



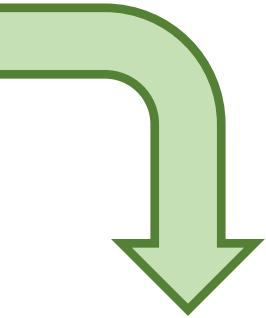
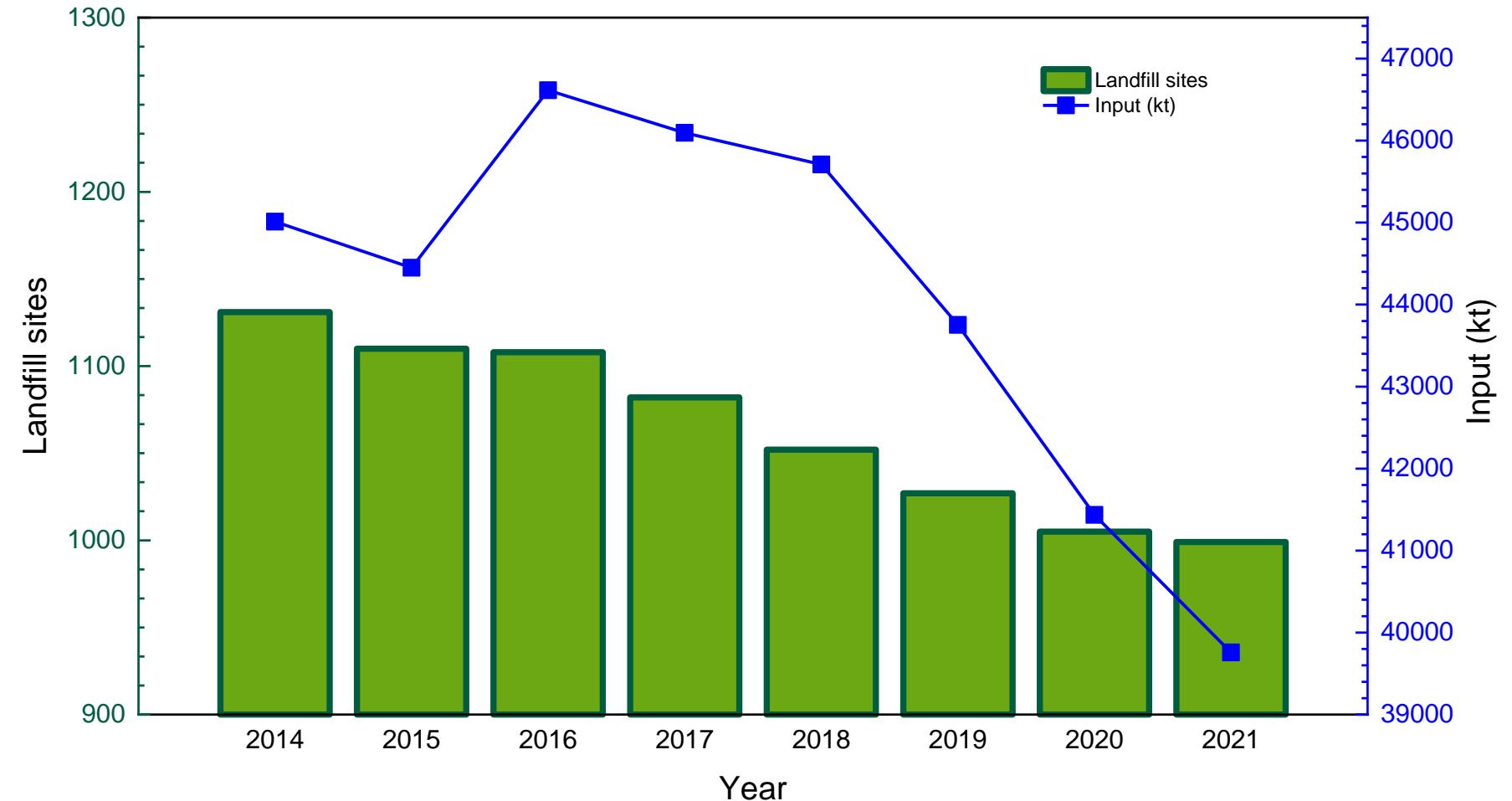
# Anwendung von Nebenprodukten aus Rückständen der Lithiumproduktion

Andreas Neumann, Julia Woskowsky  
& Stefan Stöber

INNOVATIONSFORUM  
RECYCLINGREGION HARZ 2024  
28-29 August 2024 in Wernigerode



## Motivation – Limited capacities for landfilling



Reduce & reuse  
waste,  
safe resources

Zero waste –  
From cradle to cradle

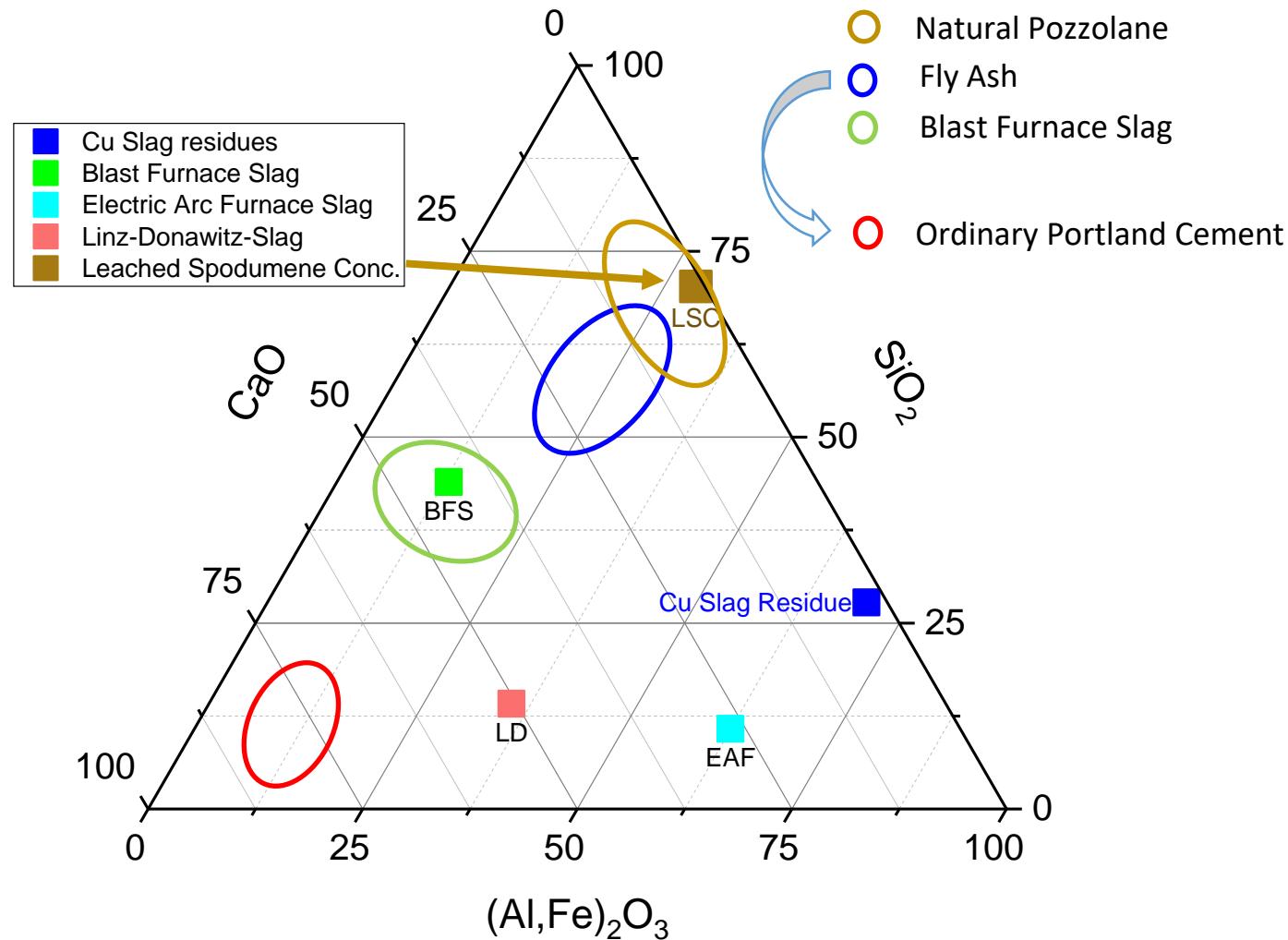
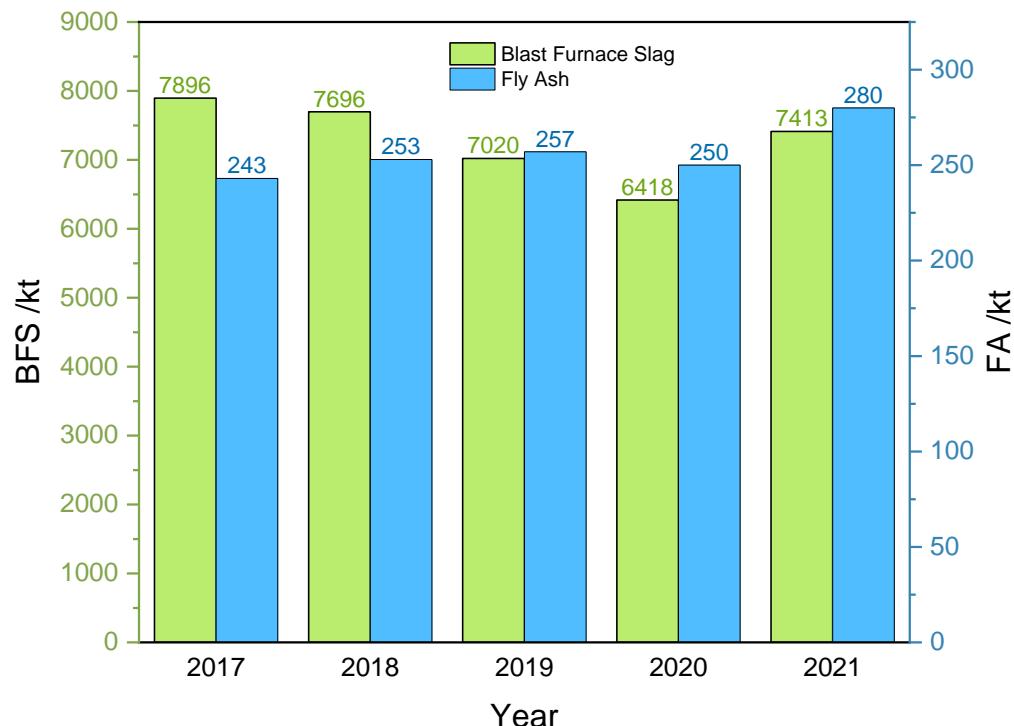
Quelle: Bundesamt für Statistik



Lowering the CO<sub>2</sub> footprint by cement blending - low clinker factor, i.e. use of SCMs

Forthcoming challenges:

- Phase out of coalfiring plants -> Lack of fly ash
- Transformation of steel industry – Lack of BFS



Source: VDZ



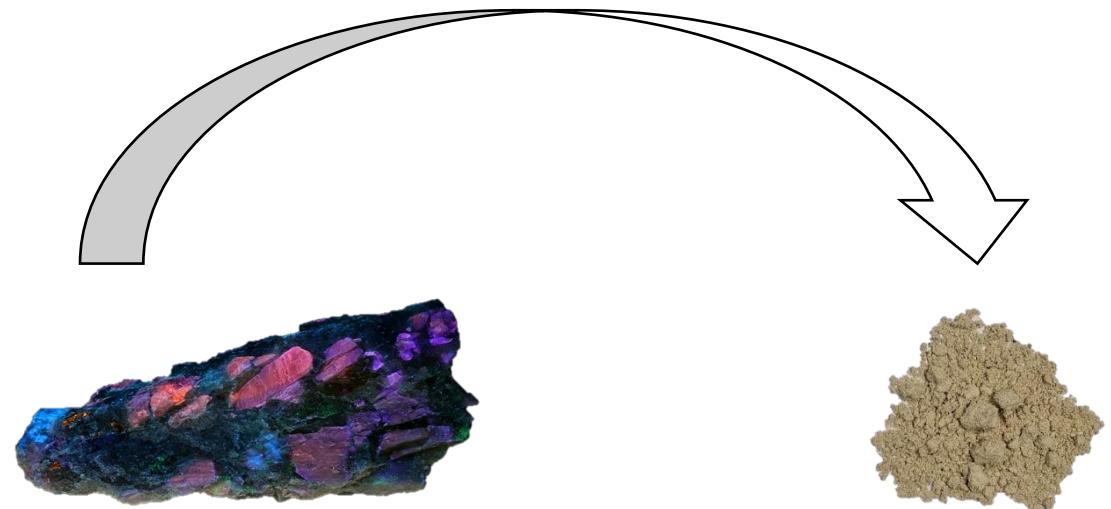
Lithium – what are the main resources?

1) Brine processing



2) Lithium extraction from hard rock mineral spodumene  $\text{LiAl}[\text{Si}_2\text{O}_6]$

Benefits from Leach residue of Li processing



Resource mineral:  
Spodumene  $\text{LiAl}[\text{Si}_2\text{O}_6]$

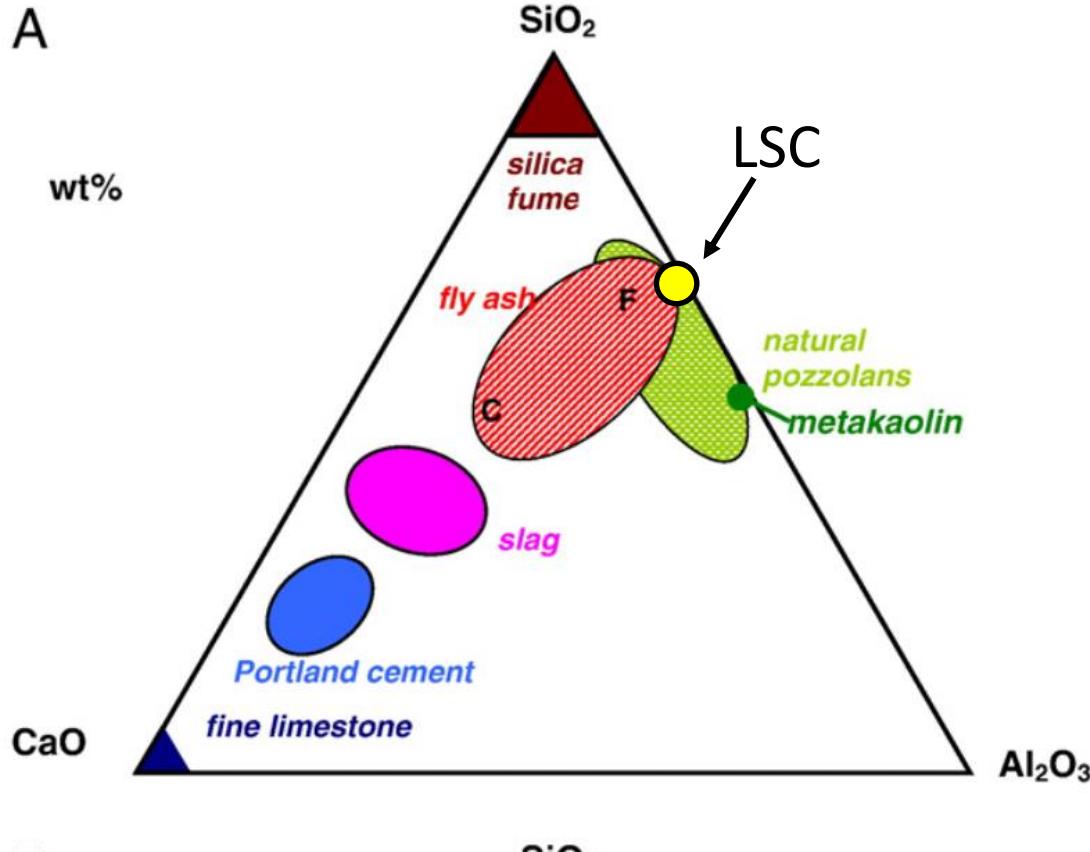
<https://www.vastavalo.net/spodumeeni-lithium-spodumene-lithium-suomalainen-mineraali-spodumeeni-642913.html>

Reuse of Leached  
Spodumene concentrate  
LSC  $\text{HAl}[\text{Si}_2\text{O}_6]$  in Ordinary  
Portland Cement (OPC)

<https://www.mining.com/chinas-central-iron-ore-buyer-may-replicate-success-in-lithium/>

# Leached Spodumene Concentrate (LSC)

Lothenbach et al. (2011) – diagram of cementitious material



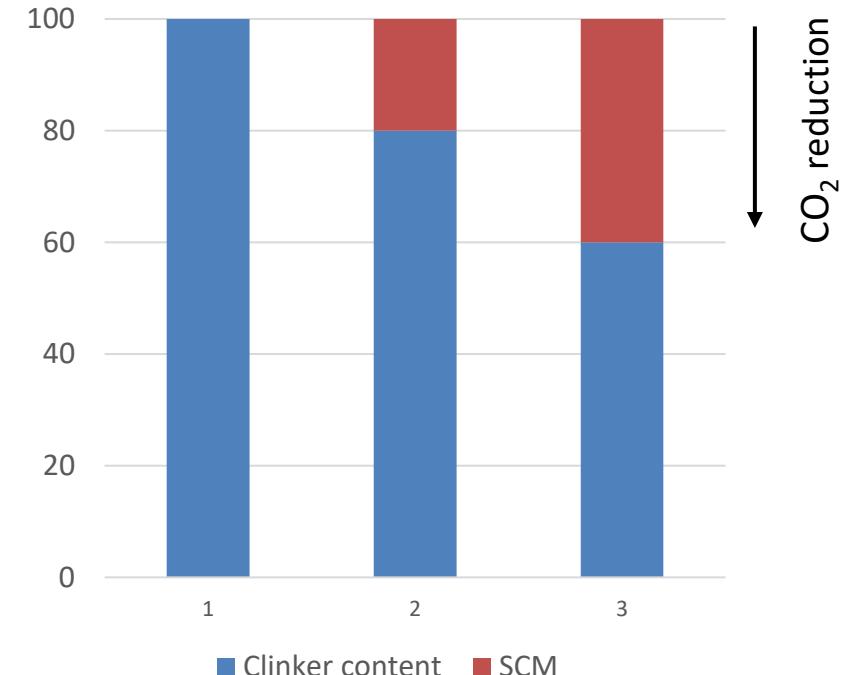
- LSC similar composition as natural pozzolans and fly ash
- used as additives (SCM) in cement
  - reduction of CO<sub>2</sub> emissions
  - can improve the strength of OPC
- does LSC behave similarly?





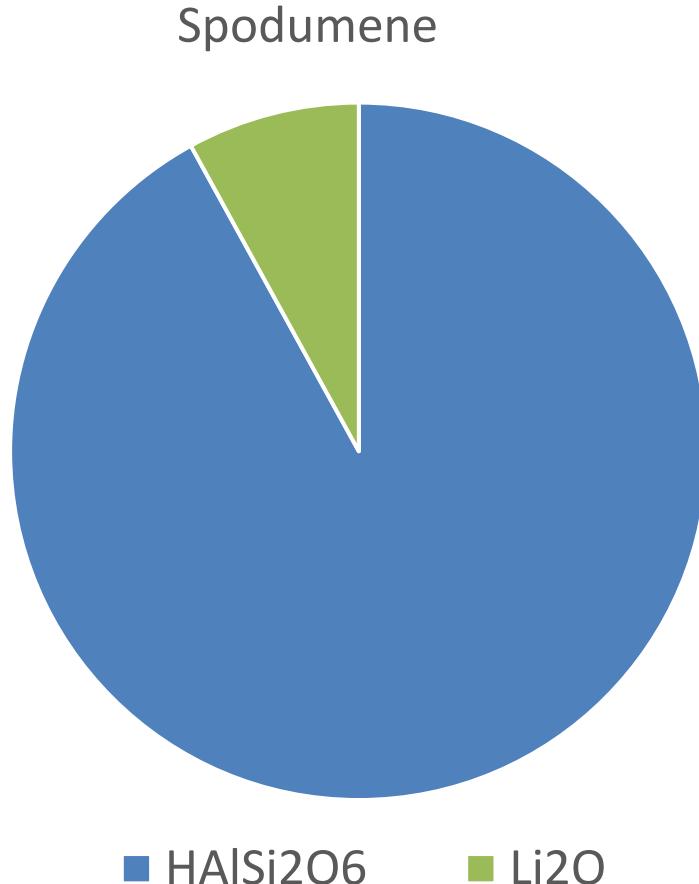
## OPC - ordinary Portland cement (100% clinker)

- 600-900 kg CO<sub>2</sub>/t (~ 5-7% CO<sub>2</sub> global emission)
- CaCO<sub>3</sub> → CaO + CO<sub>2</sub>
- improving process technologies
- other raw materials
- *Cements with a low clinker content*
  - partial substitution with SCM



**Materials that can react with the clinker and water – pozzolanic properties!**

Otherwise, the stability of the cement decreases without formation of CSH-phases!

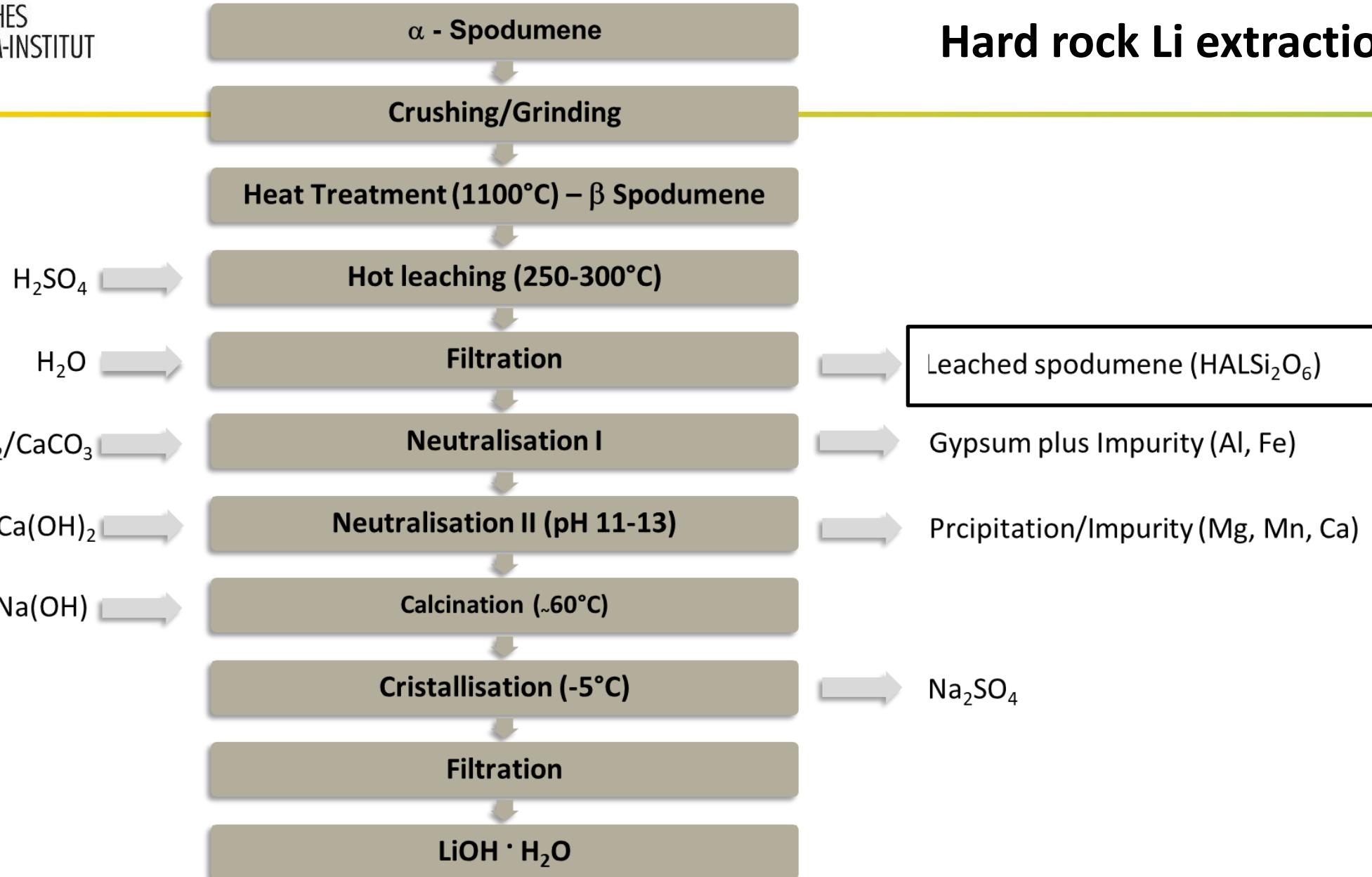


**1 ton**  
LiOH·H<sub>2</sub>O

**8-10 tons**  
leached spodumene  
concentrate (LSC)

- Electric cars
- Mobile phones
- Laptops
- Digital cameras
- ....
- Landfills
  - non-toxic
  - expensive
  - necessary?

# Hard rock Li extraction

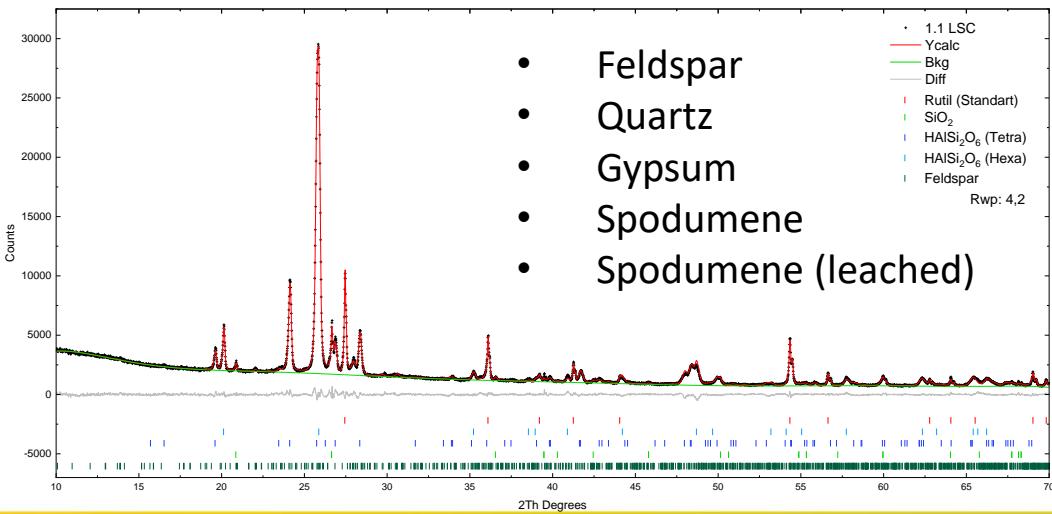


# Leached Spodumene Concentrate (LSC)

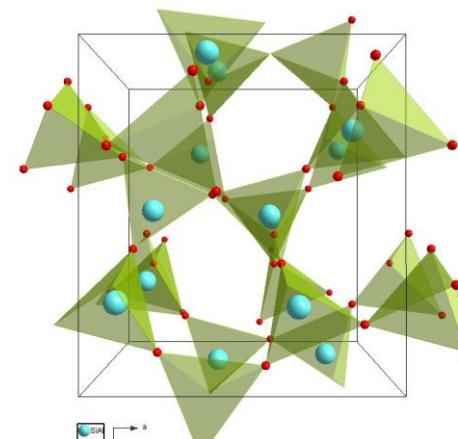
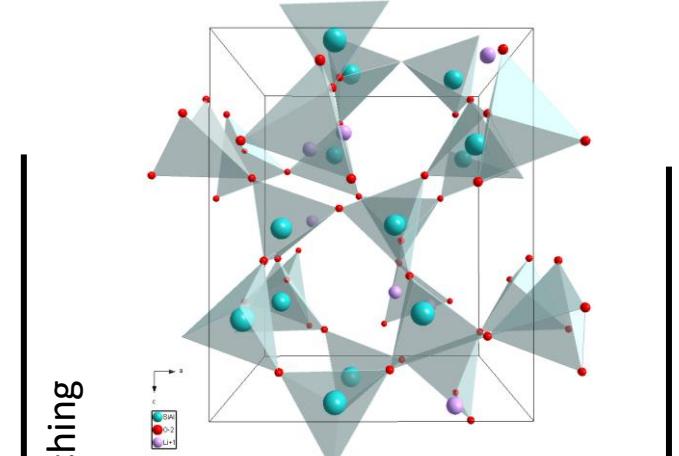
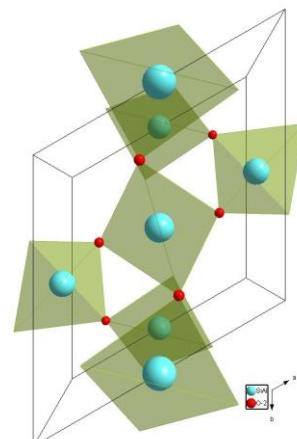
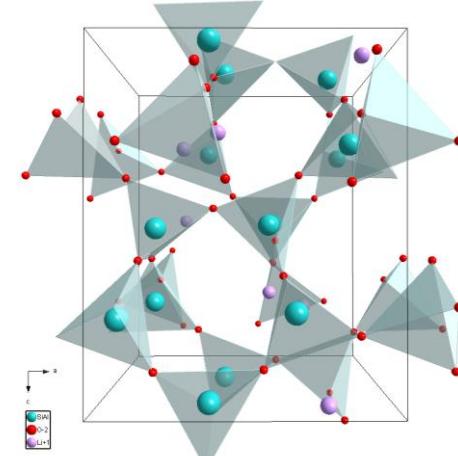
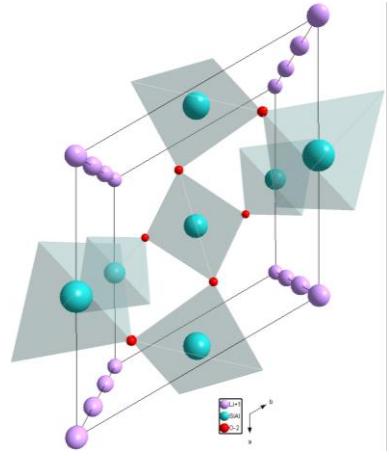
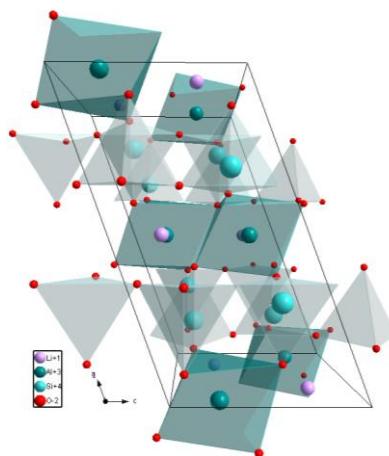


- Chemistry ✓
- Mineralogy ?

X-ray diffraction



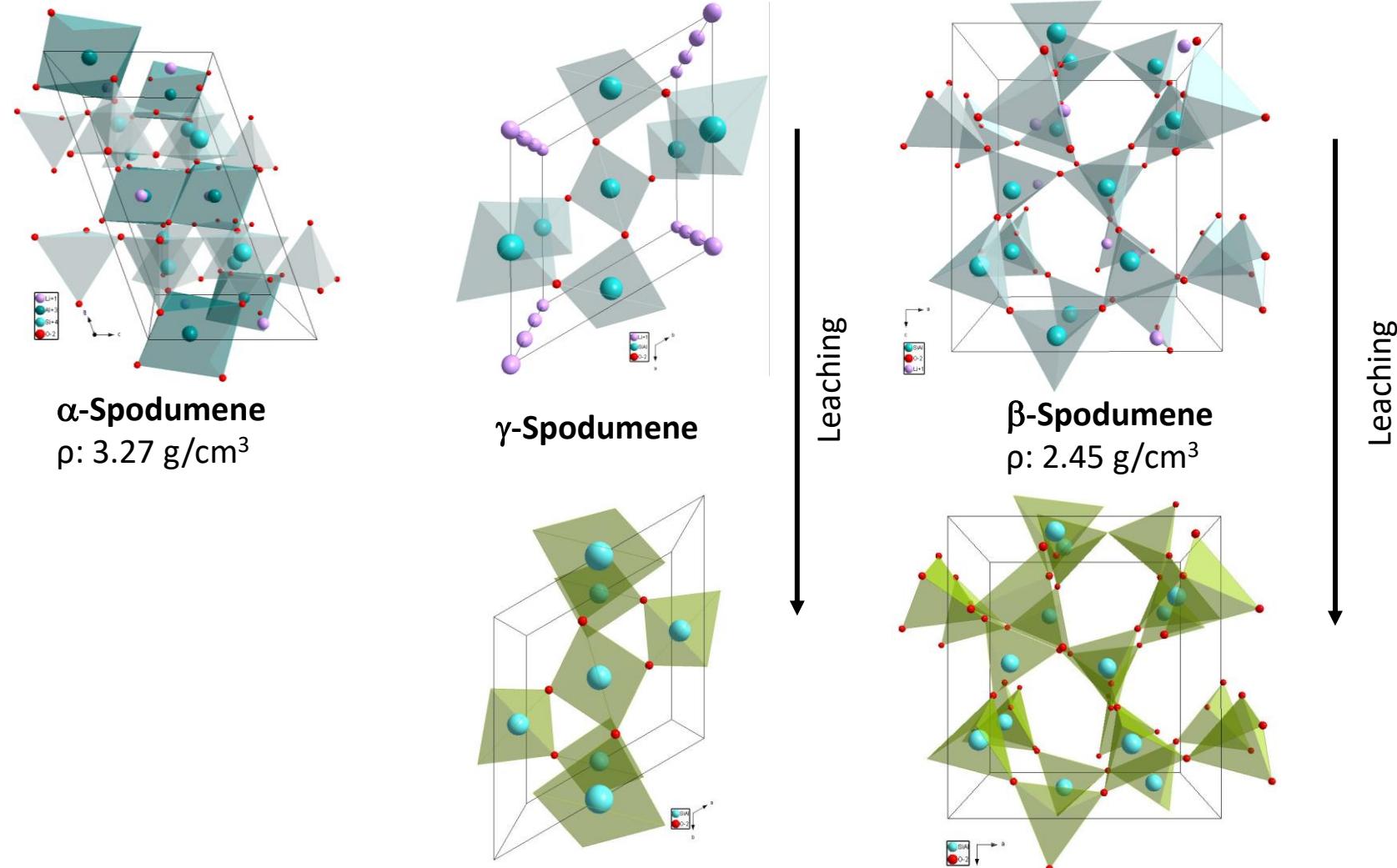
- Feldspar
- Quartz
- Gypsum
- Spodumene
- Spodumene (leached)



# Leached Spodumene Concentrate (LSC)

- Chemistry ✓
- Mineralogy ?

newscientist.com



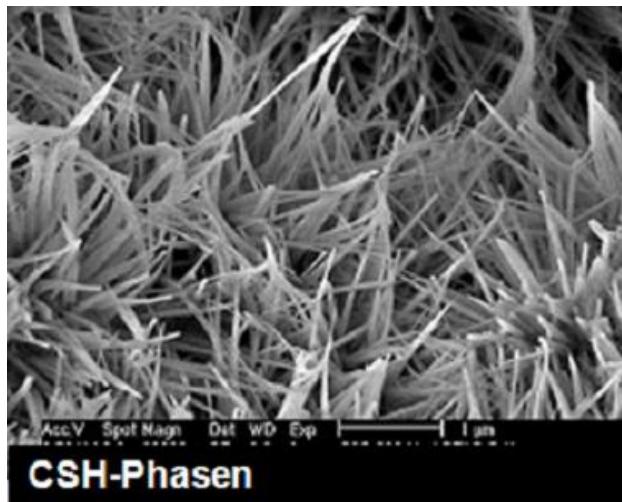
Similar but not the same!

# LSC - Properties in cement

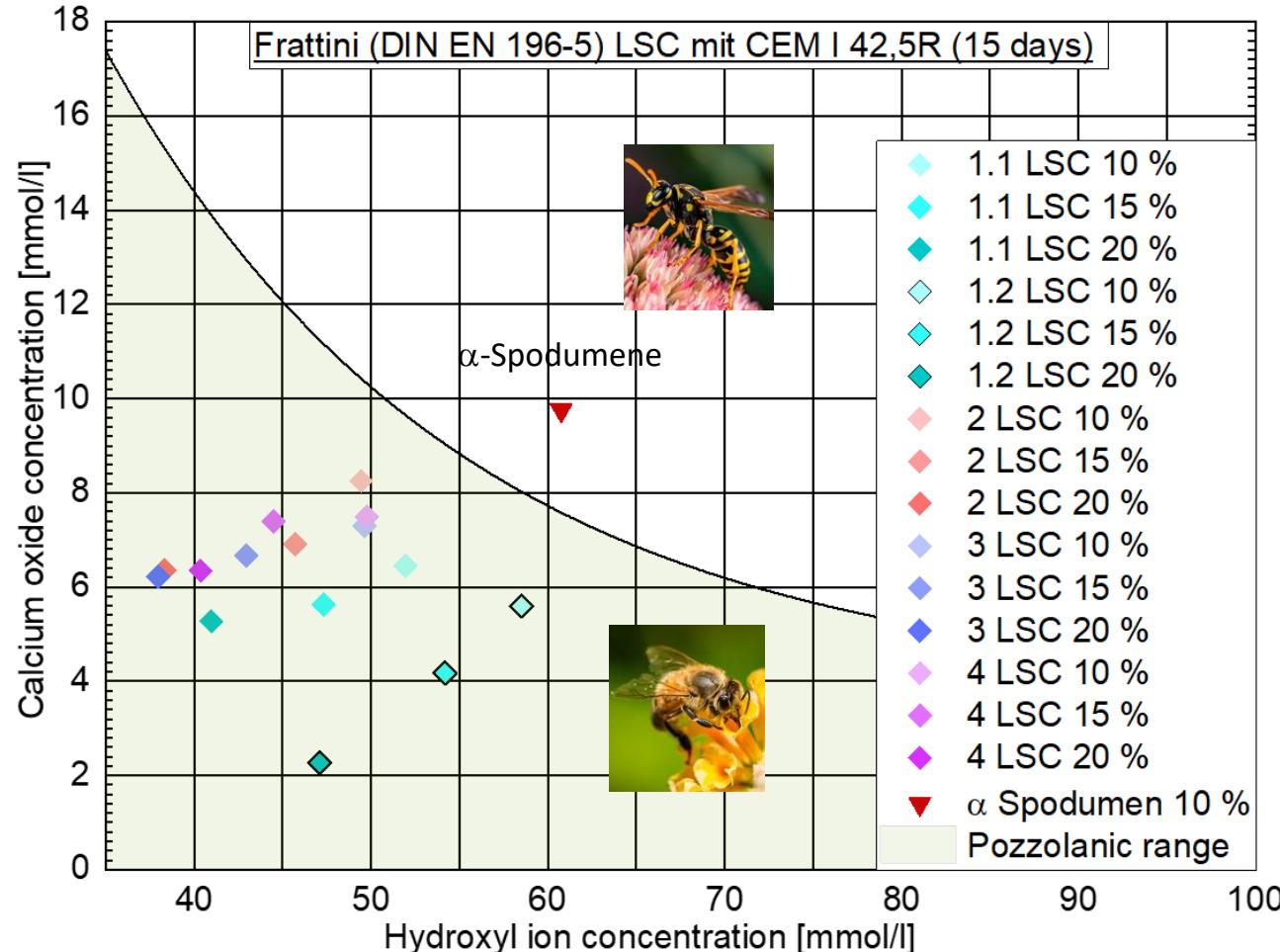
- Chemistry ✓
- Mineralogy ?
- **Reactivity**

Goal: Formation of CSH phases ( $\text{CaO}-\text{SiO}_2-\text{H}_2\text{O}$ )

- CSH:
- Needle-shaped minerals
  - grow into pores
  - contribute to strength

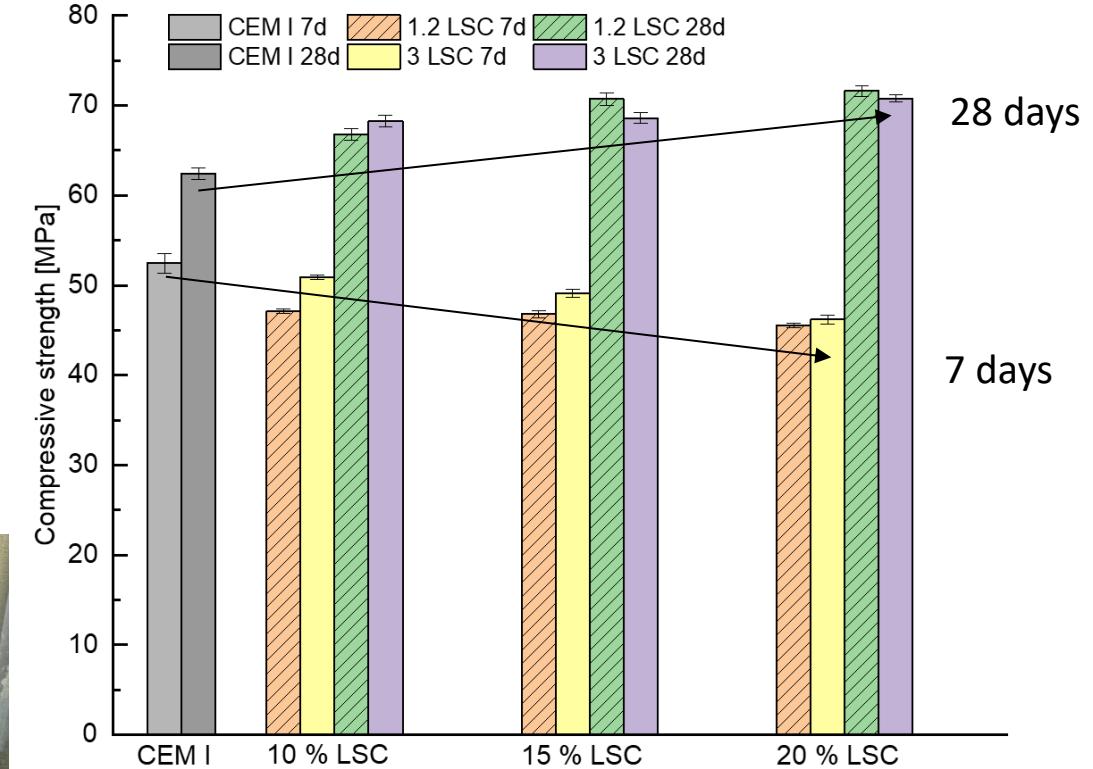
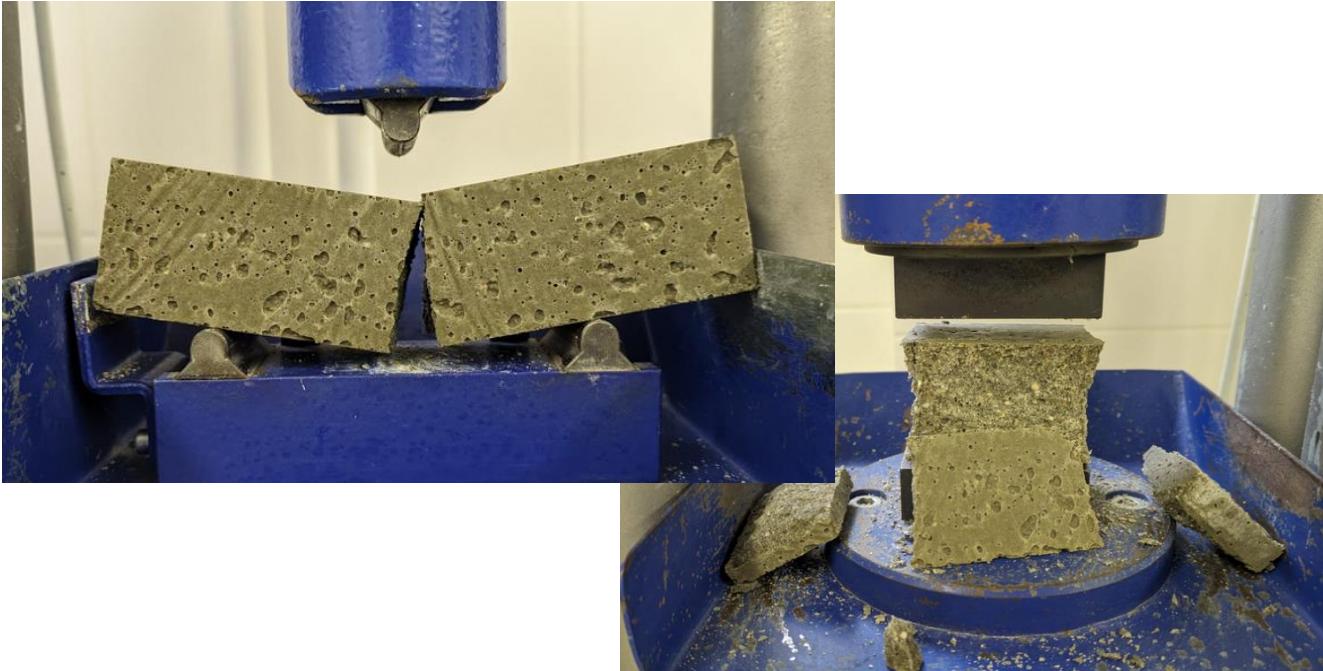


[baustoffingenieurwissenschaft.wordpress.com](http://baustoffingenieurwissenschaft.wordpress.com)



# LSC - Properties in cement

- Chemistry ✓
- Mineralogy ✓
- Reactivity ✓
- Mechanical strength in cement



- Long-term stability is better with LSC
- LSC behaves similarly to natural pozzolan or fly ash



LSC is generally suitable

Woskowski et al. 2024



Julia Woskowski, Andreas Neumann, Hans Roggendorf, Ralf Wehrspohn, Stefan Stöber,  
Properties of low sulfur leached spodumene as supplementary cementitious material in ordinary Portland cement,  
Construction and Building Materials, Volume 438, 2024,  
DOI:10.1016/j.conbuildmat.2024.137096

→ Further tests must follow

→ Suitability is not yet a guarantee

## Standardisation: DIN EN 197-1

Defines cement types

- Chemical composition
- raw materials!

**To use new additives (SCM),  
the standardization must also be adapted so that  
they can be used!**

Cement type	Clinker (%)	Slag (%)	SCM (%)	Limestone (%)
Portland limestone cement	CEM II A-L	80 - 94	-	-
	CEM II B-L	65 - 79	-	-
Portland composite cement*	CEM II A-M	80 - 94	6 - 20	
	CEM II B-M	64 - 79	21 - 35	
Blast-furnace cement	CEM III/A	35 - 64	35 - 65	-
	CEM III/B	20 - 34	66 - 80	-
	CEM III/C	5 - 19	81 - 95	-
Pozzolanic cement**	CEM IV/A	65 - 89	-	11 - 35
	CEM IV/B	45 - 64	-	36 - 55
Composite cement***	CEM V/A	40 - 64	18 - 30	18 - 30
	CEM V/B	20 - 38	31 - 50	31 - 50

\* Combination of slag, silica fume, fly ash, pozzolans, burnt shale and limestone

\*\* Combination of silica fume, fly ash and pozzolan

\*\*\* Combination of slag, low-calcium fly ash and pozzolan

Pozzolans: Natural and reactive material

LSC: Natural and reactive material *but chemically modified*

# Acknowledgments



**SCHWENK**

Baustoff leben



**knauf**

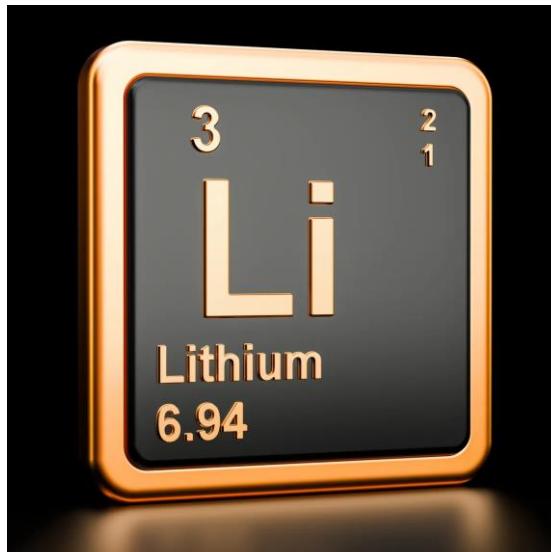


**Aurubis**

**ZINNWALD  
LITHIUM**



# Thank you for your attention!



4. Lithiumdays 25.-26.11.2024 in Iphofen  
[www.lithiumdays.com](http://www.lithiumdays.com)

