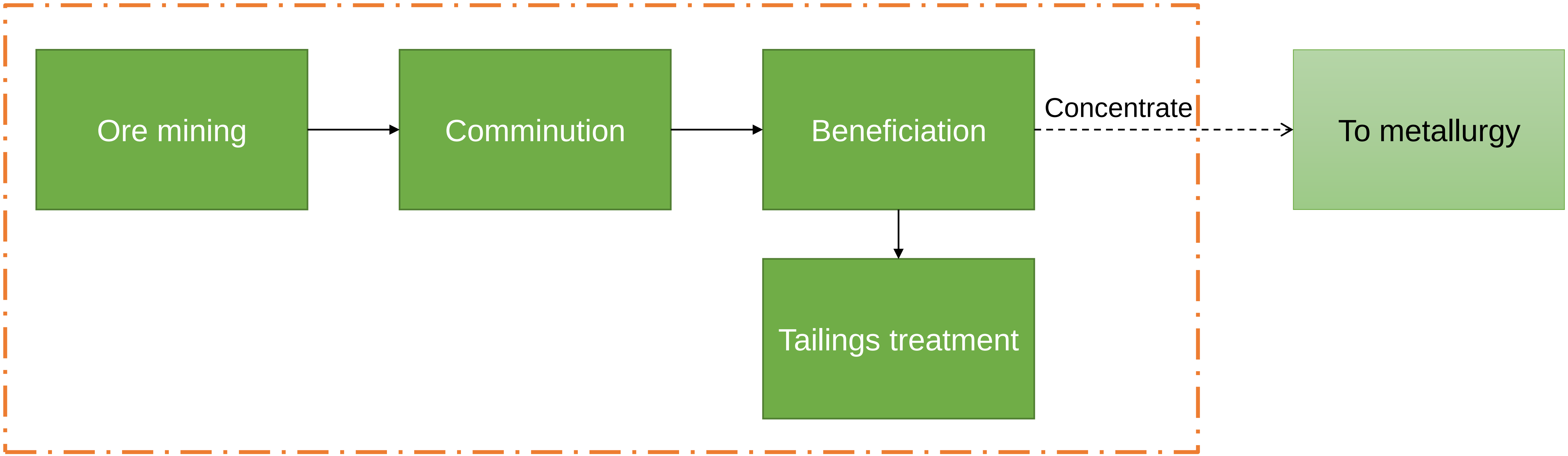
See presentation – « Limitations and recommendations of LCA databases of mining activities for some raw materials » - Session MO.1.A

Among the main issues:

- Partial LCI data
    - Incoherent mass balances
- Lack of inclusion of recent technologies

How to access more reliable data?

Concentrate production



42 months project
Horizon 2020 – Grant Agreement 730411

Concentrate production

Ore mining → Comminution → Beneficiation --Concentrate--> To metallurgy

Beneficiation → Tailings treatment

36 months project
Horizon 2020 – Grant Agreement 730480

Concentrate production

Ore mining → Comminution → Beneficiation → (Concentrate) → To metallurgy

Beneficiation → Tailings treatment

48 months project
Horizon 2020 – Grant Agreement 730294

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IMPaCT – Coupling process simulation and LCA to access representative data regarding an innovative technology

- Unlock a sustainable access to small complex deposits through the paradigm of *Switch On – Switch Off mining*

Assess the environmental performance of lead concentrate production using an **innovative technology** at **pilot scale**

Using process simulation to access reliable data to perform the environmental LCA

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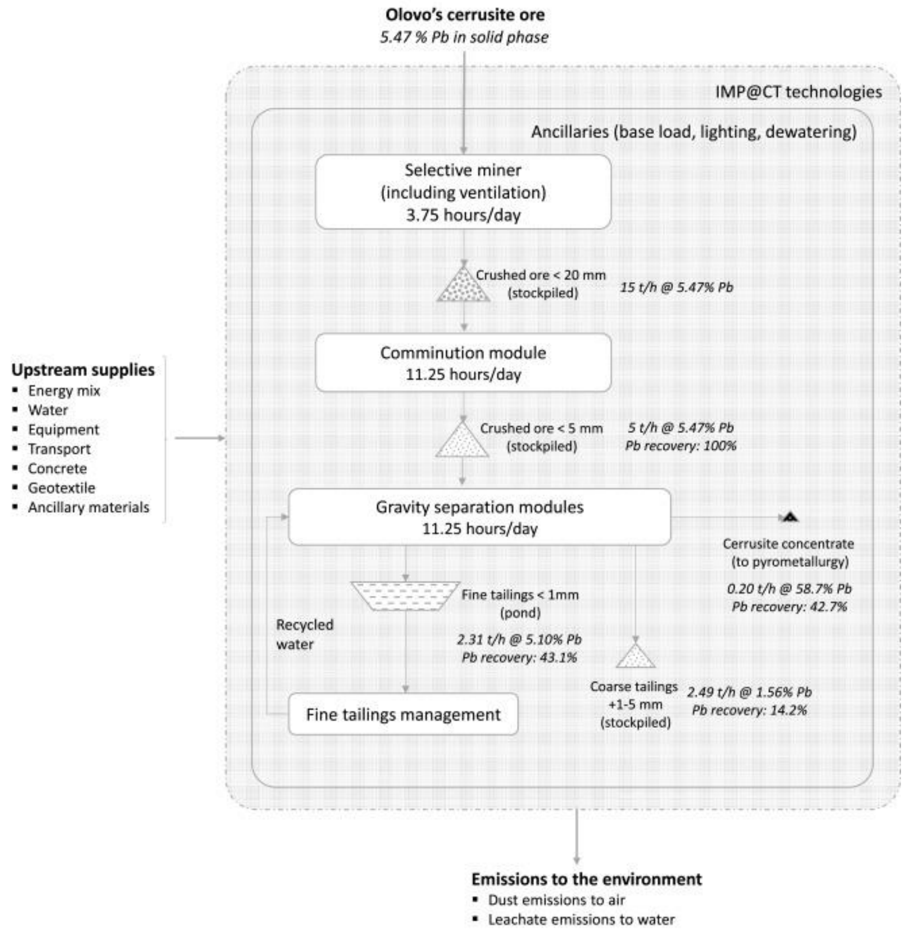
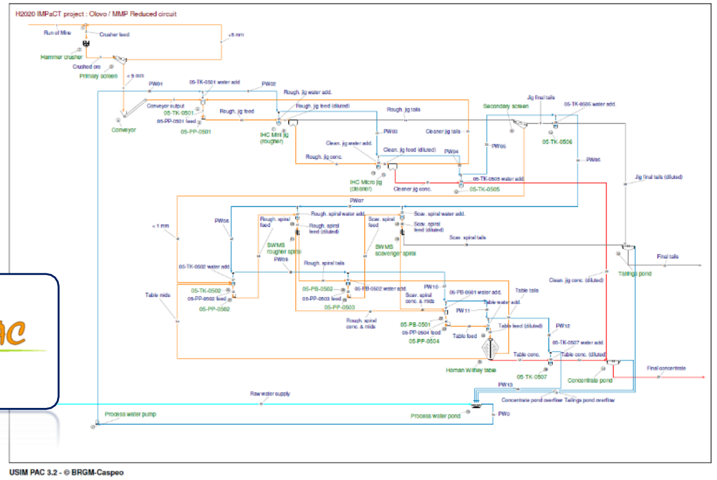
IMPaCT – Coupling process simulation and LCA to access representative data regarding an innovative technology



- Design the flowsheet of the operations
- Set up mathematical models for each unit process
- Gather experimental data to calibrate the models
- Simulate the system (for given feed conditions)

USIM PAC



Process simulations allows…

- Mass balance calculations
- Data reconciliation

Resulting in operating variables

- Flow rates (liquids and solids)
- Energy and reagents consumption
- Waste generation

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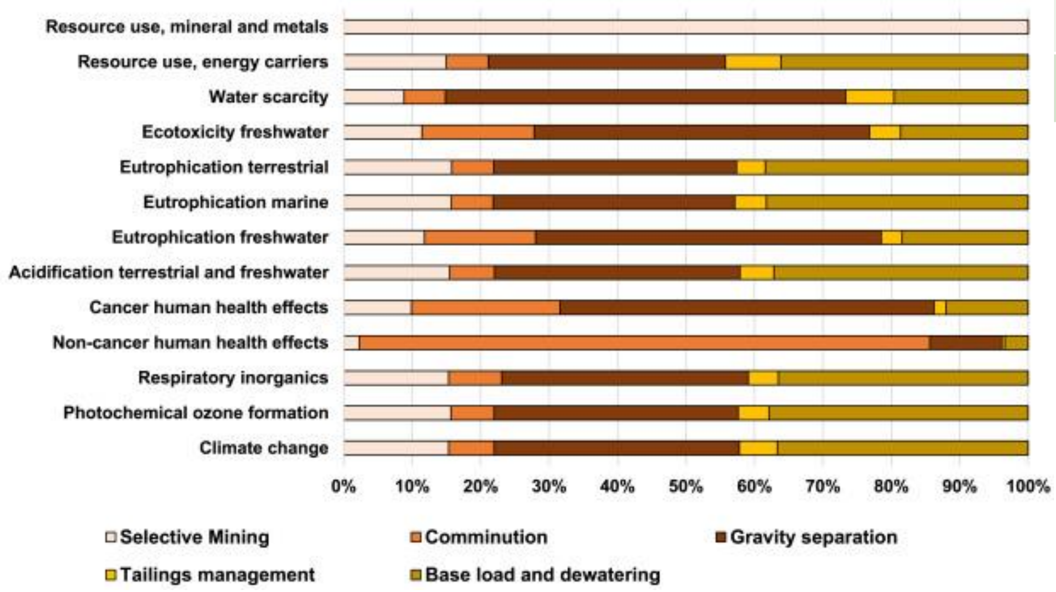
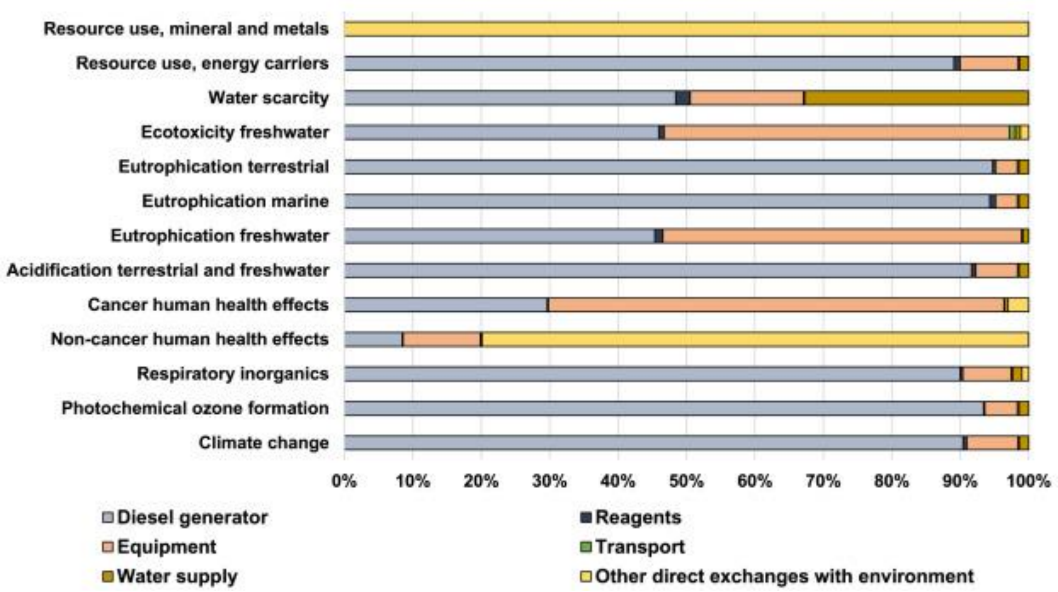
IMPaCT – Coupling process simulation and LCA to access representative data regarding an innovative technology

Operation	Output flow	Flow rate (solid phase – t/h)	Duration of operations (h/day)	Solids concentration	Pb concentration
Selective miner	Mined ore	15	4.25	100%	5.47%
Comminution	Processed ore	5	11.25	96%	5.47%
	Concentrate	0.199	1	75%	58.7%





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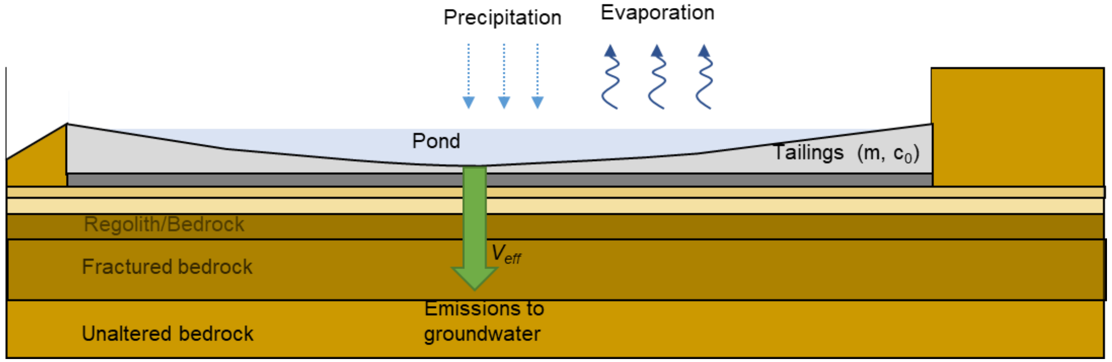
ITERAMS – Coupling reactive transport and LCA to estimate tailings long-term emissions

- Issues related to long-term emissions associated to tailings in LCA
  - Few studies « LCA of a mine » consider the tailings treatment in their product system
  - LCA databases (e.g. *ecoinvent*) use *simple* model to quantify long-term emissions associated to tailings. These models however consider, since ecoinvent 3.6:
    - Where the mine site is located (geographic parameter)
    - Which ore is treated at the mine site



  - *Simple* model based on a transfert coefficient

$$TK(t) = TK_\infty \left[1 - \exp\left(-\frac{V_{eff} * c_o}{m * TK_\infty} * t\right)\right]$$

TK_∞: fraction of the observed element (in the solid) that can be emitted (100% by default)

V_{eff}: Volume effectivement lixivié (dépends des conditions climatiques, de la hauteur du tas de tailings ou encore de sa densité)

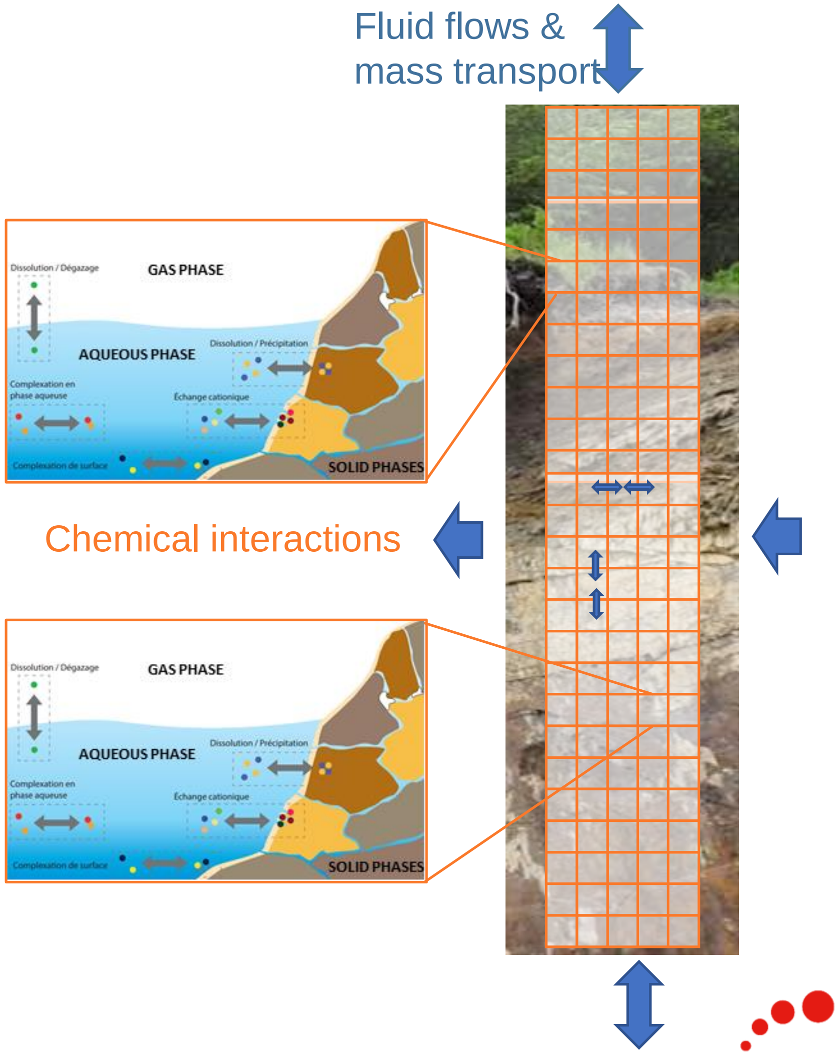
- Uncertainties associated to resulting emissions vary from 100% to 3158 %

Doka G (2017) A model for waste-specific and climate-specific lige cycle inventories of tailings impoudments. Zürich, Switzerland

ITERAMS – Coupling reactive transport and LCA to estimate tailings long-term emissions

Reactive transport modeling aims at understanding the distribution in space and time of chemical reactions occurring in a specific environment

Depends on mass transport, heat transport and geochemical reactions
Development of databases and softwares



Reactive transport model allows…
- Determining the concentration of chemical species at the outlet of the system

Resulting in mass of chemical species emitted to the groundwater

ITERAMS – Coupling reactive transport and LCA to estimate tailings long-term emissions

Generic data from ecoinvent

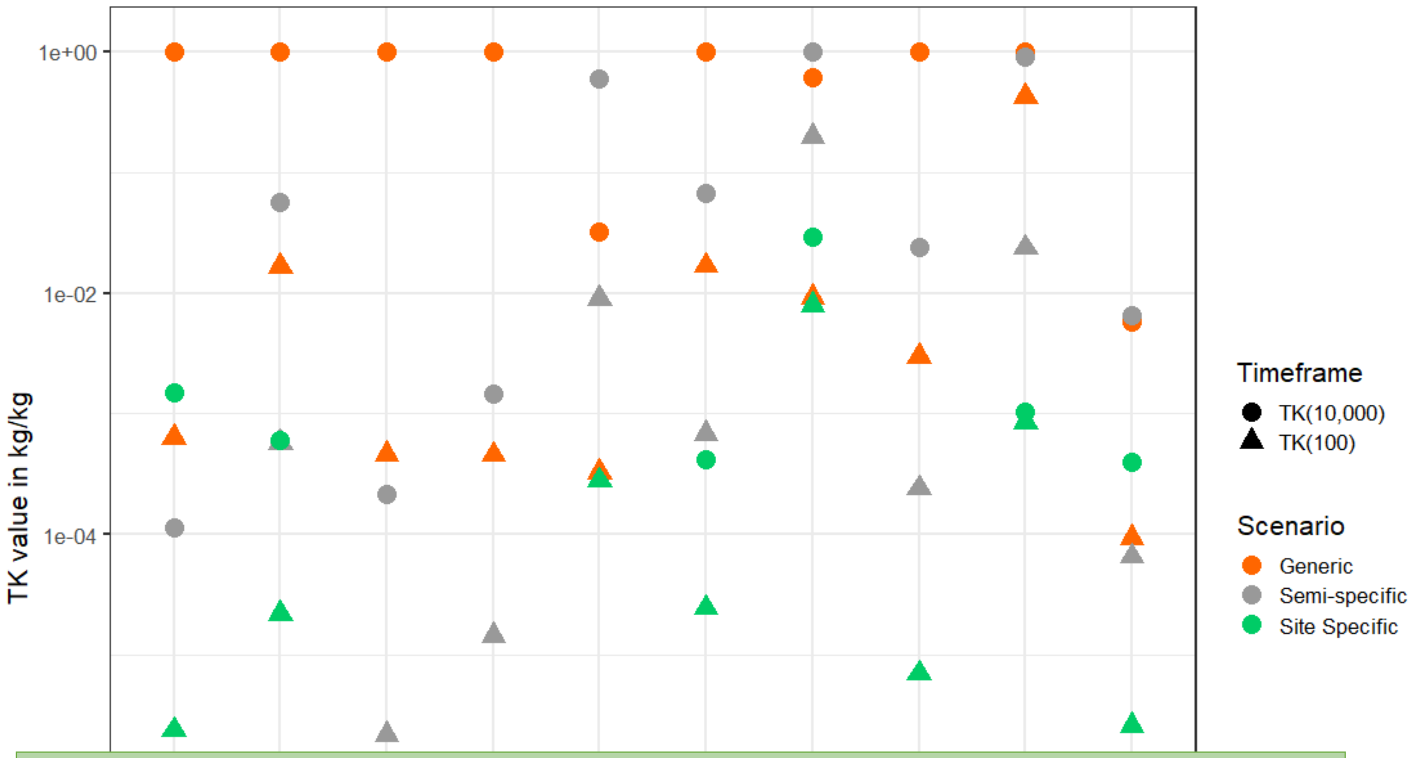
vs.

ecoinvent model refined with site specific data

vs.

Reactive transport model

Impacts	Units	Scenario		
		Generic	**Semi-specific**	**Site specific**
Non-cancer human health effects	CTUh	1.64E-9	3.77E-13	1.10E-14
Cancer human health effects	CTUh	9.19E-11	6.53E-12	1.92E-13
Ecotoxicity freshwater	CTUe	6.01E-2	3.17E-3	8.69E-5



General conclusions

→ Considering site specific values tends to minimize results compare to generic data

→ Using more sophisticated model tends to minimize results compared to simpler models

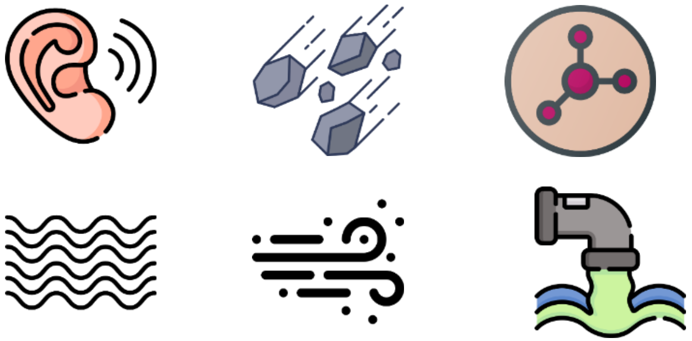
SLIM – How to generate reliable data to model the rock blasting phase?

https://www.slim-project.eu/participating-mines/

The blasting phase is today poorly taken into considerations in LCA studies, however

- Blasting is associated with environmental emissions…
  - PMs
  - Nitrates

- … and energy consumption in the downstream phases
  - Link between blasting and comminution ?



Amount of explosives

Rock fragmentation

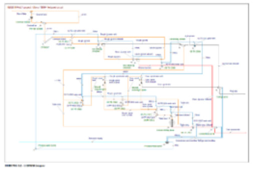
Energy use in comminution

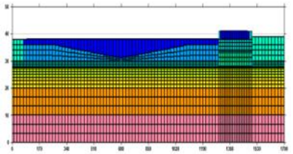
Direct link based on site characteristics ?

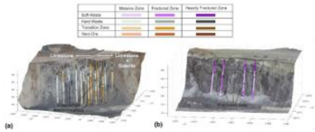
Frédéric Lai, Antoine Beylot, Rafael Navarro, Peter Schimek, Philipp Hartlieb, Daniel Johansson, Pablo Segarra, Celso Amor, Jacques Villeneuve. 2021. *The environmental performance of mining operations: Comparison of alternative mining solutions in a life cycle perspective.* Journal of Cleaner Production,Volume 315, https://doi.org/10.1016/j.jclepro.2021.128030.

Conclusions

- The importance of interdisciplinarity







Goal and scope ⟷ Interpretation

LCI ⟷ Interpretation

LCIA ⟷ Interpretation

- Towards generalisation: which trade-offs in models complexity?

From LCAs applied to specific case studies → To more reliable data available through LCI databases

GaBi Database Content

ecoinvent Centre

European Commission

PEF

Navarro, J., Seidl, T., Hartlieb, P. *et al.* Blastability and Ore Grade Assessment from Drill Monitoring for Open Pit Applications. *Rock Mech Rock Eng* **54,** 3209–3228 (2021). https://doi.org/10.1007/s00603-020-02354-2

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THANK YOU FOR YOUR ATTENTION

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