Funded by
the European Union

GA n°101138112

COST-EFFECTIVE PROCESSING AND REFINING OF LITHIUM INTO LITHIUM HYDROXIDE FROM STRATEGIC EUROPEAN MULTI-MINERAL LITHIUM HARD-ROCK PROJECTS

Thomas Abo Atia, Lien Lemmens, Carlos Arias Quintero, Rayco Lommelen, Peter Tom Jones, Koen Binnemans (KUL)

Prometia, 12th Scientific Seminar, Naples, 26/11/2025

WHAT DOES LITHOS FOCUS ON?

EU domestic processing & refining of Li

by expanding and tailoring the existing flowsheet, which was developed for regular-grade spodumene ores, so that:

1. the cut-off grade for spodumene ores is reduced, resulting in larger Li reserves, while
2. allowing the commercialisation of lower-grade pegmatite and RMG deposits.

LITHOS triggers innovations along the value chain – mineral processing, concentrate pre-treatment & hydrometallurgical refining – making it possible to deal with different levels and types of impurities in non-spodumene Li minerals (lepidolite & petalite).

LITHOS'S META-OBJECTIVE

- Unleash Europe's full Li-hard-rock ore potential to become self-sufficient by 2030–35 in terms of made-in-Europe $LiOH \cdot H_2O$.
- LITHOS has a responsible mining and refining approach by giving specific attention to closing the water loops in the mineral processing and by reducing the overall CO_2 emissions.

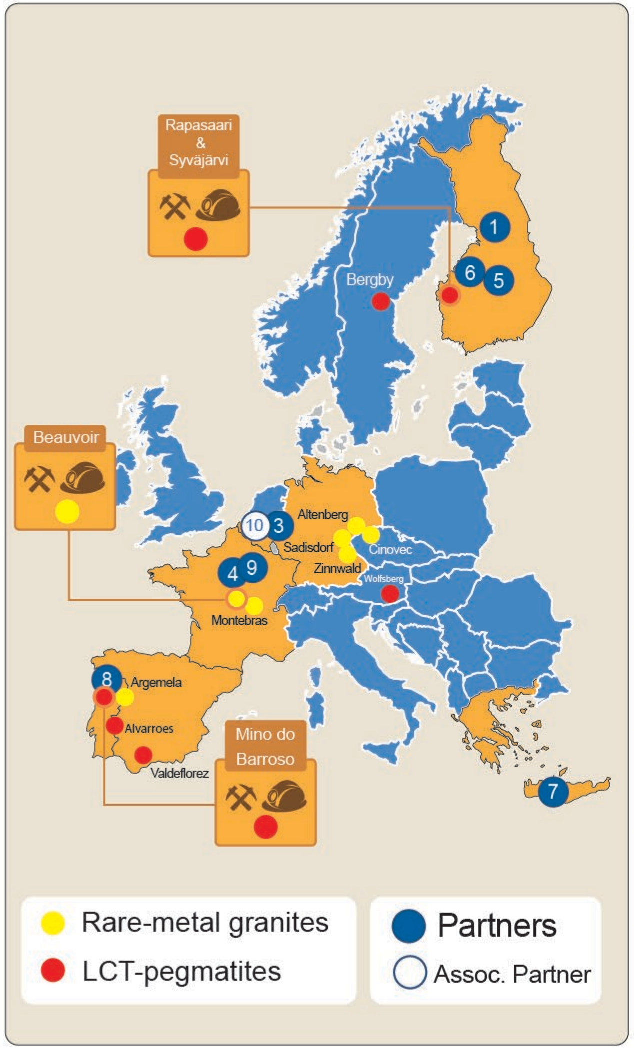
8.8Mt **Li_2O** unleashed potential

90% **less** water consumption

50% **Less** CO_2 emissions *

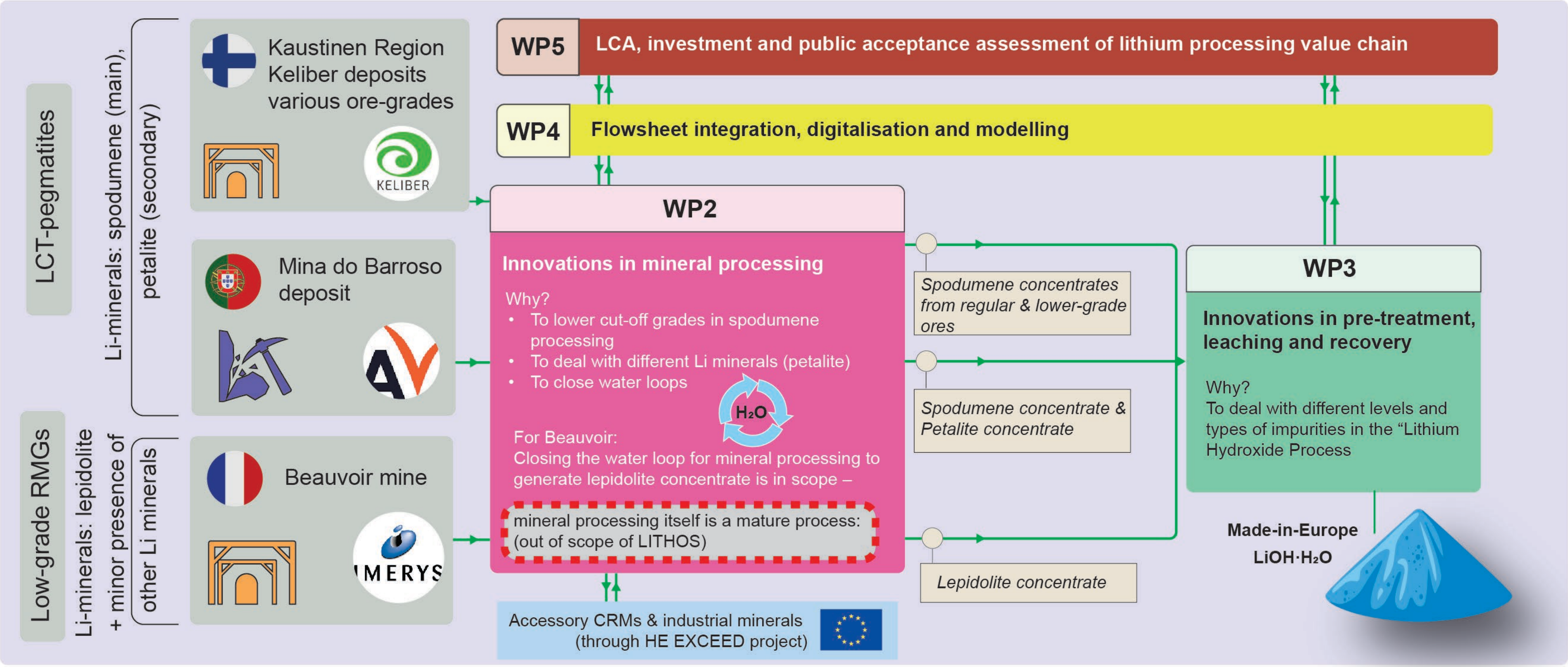
* compared to today's benchmark (production of spodumene concentrate in Australia & refining in China).

LITHOS CONSORTIUM

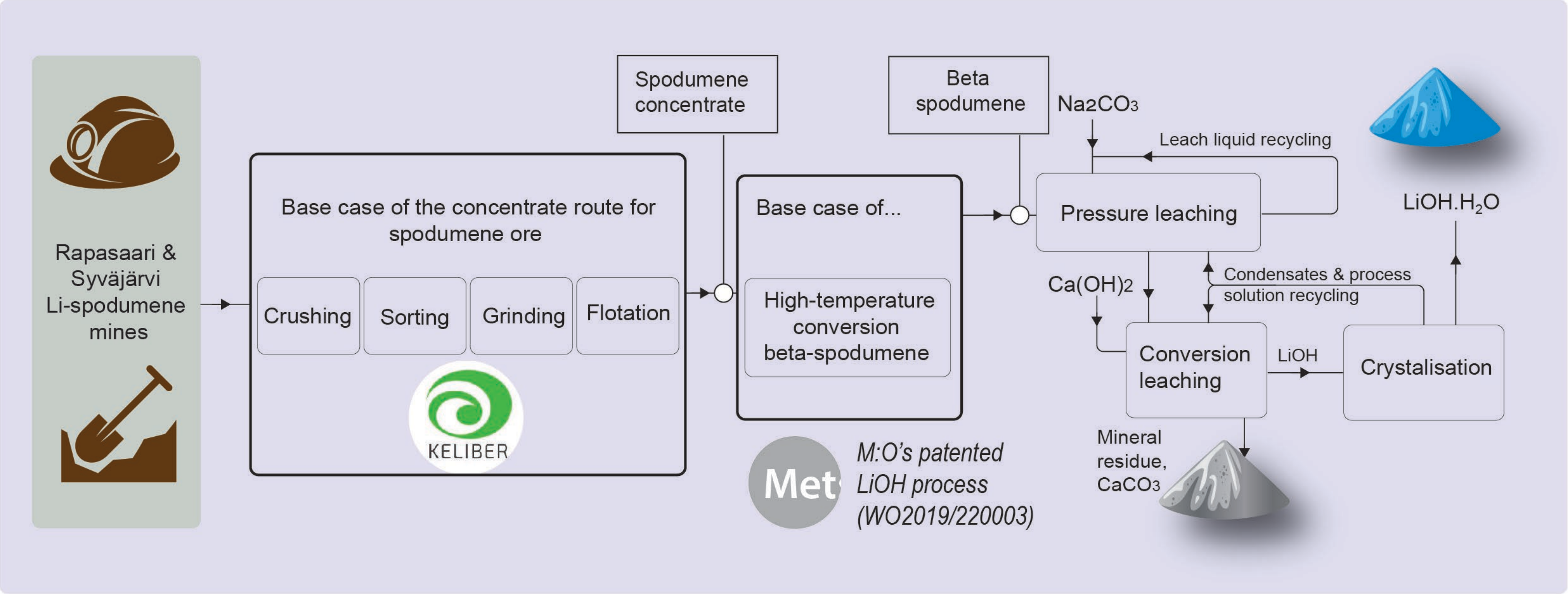


1 [VTT]	Teknologian Tutkimuskeskus VTT OY	
2 [FMG]	Suomen Malmijalostus OY	
3 [KUL]	KU Leuven	
4 [BRGM]	Bureau de Recherches Geologiques et MIniers	
5 [M:O]	Metso Outotec Finland OY	
6 [Keliber]	Keliber Technology OY	
7 [TUC]	Polytechneio Kristis	
8 [Savannah]	Savannah Lithium Limitada	
9 [Imerys]	Imerys SA	
10 [EUROMINES]	European Association of Mining Industries. Metal Ores / Industrial Minerals AISBL	

LITHOS FOCUSES ON 3 "STRATEGIC" LI-MINE/DEPOSIT CASE-STUDIES.



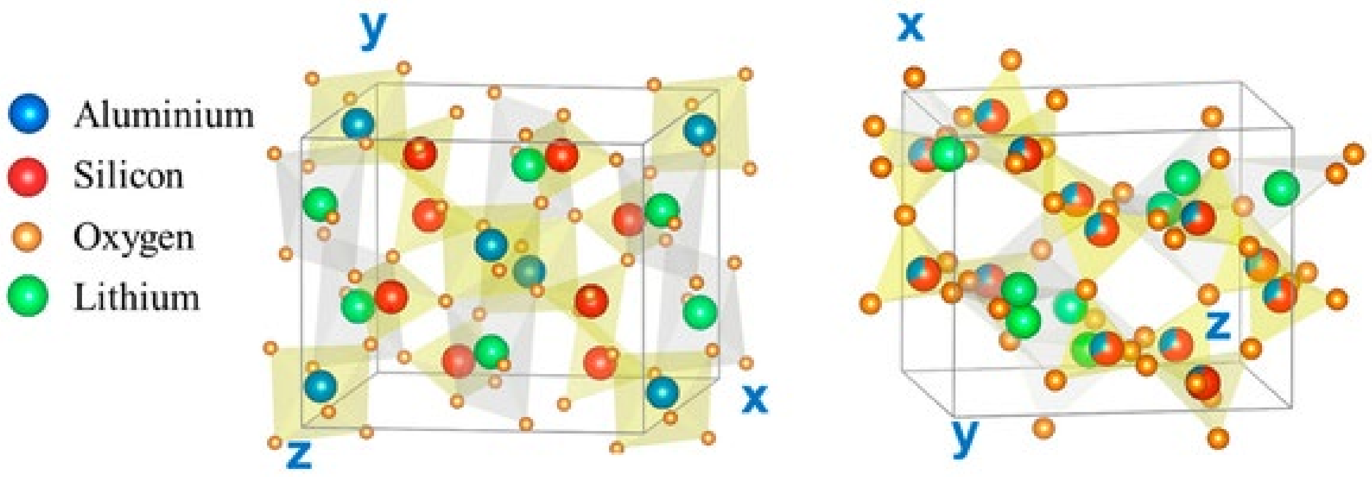
KELIBER & METSO:OUTOTEC (SIMPLIFIED) FLOWSHEET FOR PROCESSING REGULAR SPODUMENE ORE INTO LIOH·H_2O.



WP3 INNOVATIONS IN PRE-TREATMENT, LEACHING AND RECOVERY

- Keliber/M:O process application to other European ores?
- Integration of novel/alternative technologies into the Keliber/M:O process?
  - Conversion of the concentrates to accessible Li sources

α-spodumene to β-spodumene (T= 1100 °C)



(a) α-spodumene (b) β-spodumene

Sustainability **2024**, *16*(19), 8513; https://doi.org/10.3390/su16198513

WP3 INNOVATIONS IN PRE-TREATMENT, LEACHING AND RECOVERY

- Mechanochemistry/Mechanical activation as an alternative to thermal treatments
- Antisolvent crystallisation as an alternative to evaporative crystallisation of $LiOH \cdot H_2O$

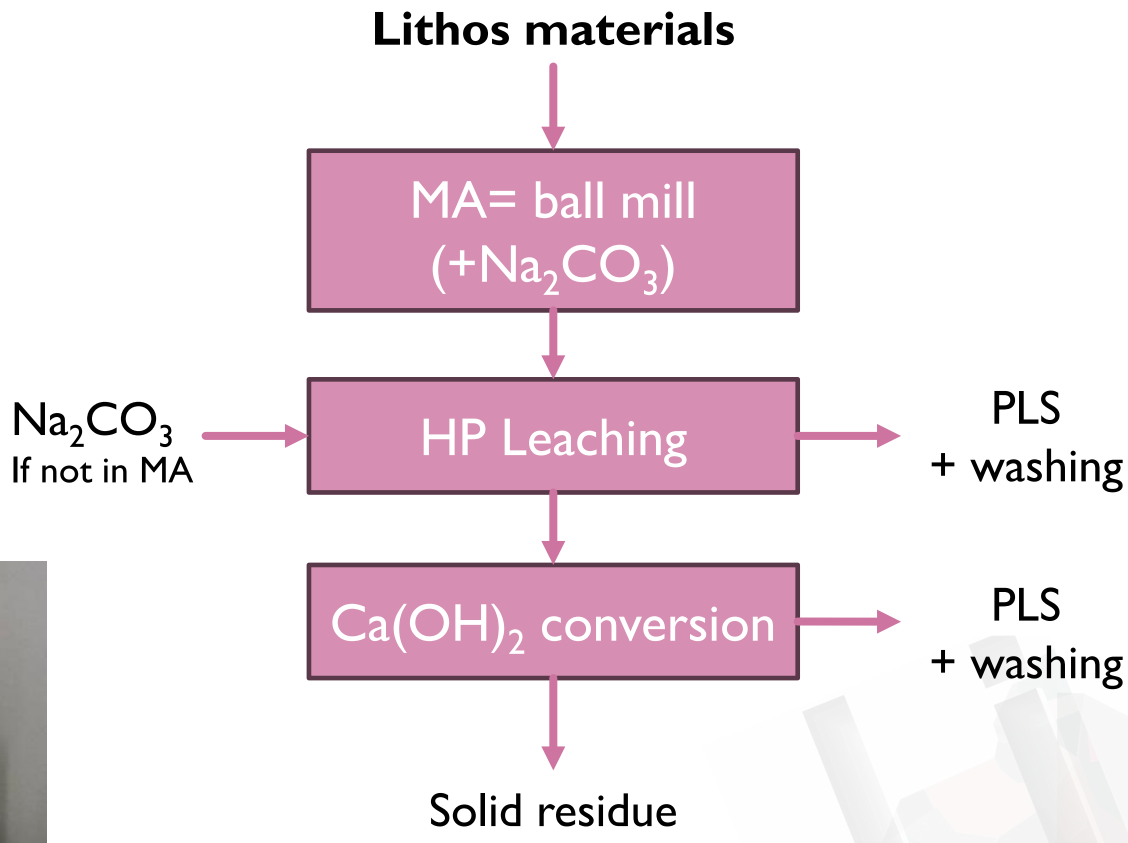
MECHANICAL-ACTIVATION PRE-TREATMENT

Spodumene, Lepidolite, and Petalite

- Ball-milling E max (w and w/o Na_2CO_3)
- HP leaching
- Conversion ($Ca(OH)_2$)

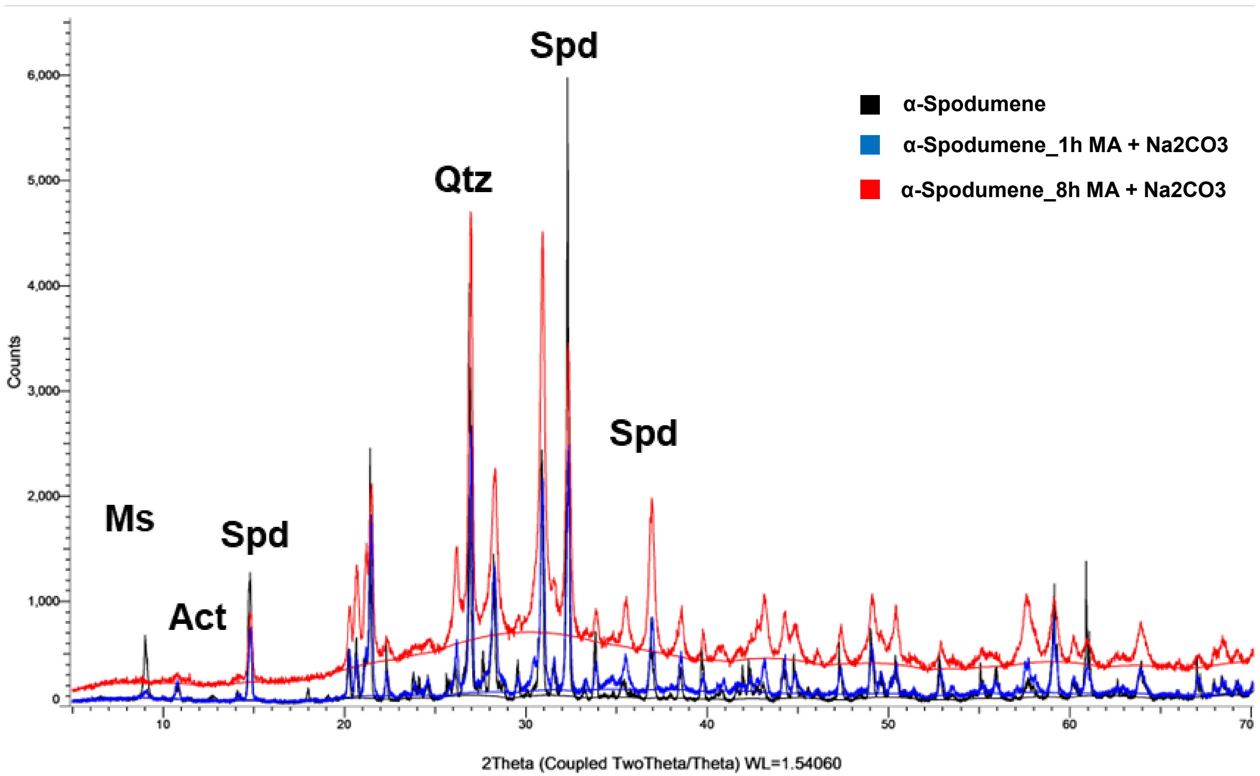
Ball-milling
1400 rpm

HP reactors
Hastelloy



MECHANICAL-ACTIVATION PRE-TREATMENT

α-Spodumene

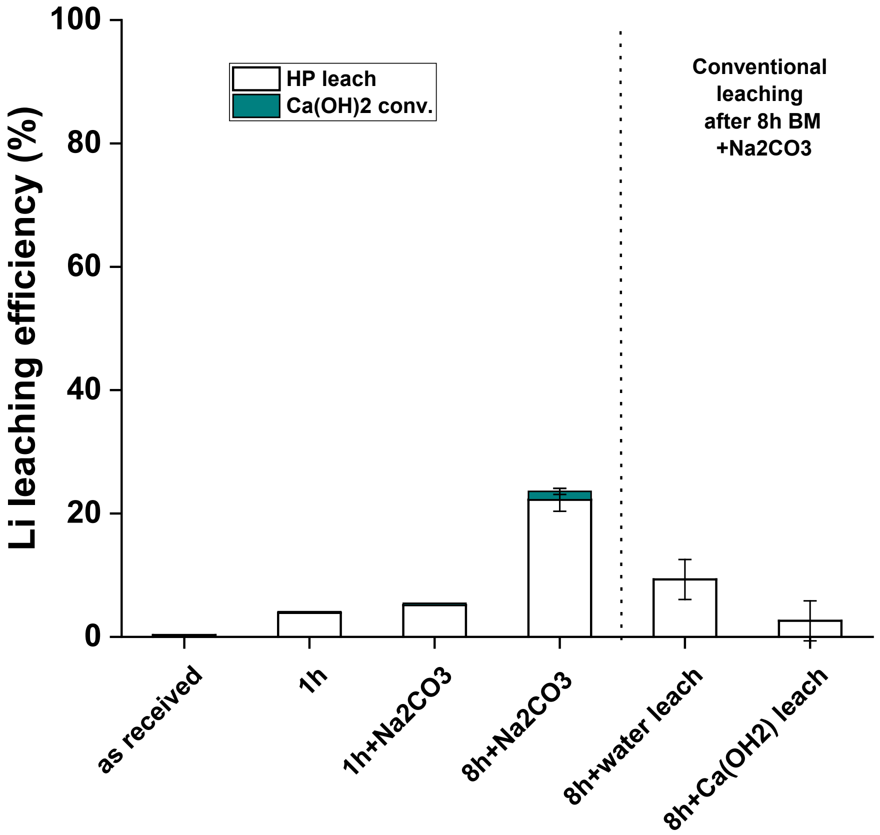


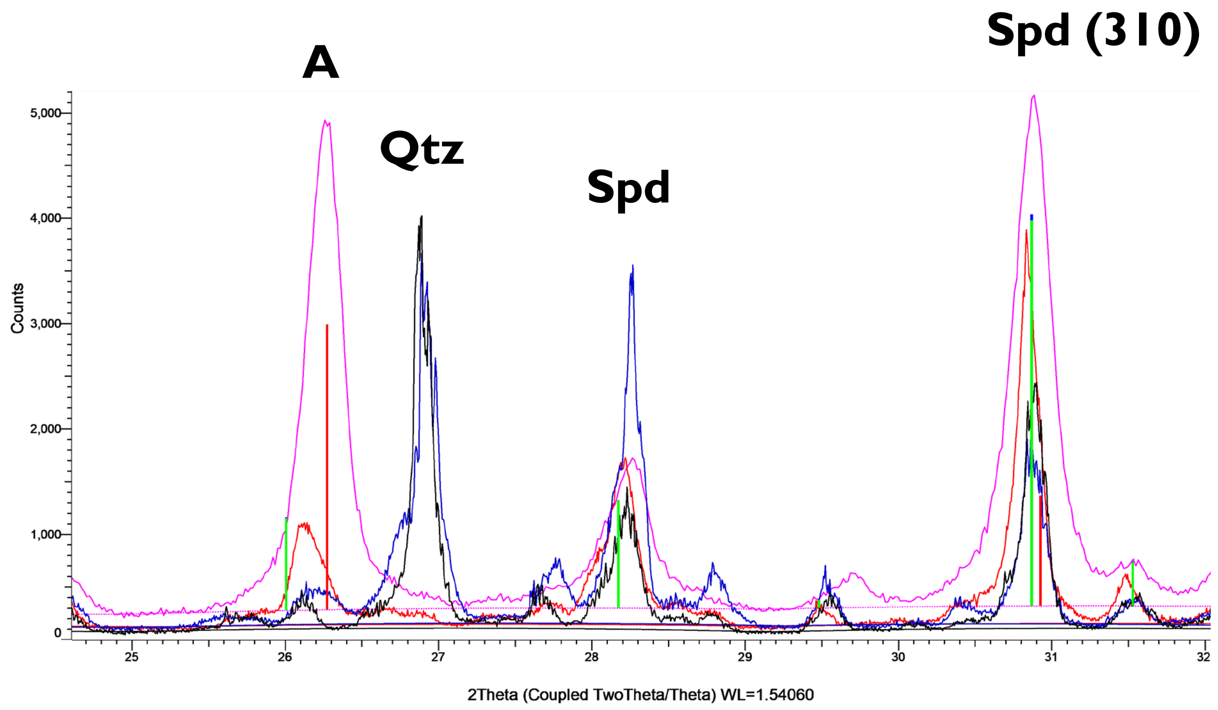
Ms = $KAl_2(Si_3Al)O_{10}(OH,F)_2$
Act = $Ca_2(Mg, Fe)_5Si_8O_{22}(OH)_2$
Spd = $LiAlSi_2O_6$
Qtz = SiO_2

- **Ball mill with Na_2CO_3 1h 10% mass loss, 8h 50% mass loss**
- **Possible cement/pozzolanic reactions => Actinolite (Ca). Strong adhesion walls/balls**

MECHANICAL-ACTIVATION PRE-TREATMENT

α-Spodumene



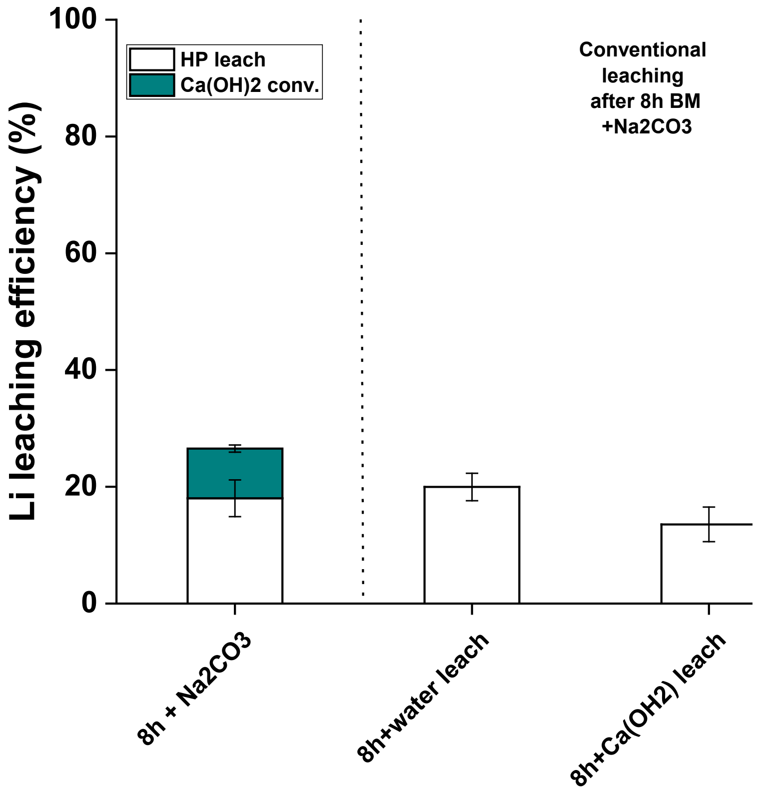


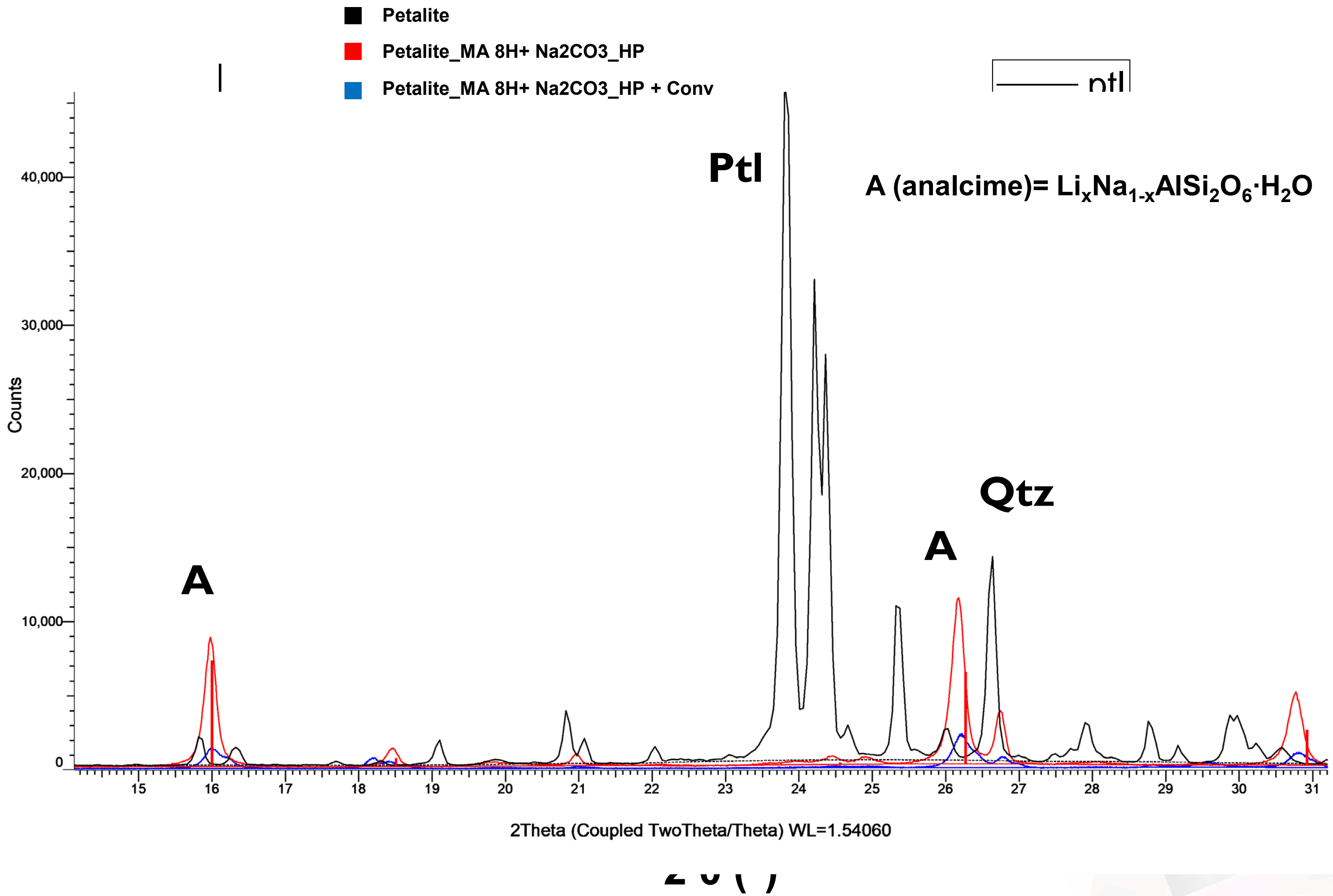
Spd = $LiAlSi_2O_6$
Qtz = SiO_2
A (analcime)= $Li_xNa_{1-x}AlSi_2O_6 \cdot H_2O$

$LiAlSi_2O_6(s) + Na_2CO_3 + H_2O \rightarrow Li_2CO_3\ (s) + NaAlSi_2O_6 \cdot H_2O\ (s)$

MECHANICAL-ACTIVATION PRE-TREATMENT

- **Petalite**

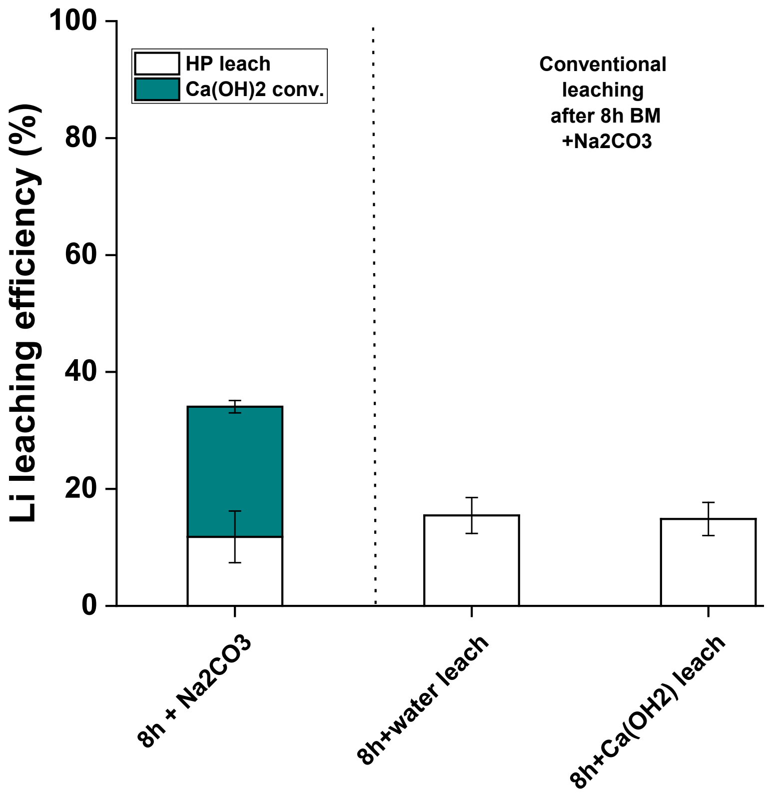


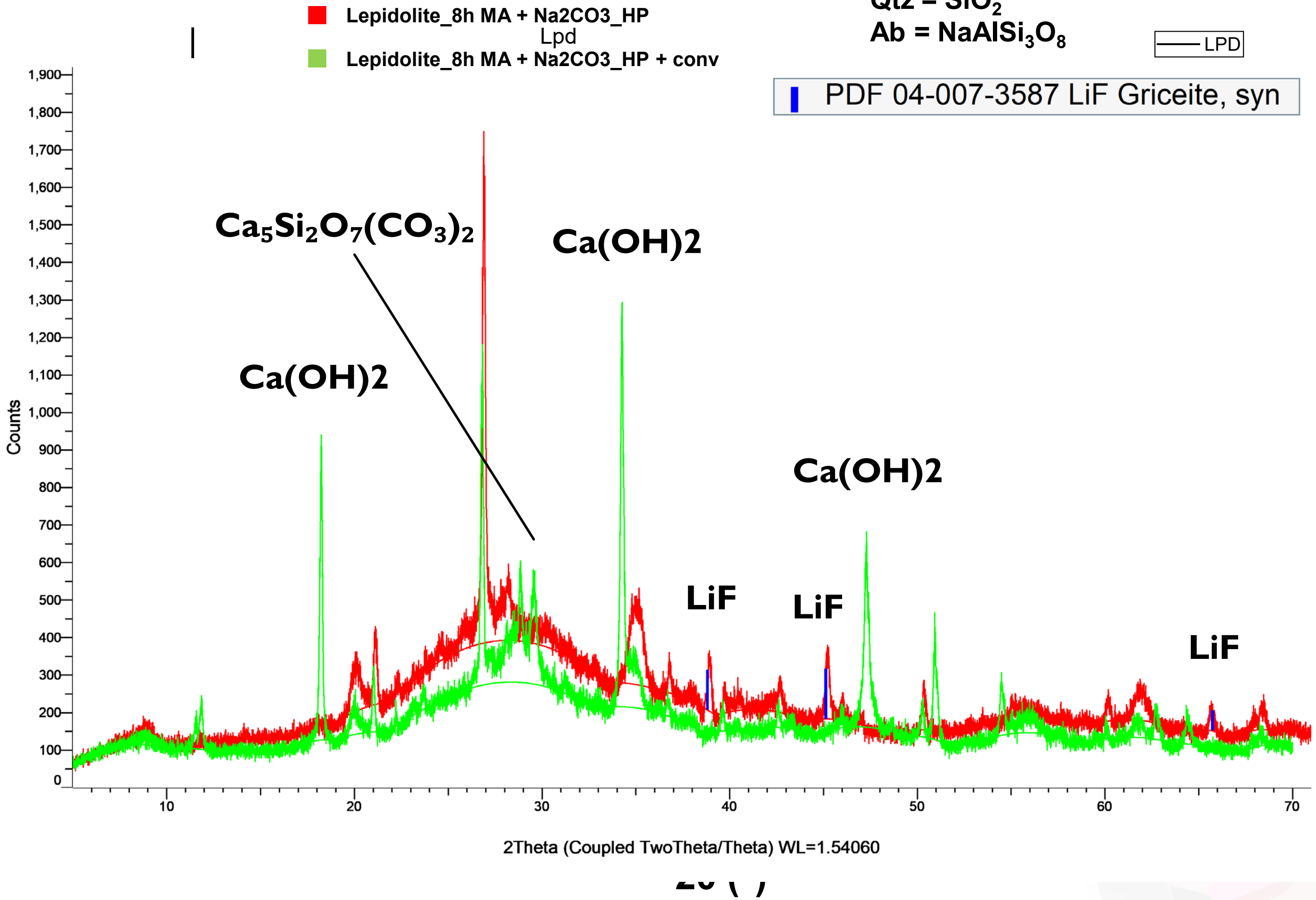


MECHANICAL-ACTIVATION PRE-TREATMENT

- **Lepidolite conc.**

Ms = $KAl_2(Si_3Al)O_{10}(OH,F)_2$
Kao = $Al_2Si_2O_5(OH)_4$
Lpd = $K(Li,Al)_3(Al, Si,Rb)_4O_{10}(F,OH)_2$
Qtz = SiO_2
Ab = $NaAlSi_3O_8$





- **LiF could be converted to LiOH**

MECHANICAL-ACTIVATION

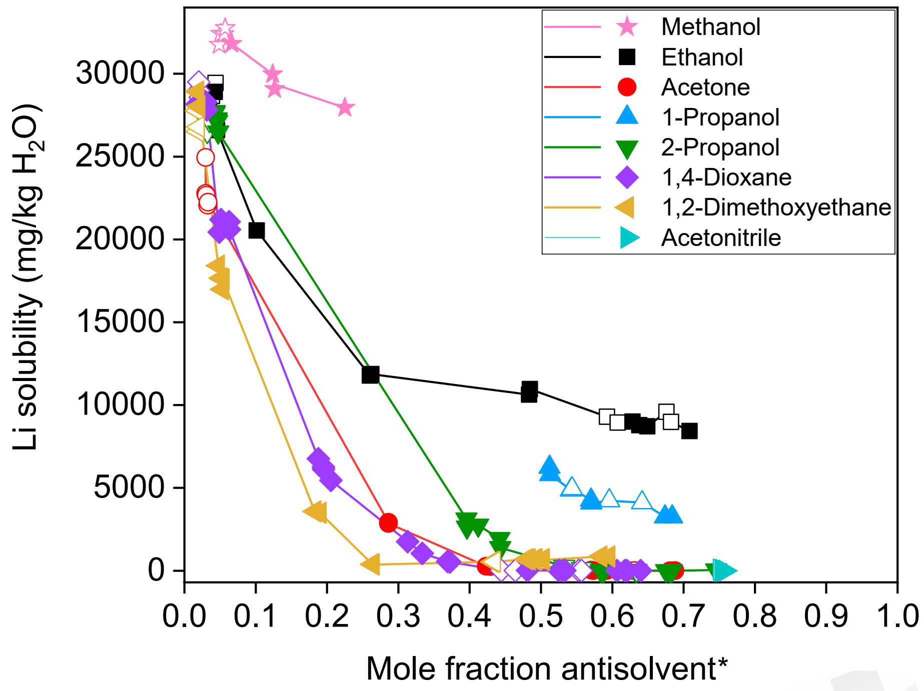
Prelimonary conclusions on mechanical activation

- **α-Spodumene**
  - possible cement reactions to be avoided (time, hydration, etc.)
  - test **β-spodumene MA**
- **Petalite**
- **Lepidolite conc.**
  - **Qtz not reactive as spod and Ptl**

- **Test MA with excess Na_2CO_3 (+ water)**
- **See if MA could decrease the dehydroxylation/conversion temperature**

ANTISOLVENT CRYSTALLISATION OF $LiOH \cdot H_2O$

- ## Key Findings:
  - <u>Isopropanol is the most promising</u>
  - Acetone: Low LiOH solubility but reacts with LiOH
  - THF and acetonitrile: Results in two liquid phases
  - 1-Propanol: Results in two liquid phases at lower mole fractions
  - Dimethoxyethane and Dioxane: not sustainable



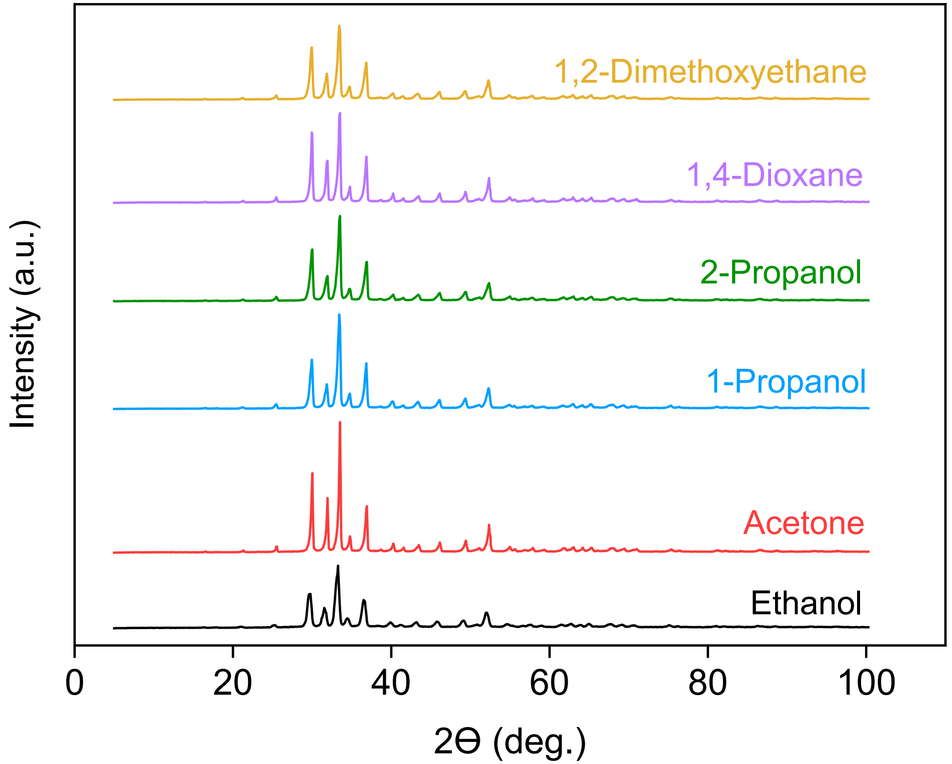
Open symbols: isothermal dissolution method
closed symbols: precipitation method

- ## Next steps
  - Investigate the effect of impurities (Na, K, others)
    - Investigate the morphology at different conditions

*Mole fraction of antisolvent at equilibrium, calculated as moles of antisolvent / (moles of LiOH + moles of antisolvent + moles of water)

ANTISOLVENT CRYSTALLISATION OF $LiOH{\cdot}H_2O$

- XRD and TGA: Confirmed $LiOH{\cdot}H_2O$ formation, no significant Li_2CO_3 formation
- Acid-base titration: No significant Li_2CO_3 formation



XRD diffractograms of crystals obtained with different antisolvents at an O/A-ratio of 2/1. All diffraction peaks match the reference pattern of $LiOH{\cdot}H_2O$, indicating its consistent formation regardless of antisolvent type. Identical phase formation was observed across all investigated O/A ratios. Methanol: no crystals; THF & acetonitrile: 2 liquid phases

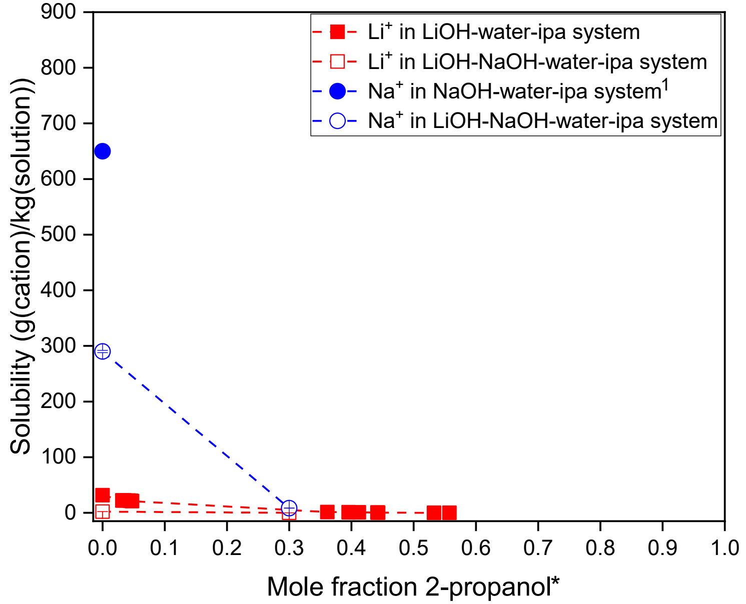
ANTISOLVENT CRYSTALLIZATION OF LIOH·H_2O

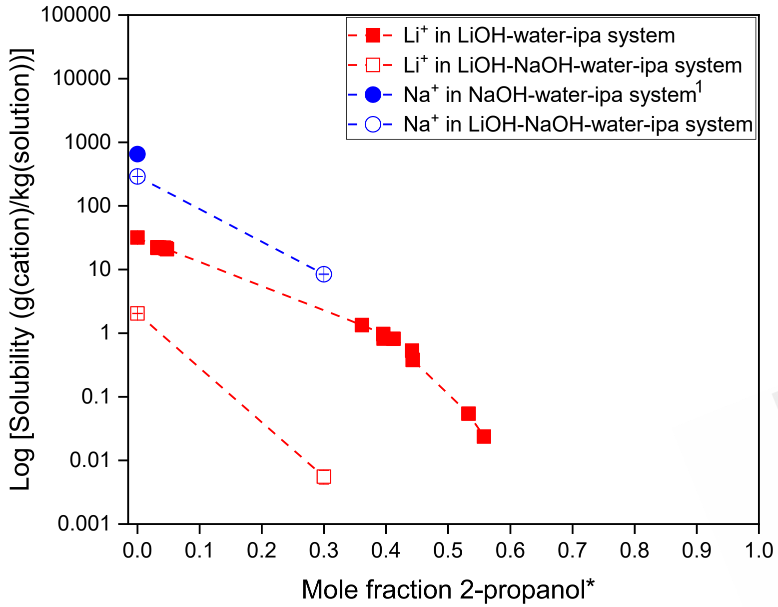
Next steps

- Investigate the effect of impurities (with 2-propanol)
  - NaOH & KOH

Goal: Determine LiOH + NaOH solubility in mixed systems at thermodynamic equilibrium to define the maximum NaOH impurity for pure LiOH crystallization

Preliminary results:





*Mole fraction of 2-propanol at equilibrium

[1] Рабинович В.А., Хавин З.Я. Краткий химический справочник. - Л.: Химия, 1977 [Russian]

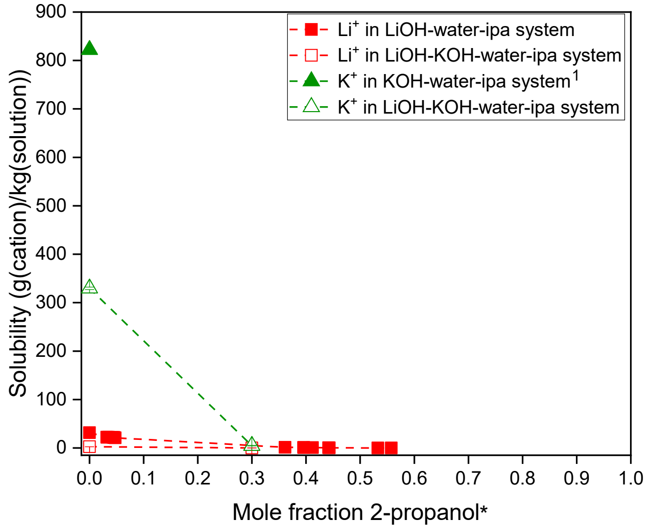
ANTISOLVENT CRYSTALLIZATION OF $LiOH{\cdot}H_2O$

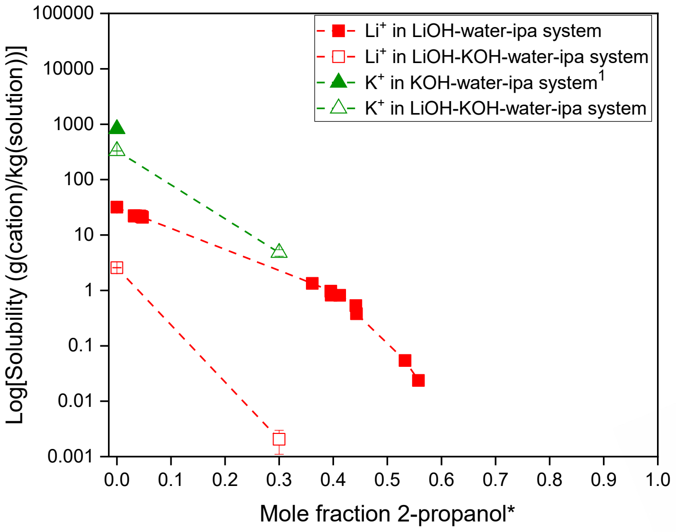
Next steps

- Investigate the effect of impurities (with 2-propanol)
  - NaOH & KOH

Goal: Determine LiOH + KOH solubility in mixed systems at thermodynamic equilibrium to define the maximum KOH impurity for pure LiOH crystallisation

Preliminary results:





*Mole fraction of 2-propanol at equilibrium

[1] Рабинович В.А., Хавин З.Я. Краткий химический справочник. - Л.: Химия, 1977 [Russian]

Testing on real solutions is ongoing => avoid IX


SIM² KU LEUVEN & STORYRUNNER
PRESENT
EUROPE'S
3
6.941
Li THIUM
PARADOX
ON TOUR IN
EUROPE & BRAZIL
22 MAY - DELFT
27 MAY - ANTWERP
04 JUN - LISBON
09 JUL - JEQUITINHONHA
10 JUL - BERLIN
27 AUG - FREIBERG
16 SEP - TALINN
07 OCT - HEVERLEE
09 OCT - LEUVEN
14 OCT - COPENHAGEN
21 OCT - LISBON
27 OCT - YLE TV FINLAND
22 OCT - HASSELT
17 NOV - BRUSSELS
25 NOV - UTRECHT
DIRECTED BY STIJN VAN BAARLE PRESENTED BY PETER TOM JONES PRODUCED BY SIM² - KU LEUVEN & STORYRUNNER
CINEMATOGRAPHY BY JOCHEN MAES & MICHAEL VAN DE VELDE EDITED BY 2FRAME

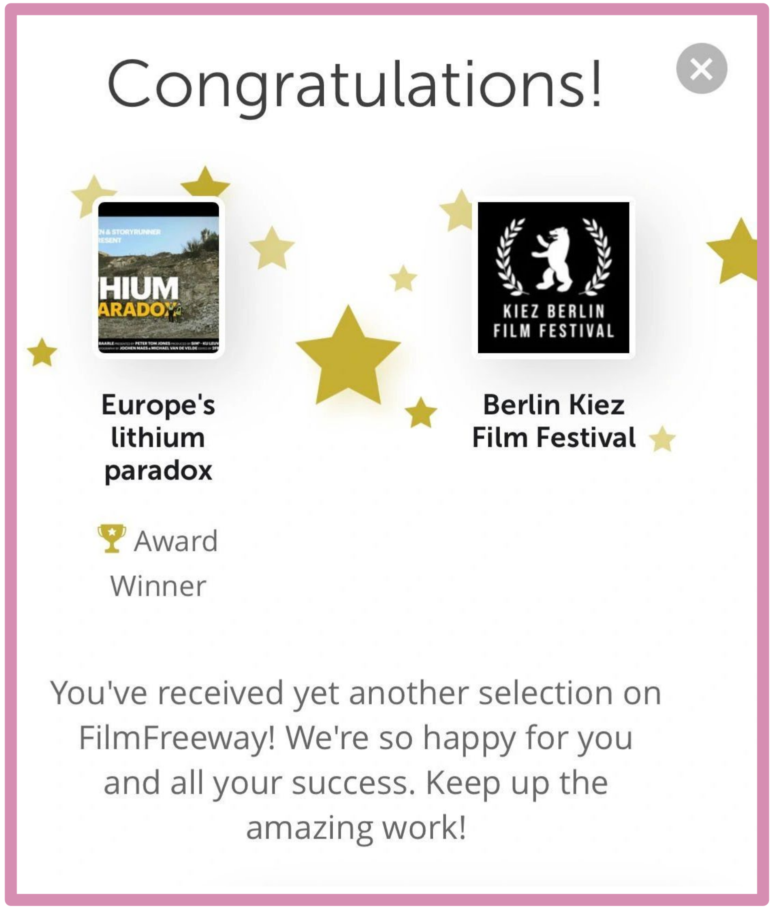
STORYRUNNER: https://www.storyrunner.be/

AWARDS

JOURNEYMAN PICTURES

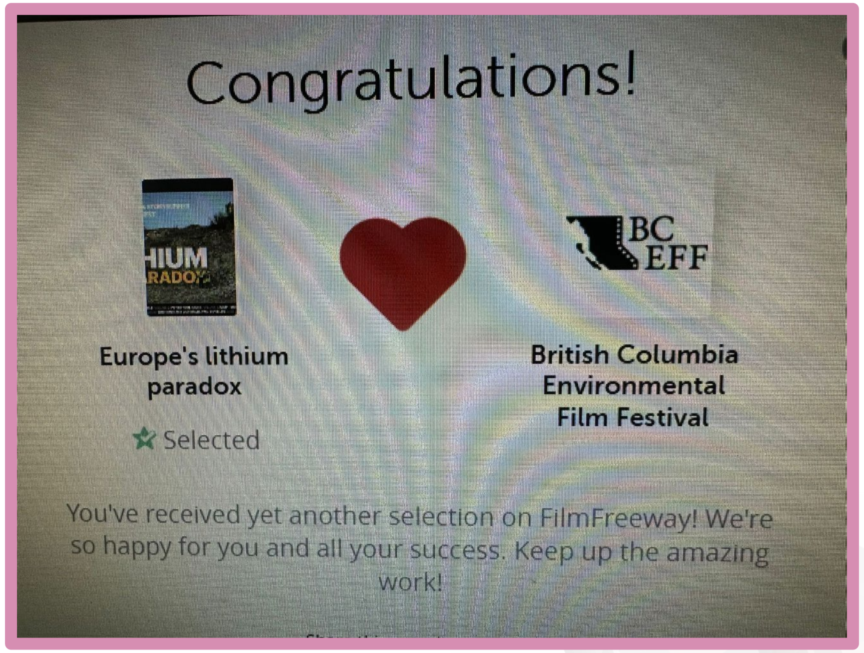
LiTHOS

prime video



2nd of July 2025

23rd of July 2025



24th of July 2025

Funded by
the European Union

GA n°101138112

THANK YOU FOR YOUR ATTENTION!

- Thomas Abo Atia
- Research manager, KUL • Solvomet • SIM²
- thomas.aboatia@kuleuven.be
- https://solvomet.eu/
- https://kuleuven.sim2.be/