

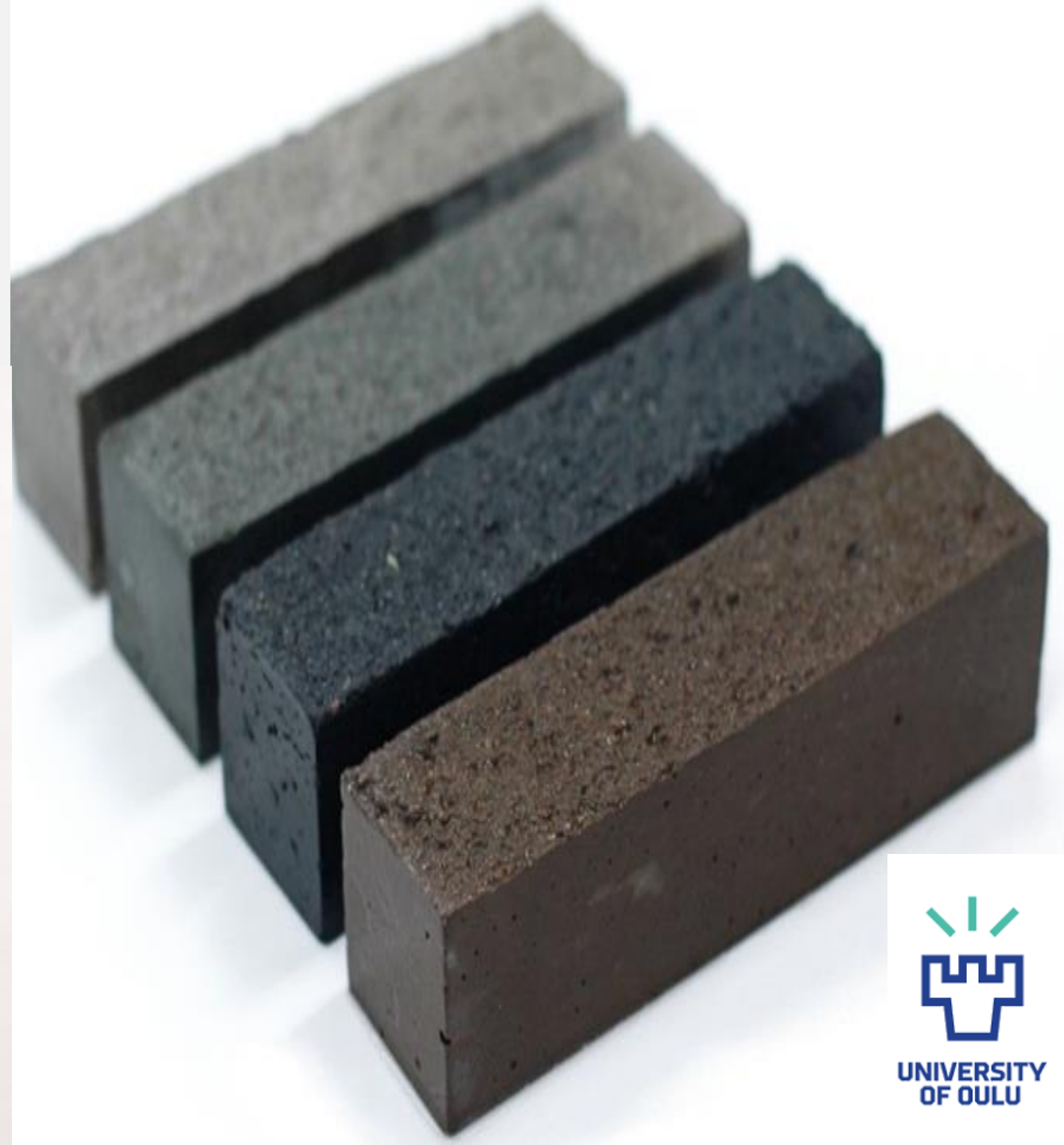
SUSTAINABLE MINING PRACTICES: INNOVATIVE TECHNOLOGIES ON TAILINGS MANAGEMENT

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OF OULU



Contents

- **Mining Industry & Residues**
- **Application as construction materials**
 - Alkali activated materials
 - Supplementary cementitious materials
 - Aggregates
 - Ceramics
 - Onsite applications in mine environment
- **Circular and sustainable mining solutions**
- **Points to Ponder**

Mining Industry





Industrial Resources

Mineral waste generation in Finland 2022 (tonnes)

Mining and quarrying	84 682 000
Wood and wood products	602 000
Paper and paper products	2 496 000
Non-metallic mineral products	894 000
Basic metals and metal products	1 721 000
Electricity, gas, steam	972 000
Construction	10 675 000
CO2	40 629 000

Source: Waste statistics 2022, Greenhouse gases 2023 Statistics Finland





Inorganic Circular Materials

Fostering circular economy - from industrial residues to valuable products



50+

Researchers

20+

Doctoral theses

> 7 MEUR

Funding

> 300

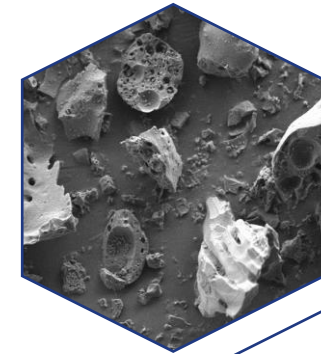
Publications

50+

Industrial partners

1

Spin-off-company

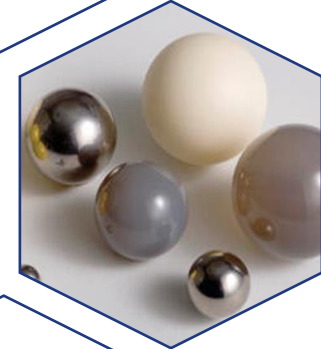


Material reactivity

Physical properties
Chemical properties
mineralogy

Methods to improve the reactivity

Mechanical processing
Thermal processing
Chemical methods



Binder design

Alkali activated materials
Supplementary cementitious materials



End products

Aggregates
Mortars
Concrete
Stabilization





Sustainability

Sustainability is most often defined as meeting the needs of the present without compromising the ability of future generations to meet theirs. It has three main pillars: **economic, environmental, and social.**



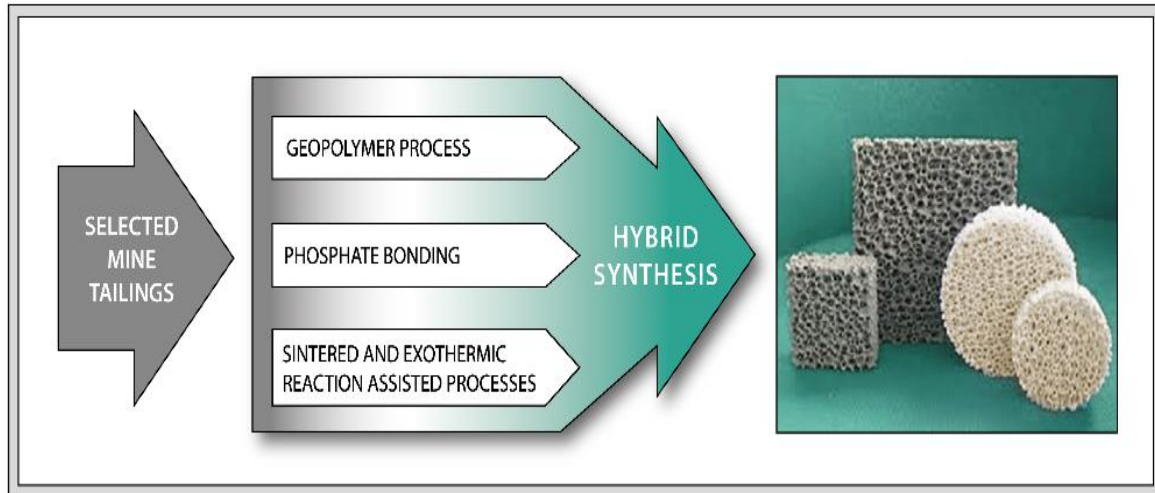
- Construction materials are primarily made of natural resources such as minerals, rocks, sand, wood and so on.
- Creating sustainability in construction materials need 3R method: Reduce, recycle and Reuse



History of projects about Tailings utilization @ UOulu



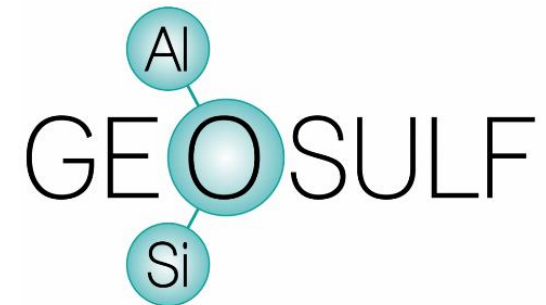
European Training Network for the Remediation and Reprocessing of Sulfidic Mining Waste Sites



AGNICO-EAGLE



ACADEMY OF FINLAND

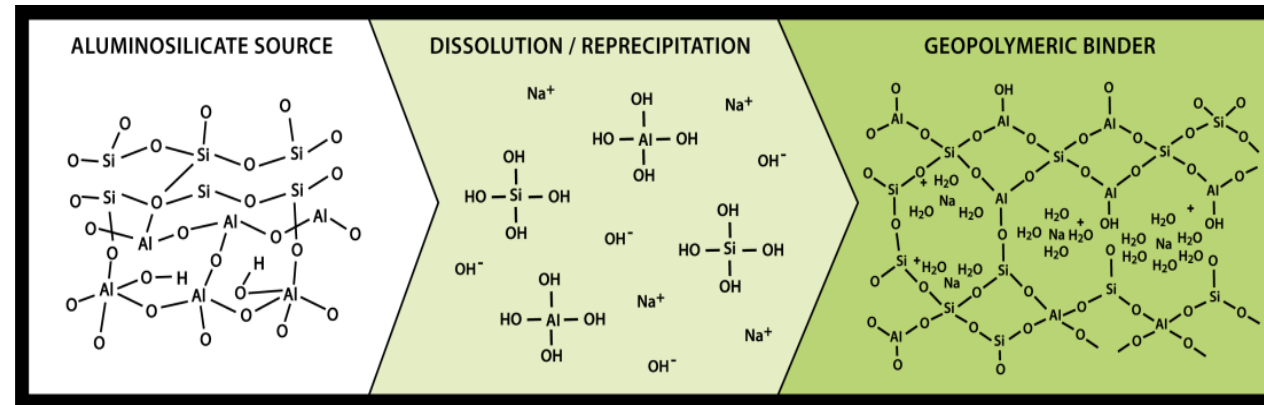




1. Alkali activation (geopolymer) technology

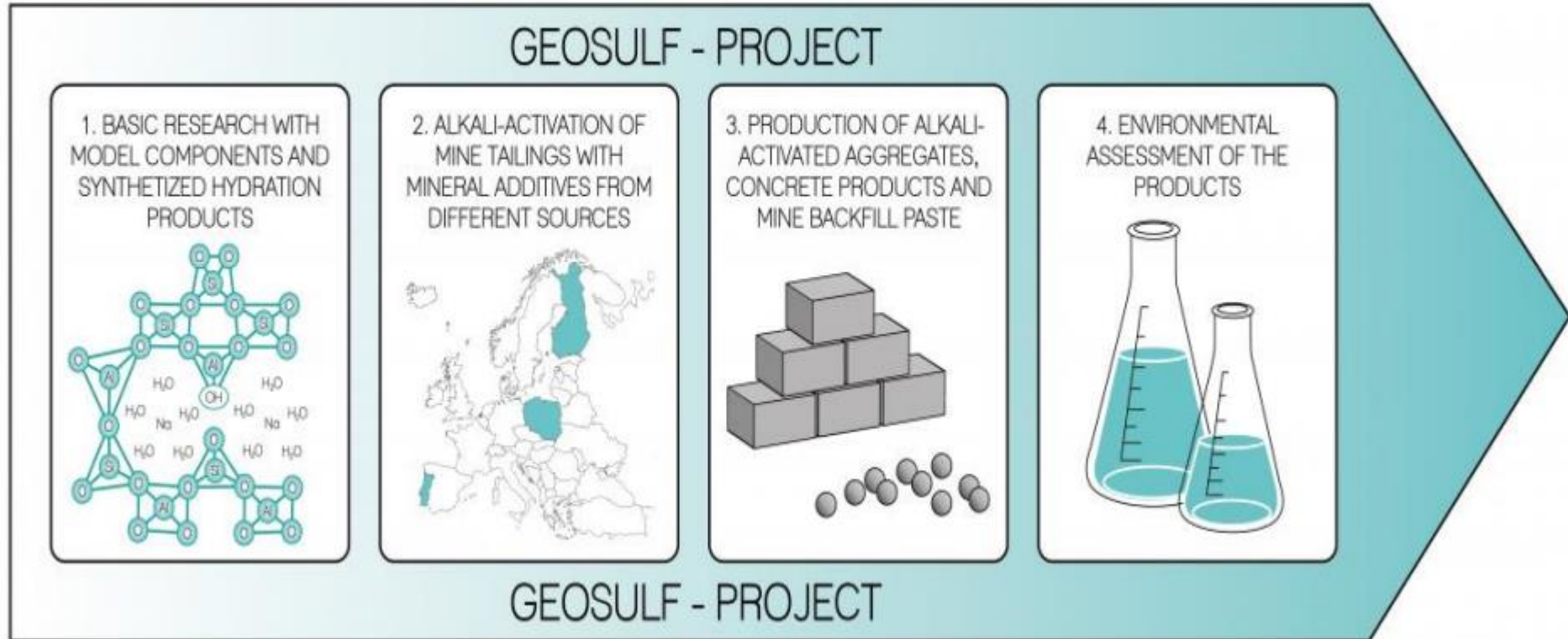
- Mixing Si/Al containing solid raw material with water and alkaline reagent (NaOH, Na-Sil etc.)

→ Hardened concrete like structure





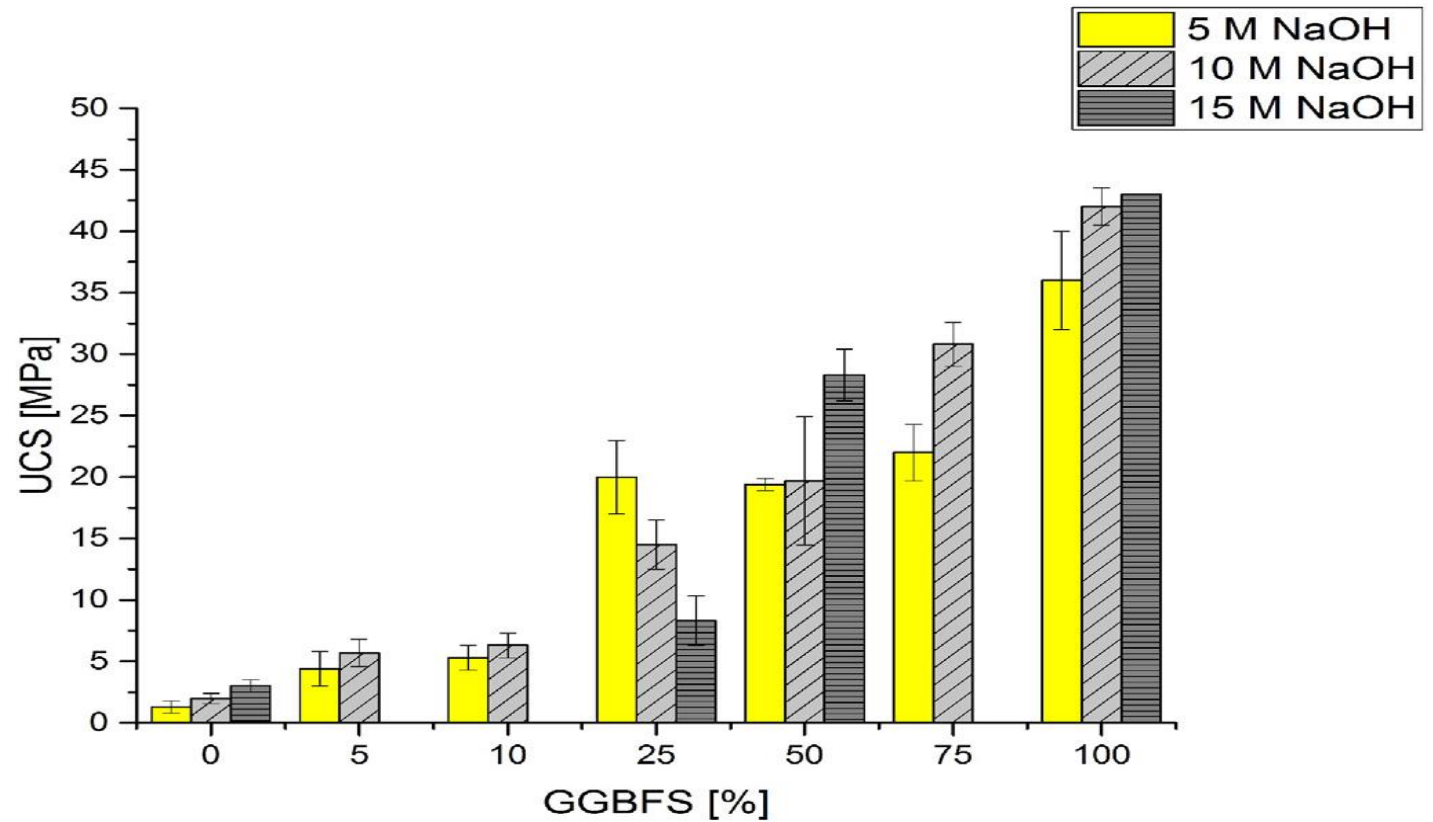
Stabilization of hazardous elements



UTILIZATION OF SULPHIDE MINE TAILINGS IN GEOPOLYMER MATERIALS (2014 – 2017)

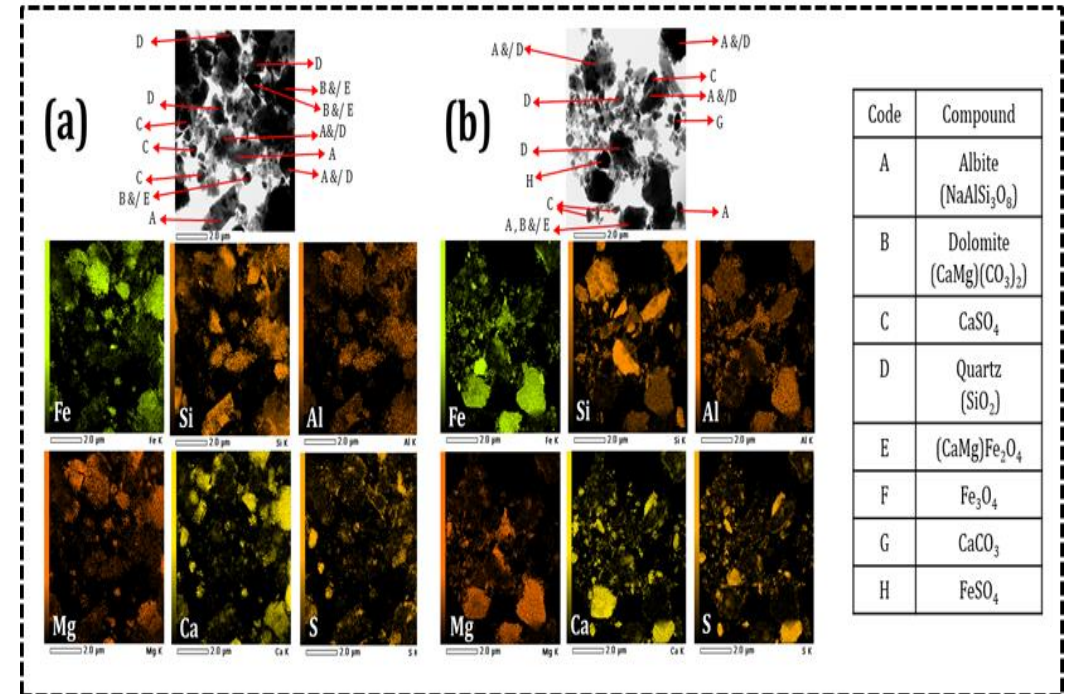
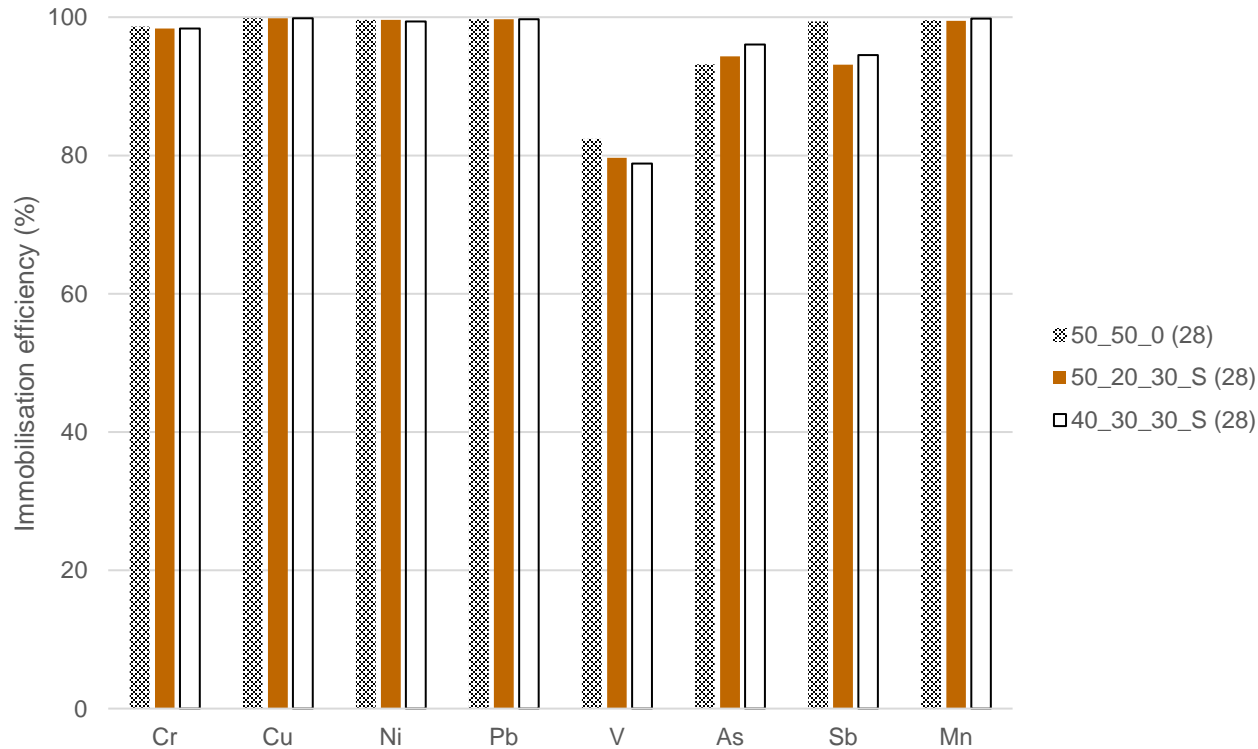


Stabilization of sulphidic tailings – gold tailings Kittilä





Stabilization of sulphidic tailings



*Kiventerä, J., Golek, L., Yliniemi, J., Ferreira, V., Deja, J., Illikainen, M., 2016. Utilization of sulphidic tailings from gold mine as a raw material in geopolymerization. *Int. J. Miner. Process.* 149, 104–110
 Kiventerä, J., Lancellotti, I., Catauro, M., Poggetto, F.D., Leonelli, C., Illikainen, M., 2018. Alkali activation as new option for gold mine tailings inertization. *J. Clean. Prod.* 187, 76–84



Alkali activation of mine tailings

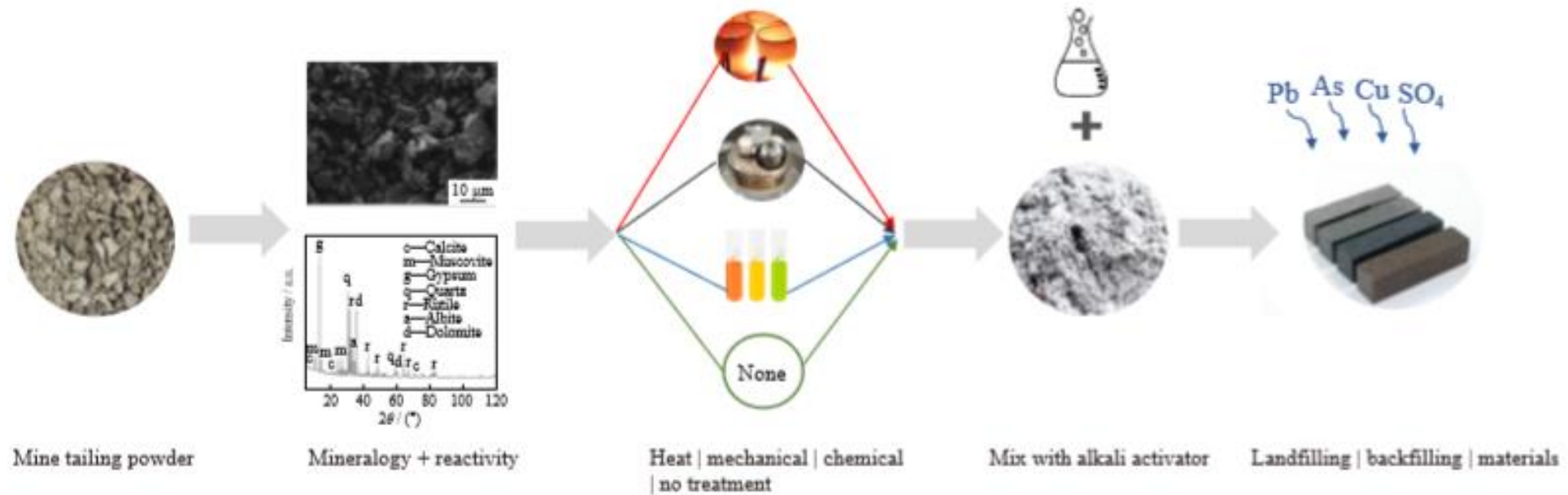
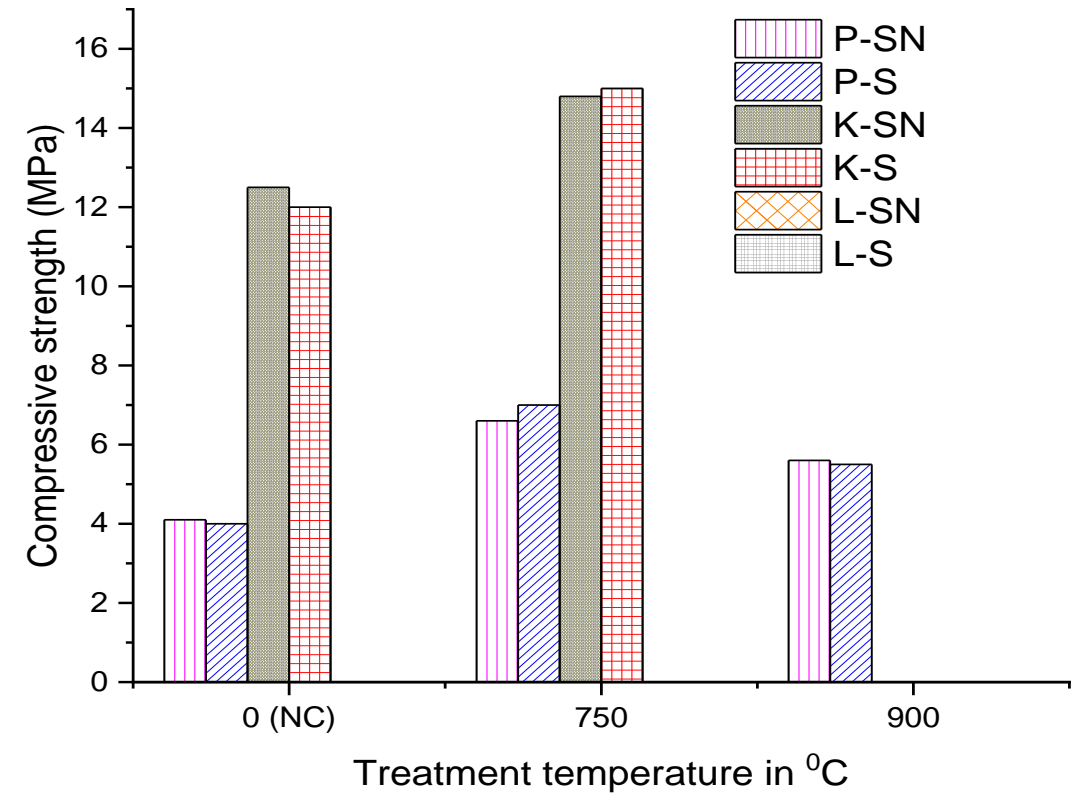
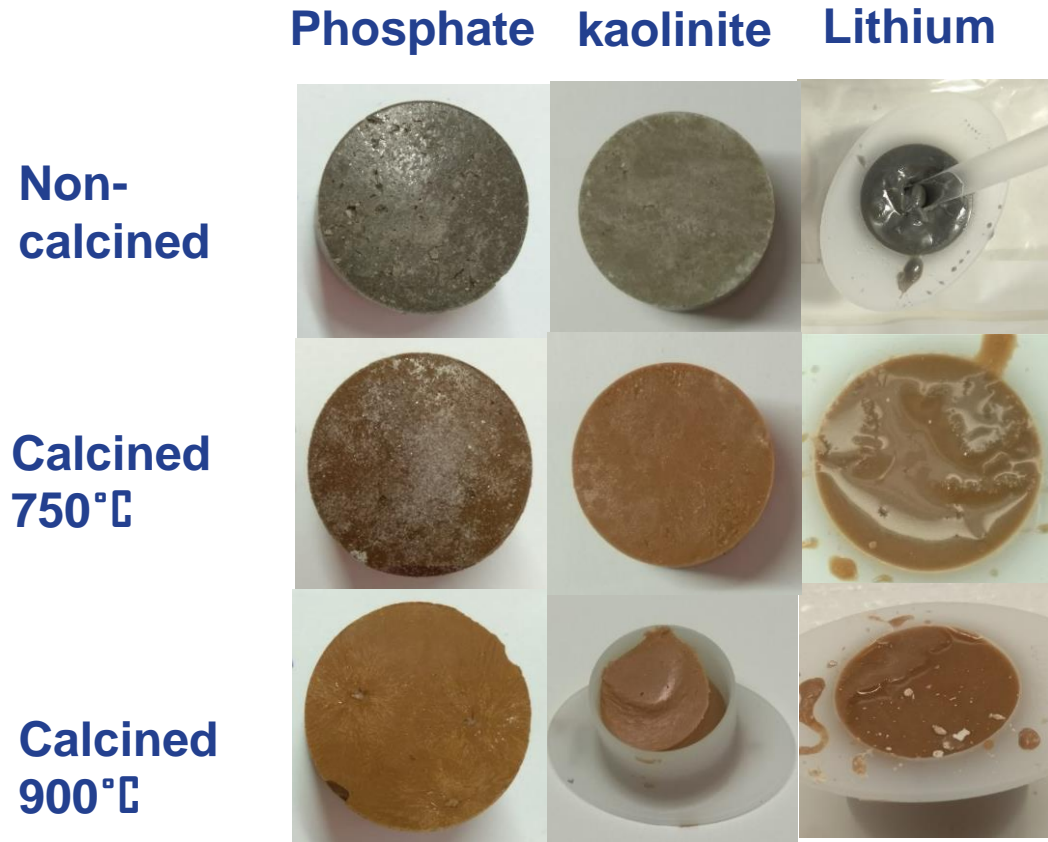


Fig. 1. Alkali activation process for mine tailings.

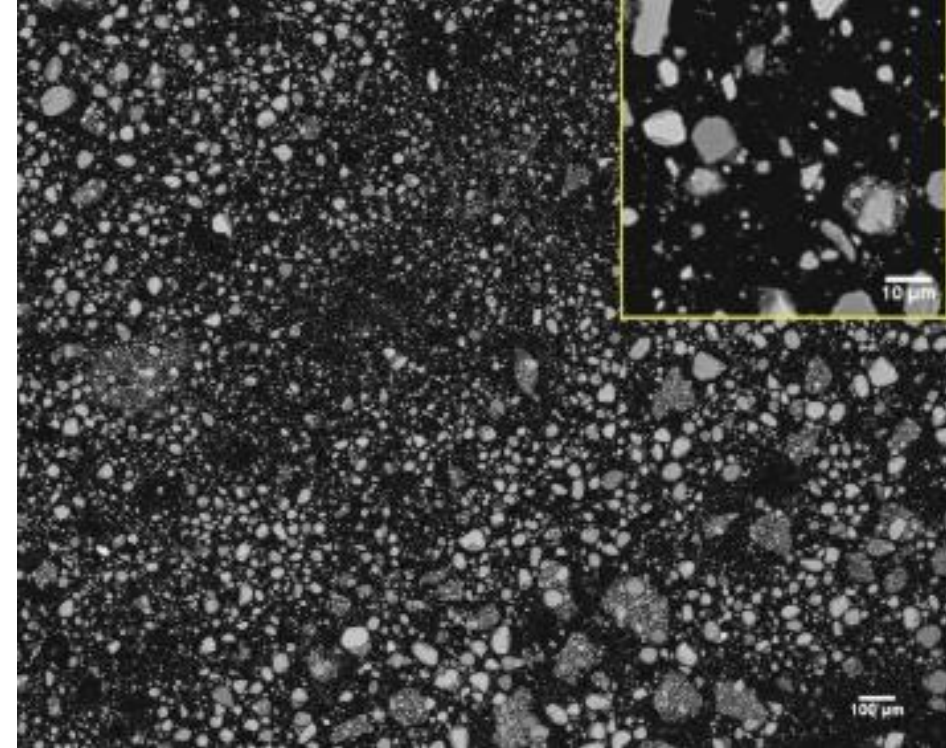
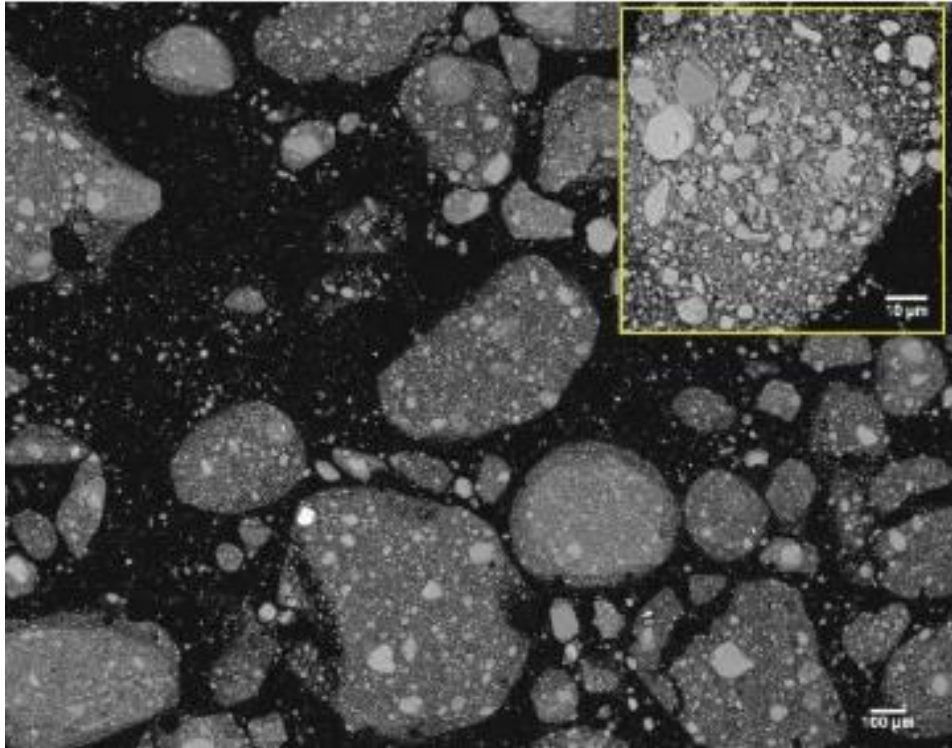


Alkali activated tailings: Thermal treatment



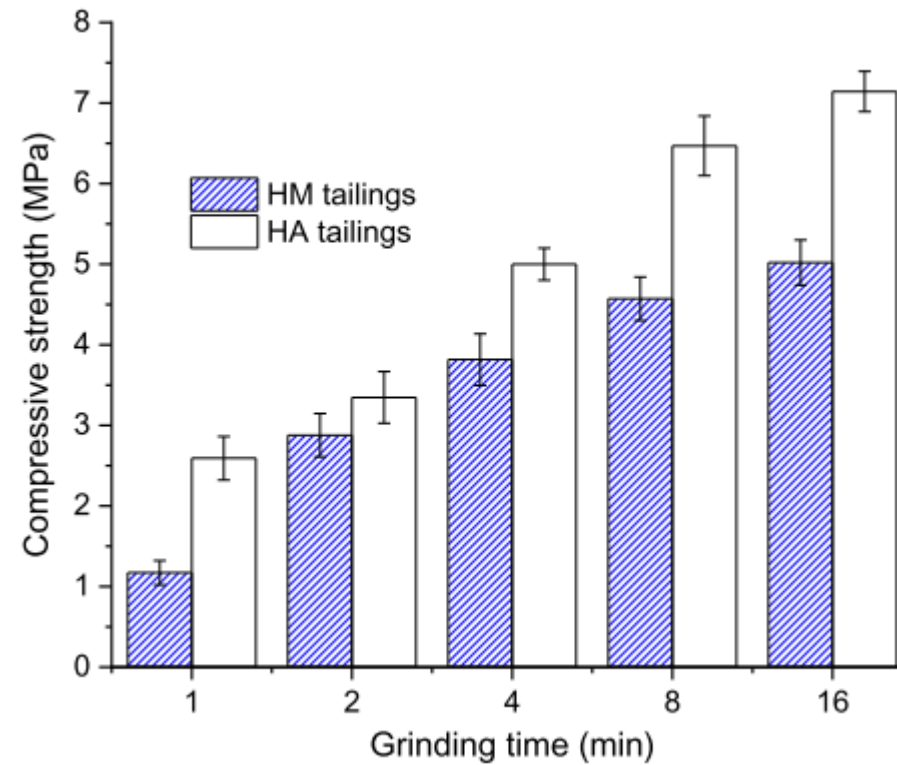
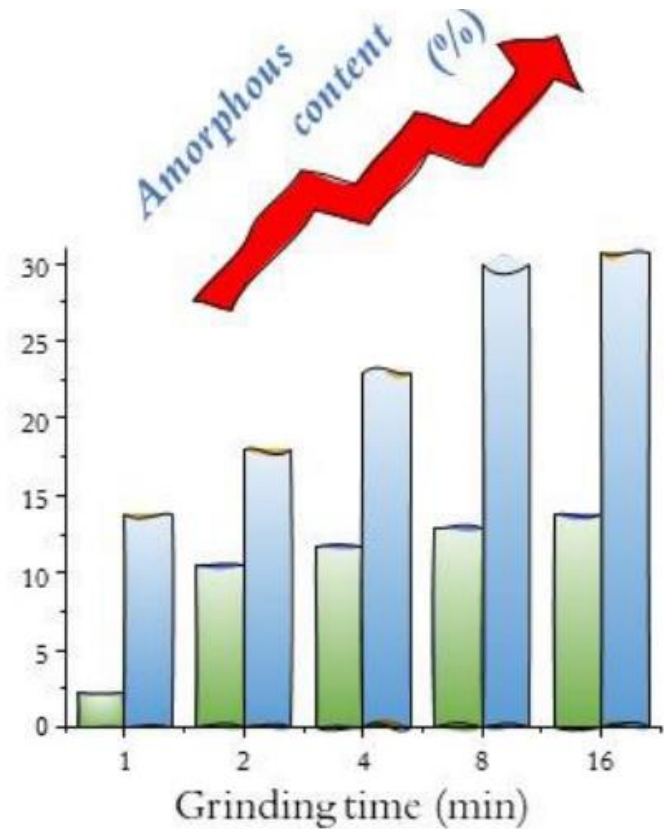


Alkali activated tailings: Mechanical treatment



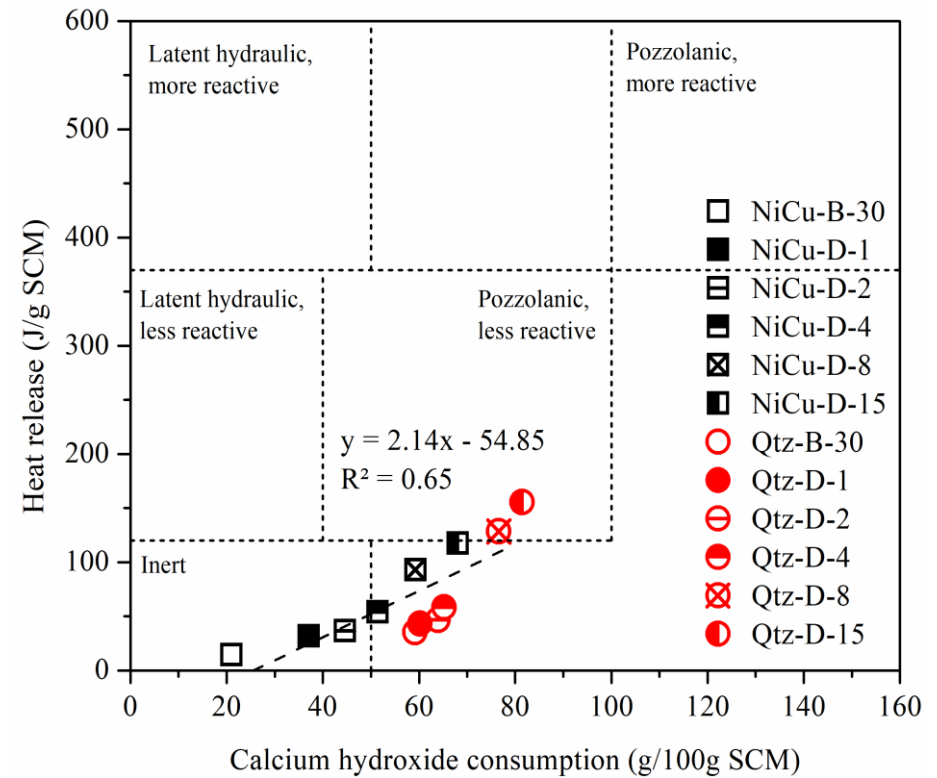
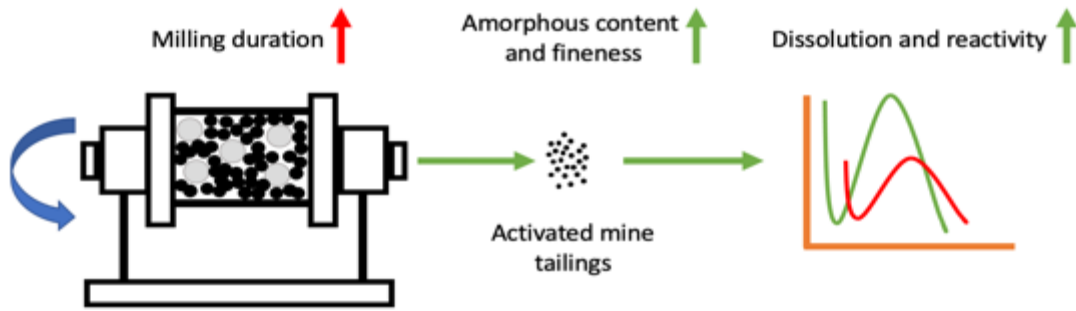


Alkali activated tailings: Mechanical treatment



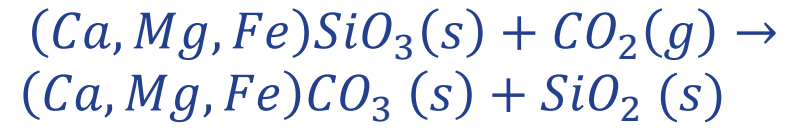


2. Supplementary cementitious materials





3. Tailings aggregate: Granulation and carbonation

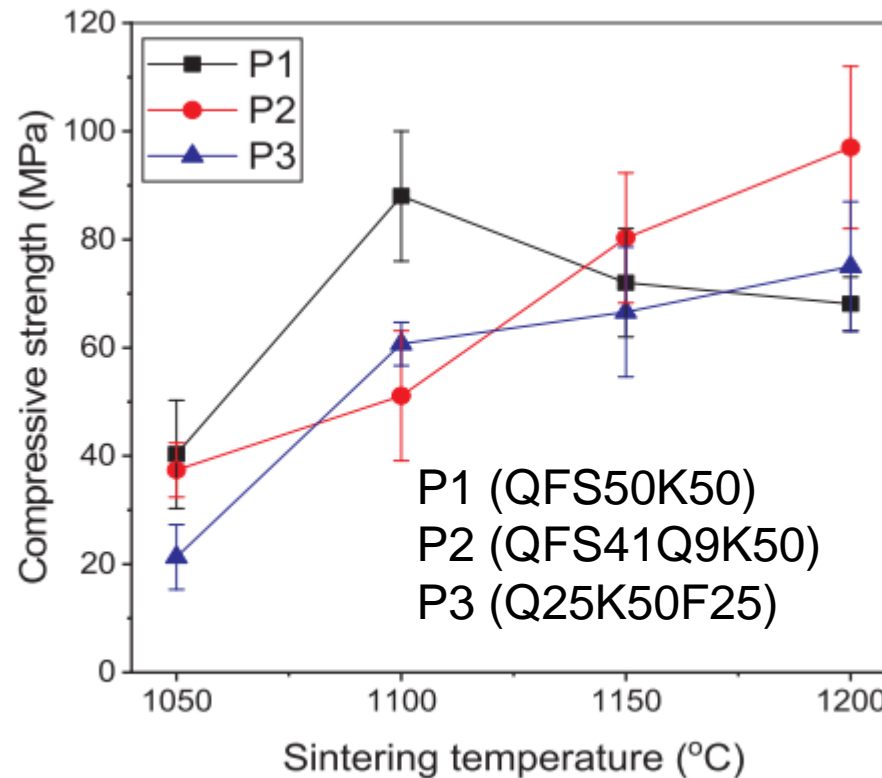




4. Tailings as ceramics



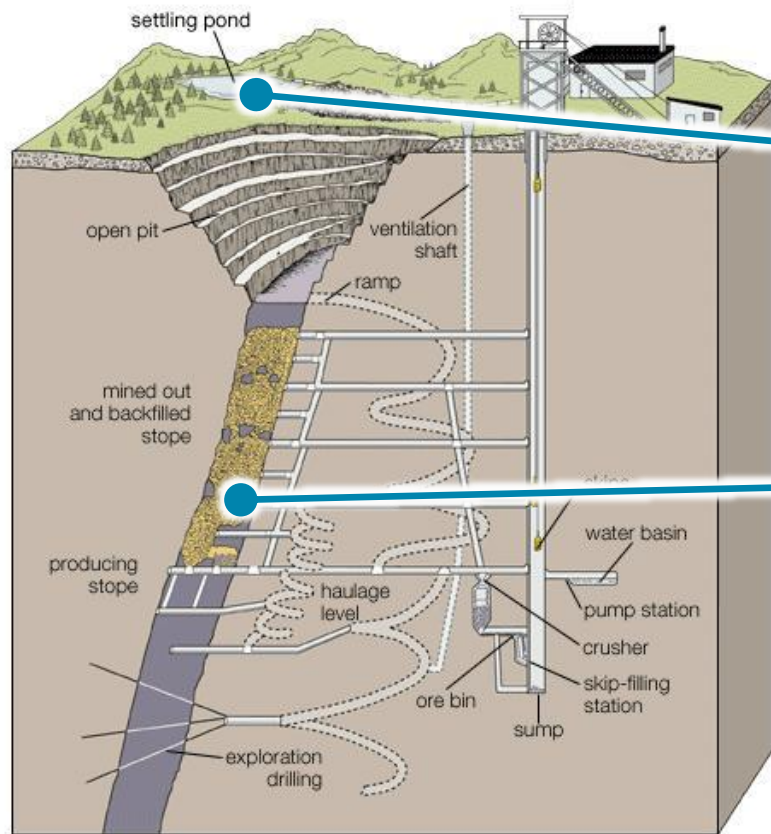
QFS, Lithium tailings



- QFS has albite, reacts at $> 1000^{\circ}\text{C}$
- Porcelain, typically kaolin, feldspar and quartz



5. Applications in mining site



Cover materials for tailings on the surface

- Impermeable, flexible

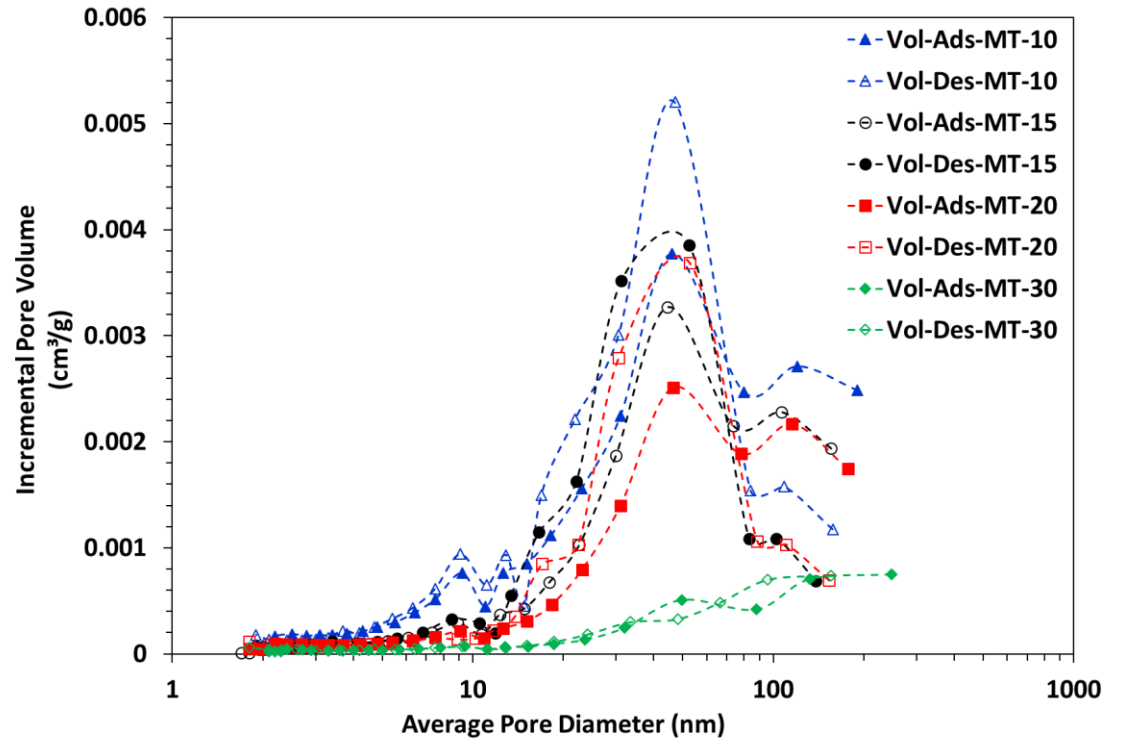
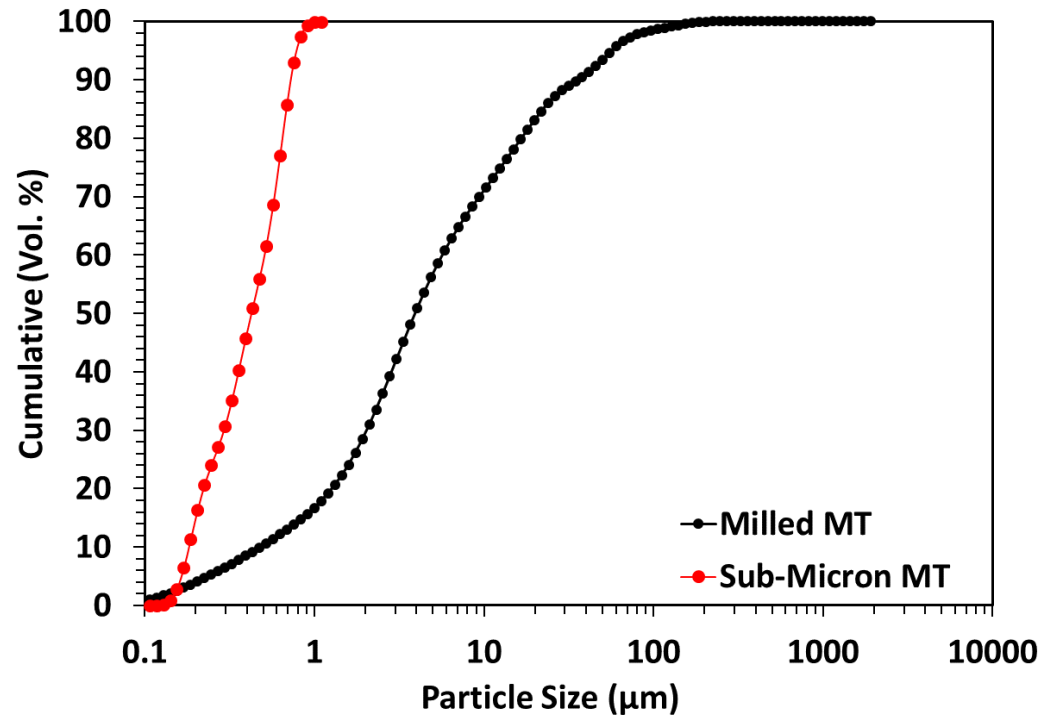
Underground backfill

- Strength – 0,2 to 5 MPa
- Rapid strength development for cut and fill operations

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Applications in mining site





Circular and sustainable mining, ongoing projects @ UOulu

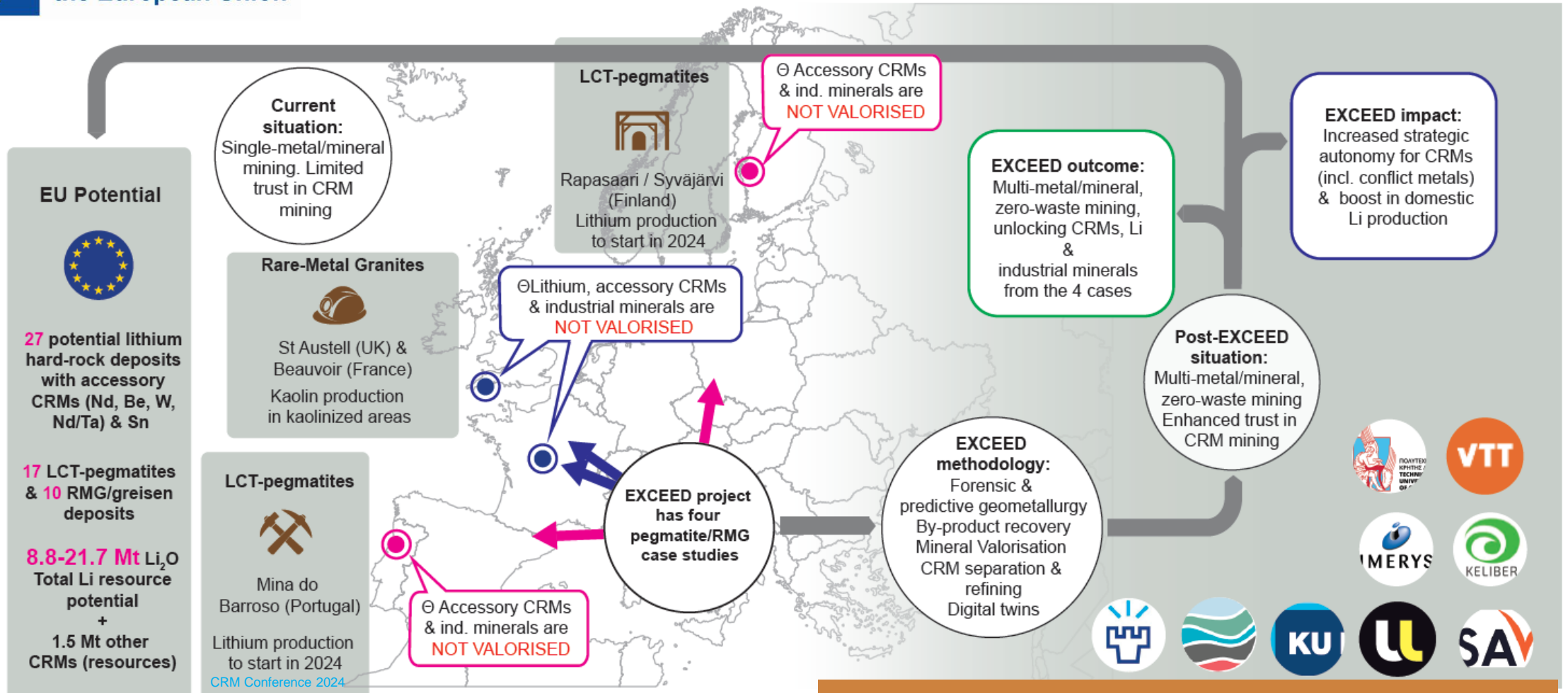


1. EXCEED

- Cost-effective, sustainable and responsible extraction routes for recovering distinct critical metals and industrial minerals as by-products from key European hard-rock lithium projects



Funded by the European Union





Tailings management



Parinus Vedadi
Doctoral
Researcher



Dr. Anshumali Mishra
Postdoctoral
researcher

 Keliber
(Quartz, feldspar,
mica)

 Savannah
(Quartz, feldspar,
mica)

 St Austell
(Mica)

 Beauvoir
(Quartz, feldspar)

WP3: Valorisation of residual and industrial minerals

Water, 10 % Kaolin if needed

High temperature ceramics
(milling, mixing, shaping, firing at 1000-
1200 °C)

Ceramic roof tiles,
pavers, facing
bricks and blocks



Na/K-silicates, Na/K-hydroxides

Alkali activated materials
(mixing, curing at 60°C and ageing 7-28
days)

Eco and user-
friendly masonry
bricks, tiles and
alternative binders



Supplementary cementitious materials
(milling, Mechanochemical activation)

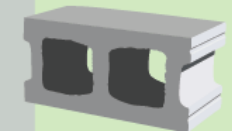
OPC replacement
(10-30%) material in
concrete production



Water, Kaolin if needed, Na/K-silicates

Lightweight aggregate
(milling, mixing, granulation, curing at 20-
60 °C or firing at 1000-1200°C)

Lightweight
concrete for
insulation, acoustic
panels, partition
walls



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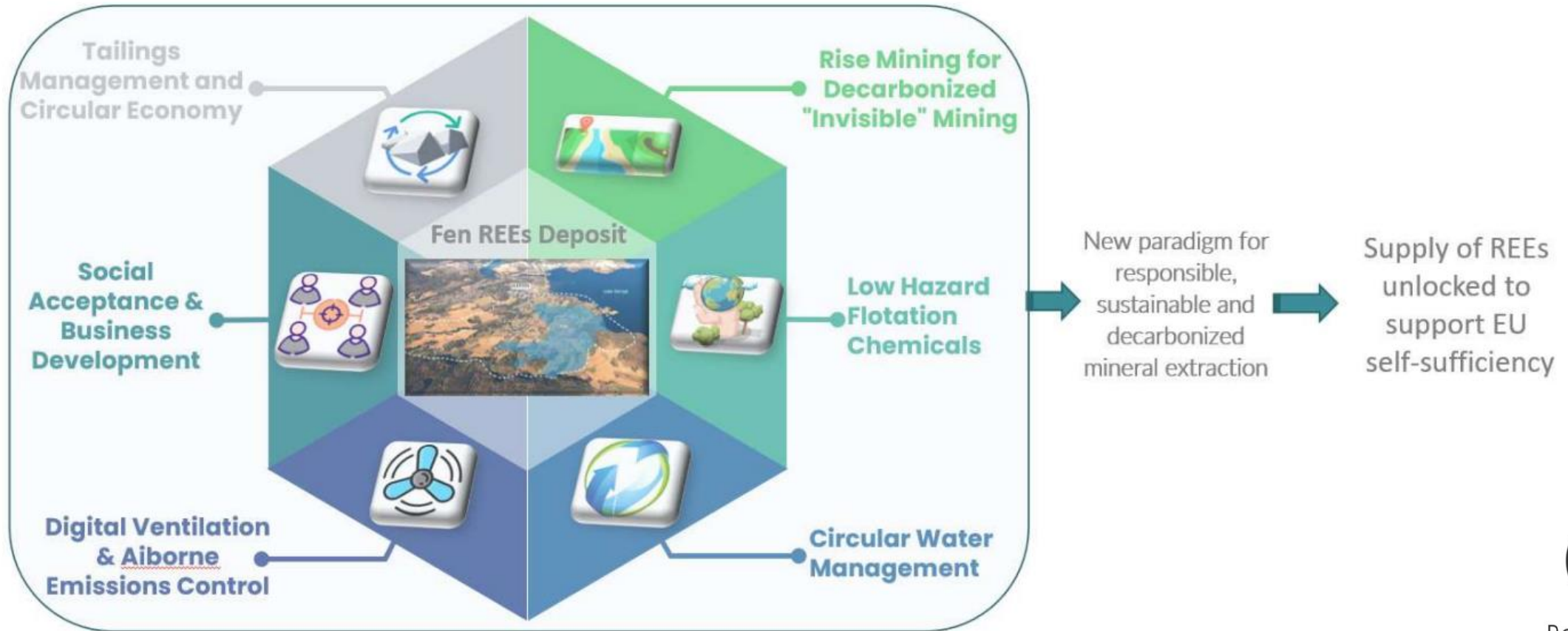
BETOLAR





2. REESOURCE

- Unlocking the Supply of Rare Earth Elements in Europe Through Responsible, Sustainable and Decarbonised Innovative Technologies



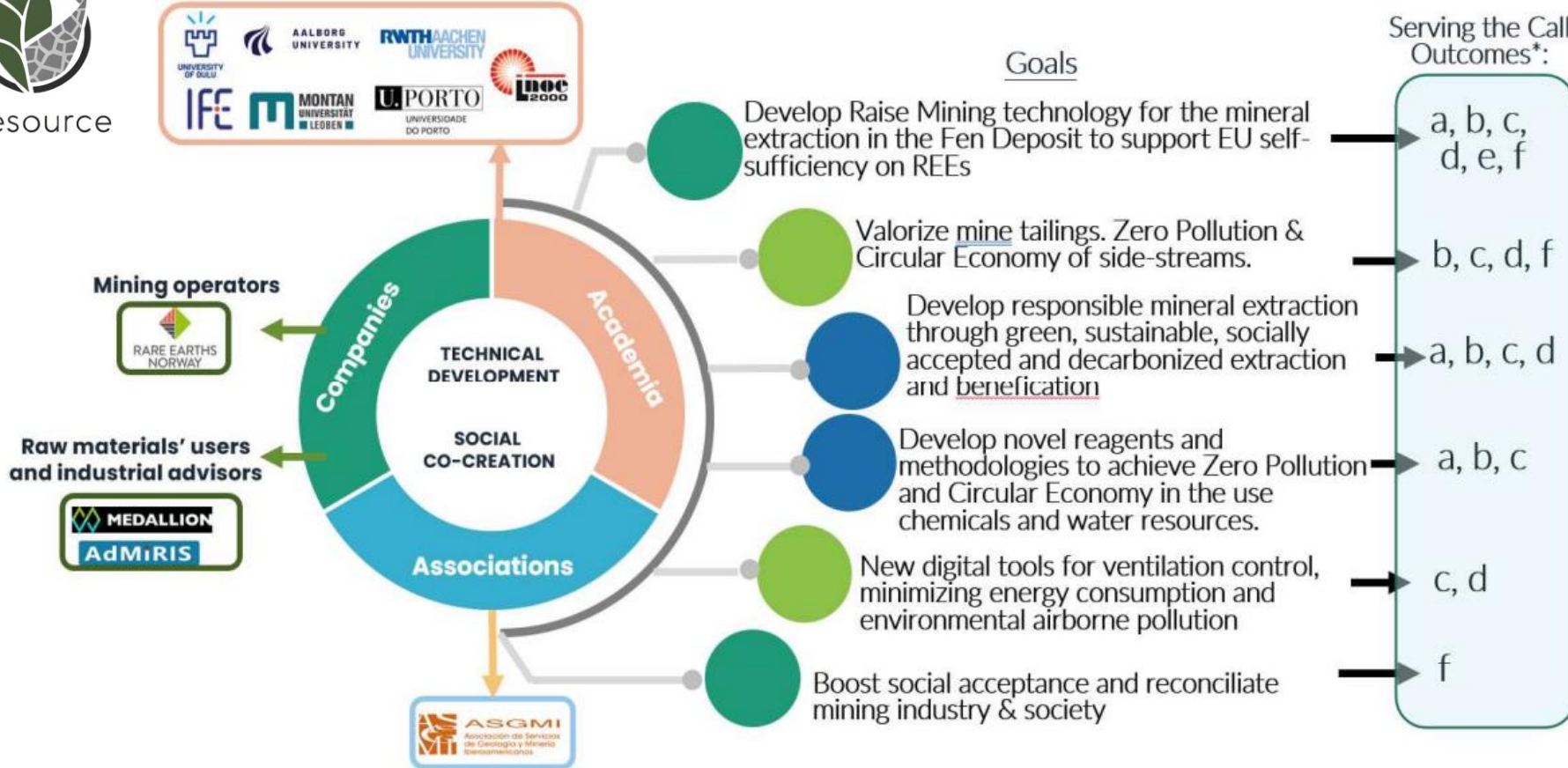
Reesource



Tailings management



Reesource



Mining operators



Raw materials' users and industrial advisors



Companies

TECHNICAL DEVELOPMENT

SOCIAL CO-CREATION

Associations

Academia



*Call Outcomes

- a) **Develop** innovative technologies for extraction of raw materials in the European Union
- b) **Increase** the domestic EU sourcing of raw materials.
- c) **Improve** responsible supply of raw materials to Europe in line with the EU principles for sustainable raw materials,
- d) **Show** the potential to reduce substantially the (GHGs) emissions intensity of extraction per ton of the material
- e) **Promote** the utilisation of UNFC and UNRMS
- f) **Accelerate** development of EU domestic raw materials exploration projects integrating innovative technologies.



Key takeaway

- **Mining is inevitable for technology and green transition**
- **Possible to create a sustainable mining environment**
- **Proper mine planning will help in circular material flow**
- **One step at a time: Start with the tailings-based solution in mine environment**



Acknowledgement



Thank you!

**For further details/ collaborations,
priyadharshini.perumal@oulu.fi**

<https://www.oulu.fi/en/research-groups/sustainable-construction-materials-and-applications>