centre for High Temperature Processes and Sustainable Materials Management

KATHOLIEKE UNIVERSITEIT LEUVEN

Supercooling of slags: Design of inorganic polymer precursors

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Centre for High Temperature Processes and Sustainable Materials Managment

Geopolymer Camp, July 9-11, 2012

Introduction – Slag to geopolymer precursor

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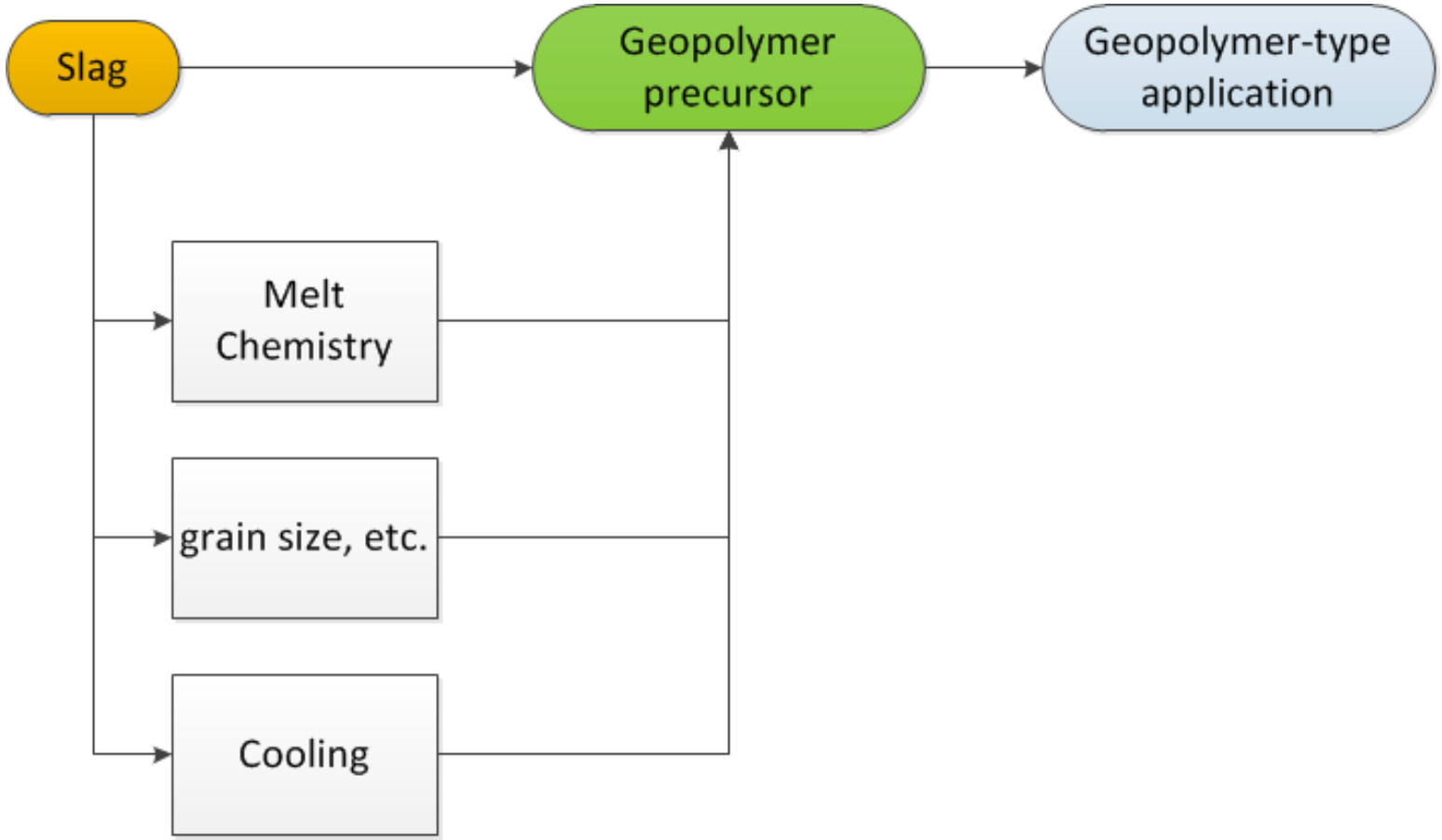
Industrial waste stream → Raw material → Highly added value product

Slag → Geopolymer precursor → Geopolymer-type application

Introduction – Slag to geopolymer precursor



Introduction – Slag to geopolymer precursor

Slow cooling in slag yard

- Difficult to control
- Heterogeneous
- Waste or low value application
  E.g. aggregates

Slow cooling vs. Supercooling

Example: cooling of Thermal Valorization Slag

Standard practice = Slow cooling in slag pot

Slow cooling vs. Supercooling

Can we make Inorganic polymers of this?

Yes, 90 MPa can be reached, but ..

hardening takes weeks to months.. very slow reaction rate

To increase reactivity

⇒ Very fine milling => energy

⇒ High pH => highly concentrated NaOH

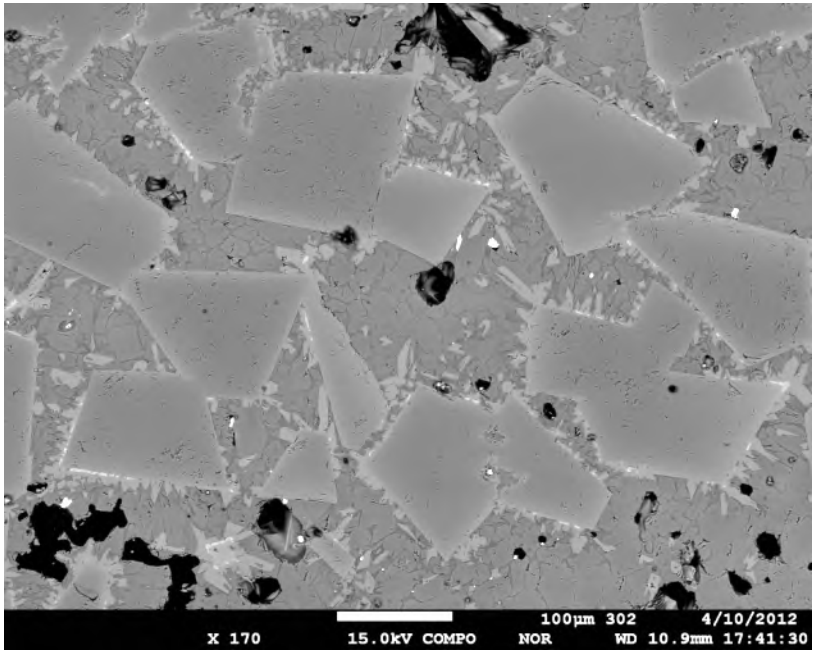
⇒ Costly

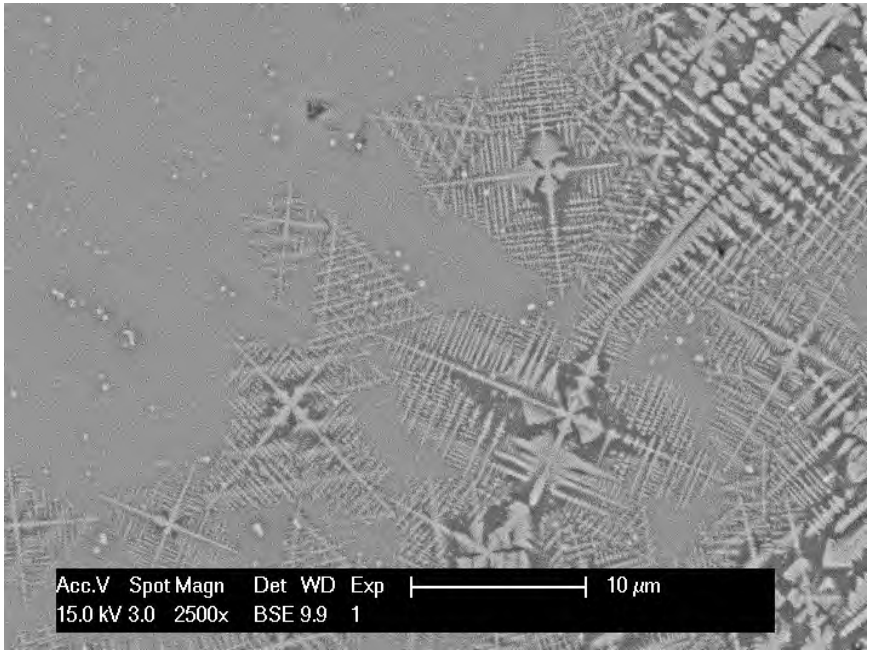
Slow cooling vs. Supercooling

Slag pot
Slow cooling

Quenched in water
Supercooling

Slow cooling vs. Supercooling





90% crystalline phases

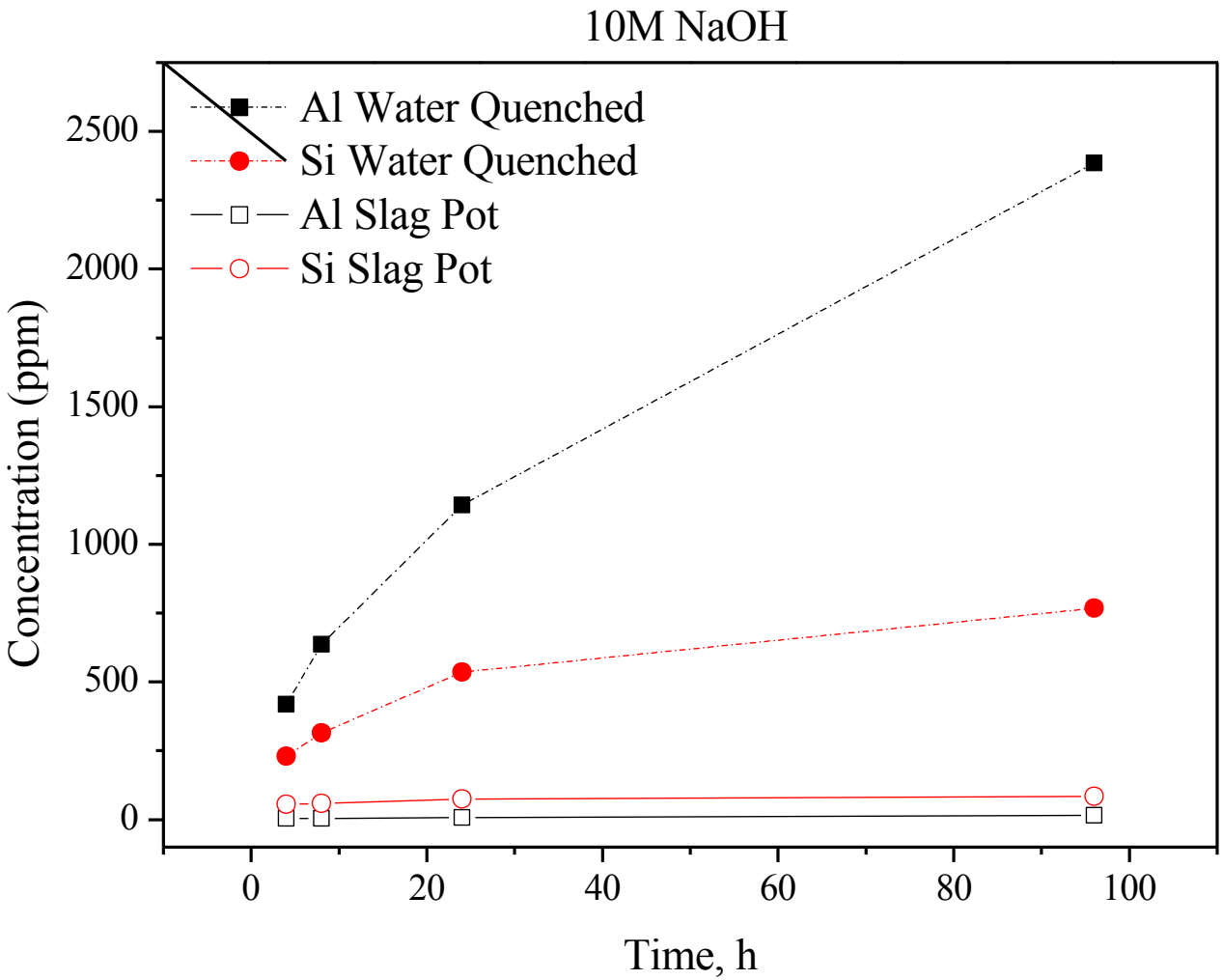
90% glassy phase

Slag pot
Slow cooling

Quenched in water
Supercooling

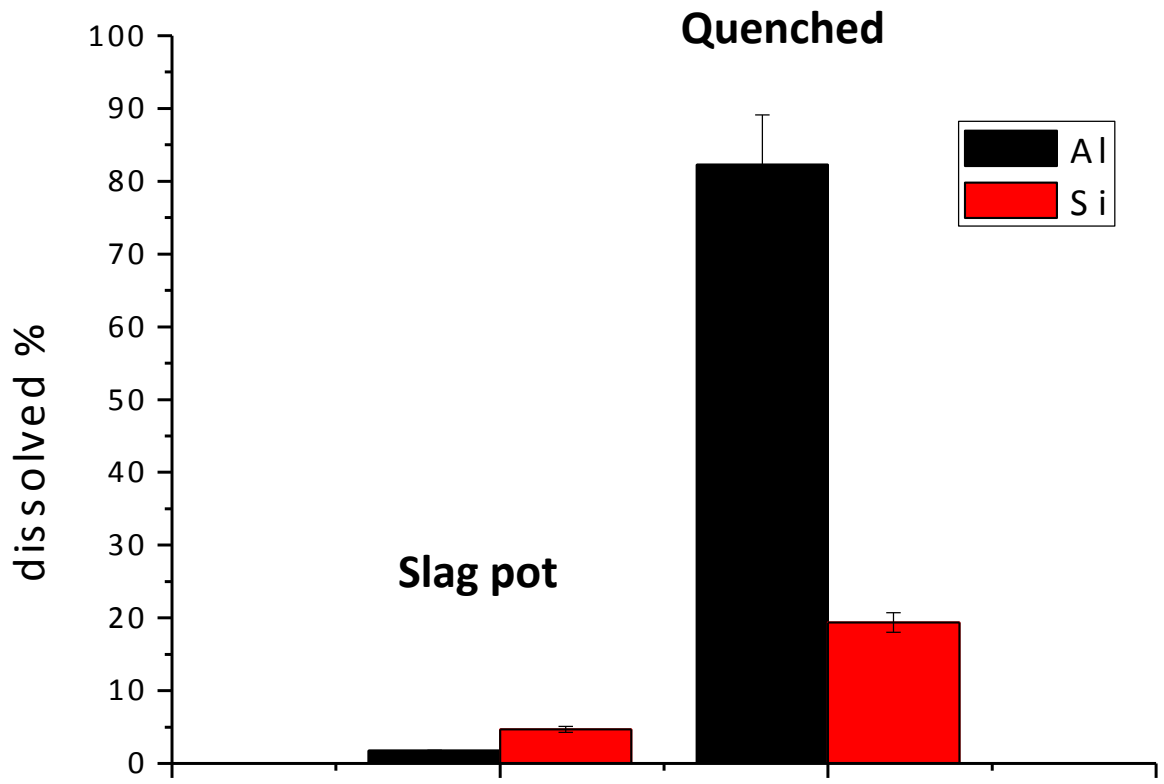
Slow cooling vs. Supercooling

Dissolution at alkaline pH => reactivity as inorganic polymer



Slow cooling vs. Supercooling

10M NaOH - 24h



Slow cooling vs. Supercooling

Inorganic polymer from supercooled precursor

⇒ Very high reaction rate

⇒ hardening in minutes

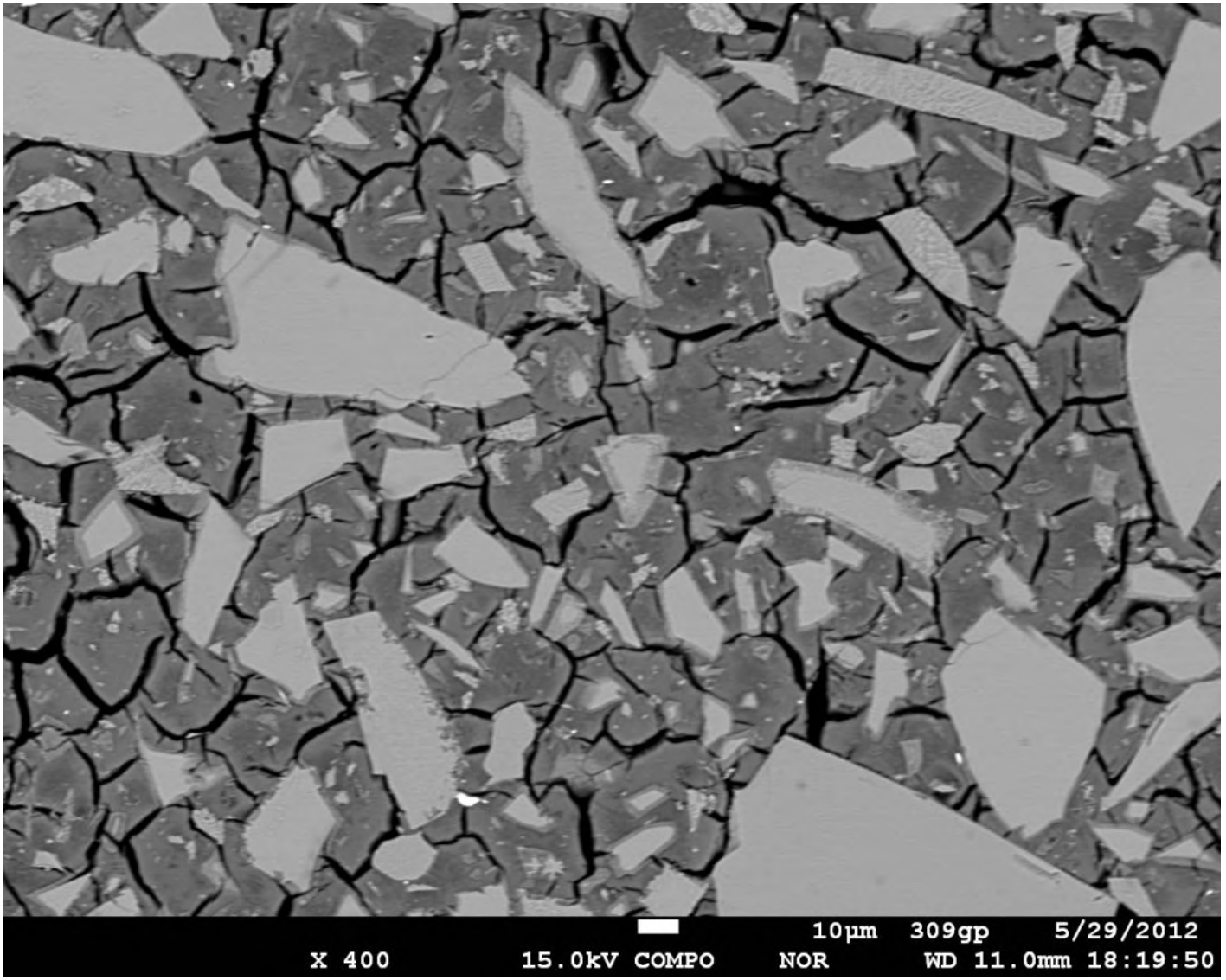
But: crack formation, lower strength, 60 MPa

⇒ less fine grain size

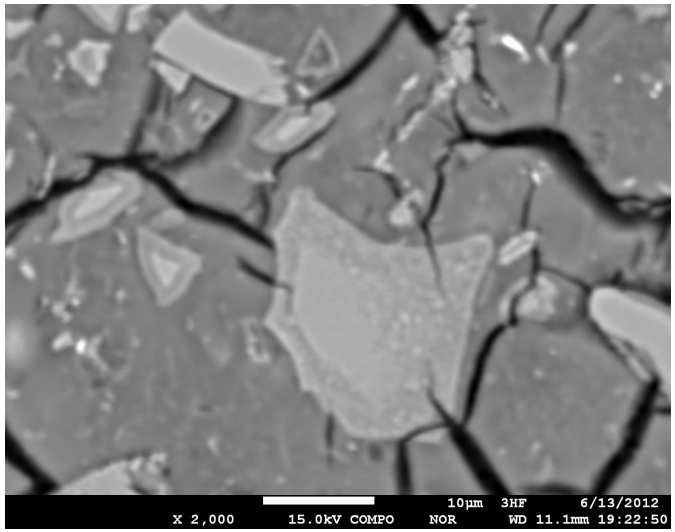
⇒ less NaOH needed => used friendly

⇒ less costly

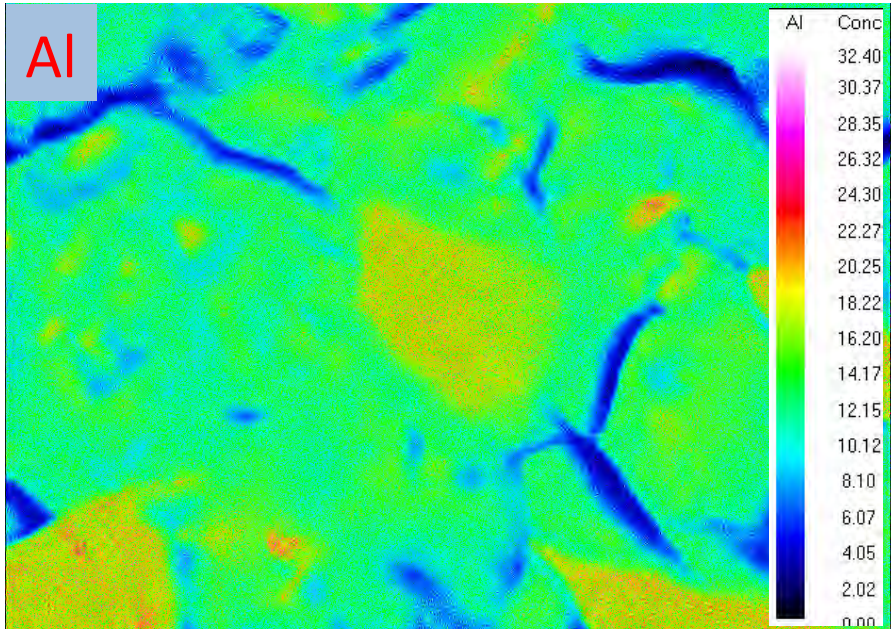
Slow cooling vs. Supercooling

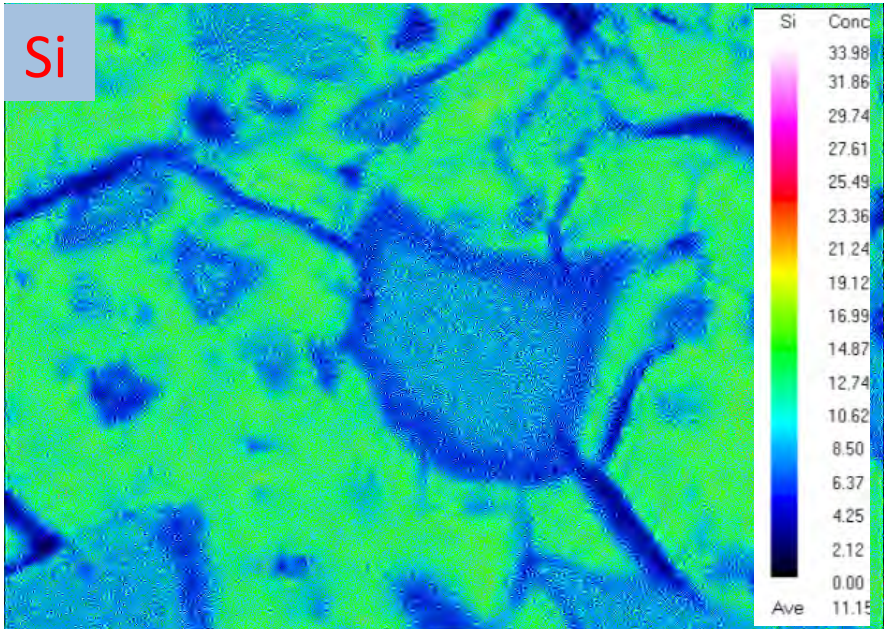


Inorganic Polymer Chemistry

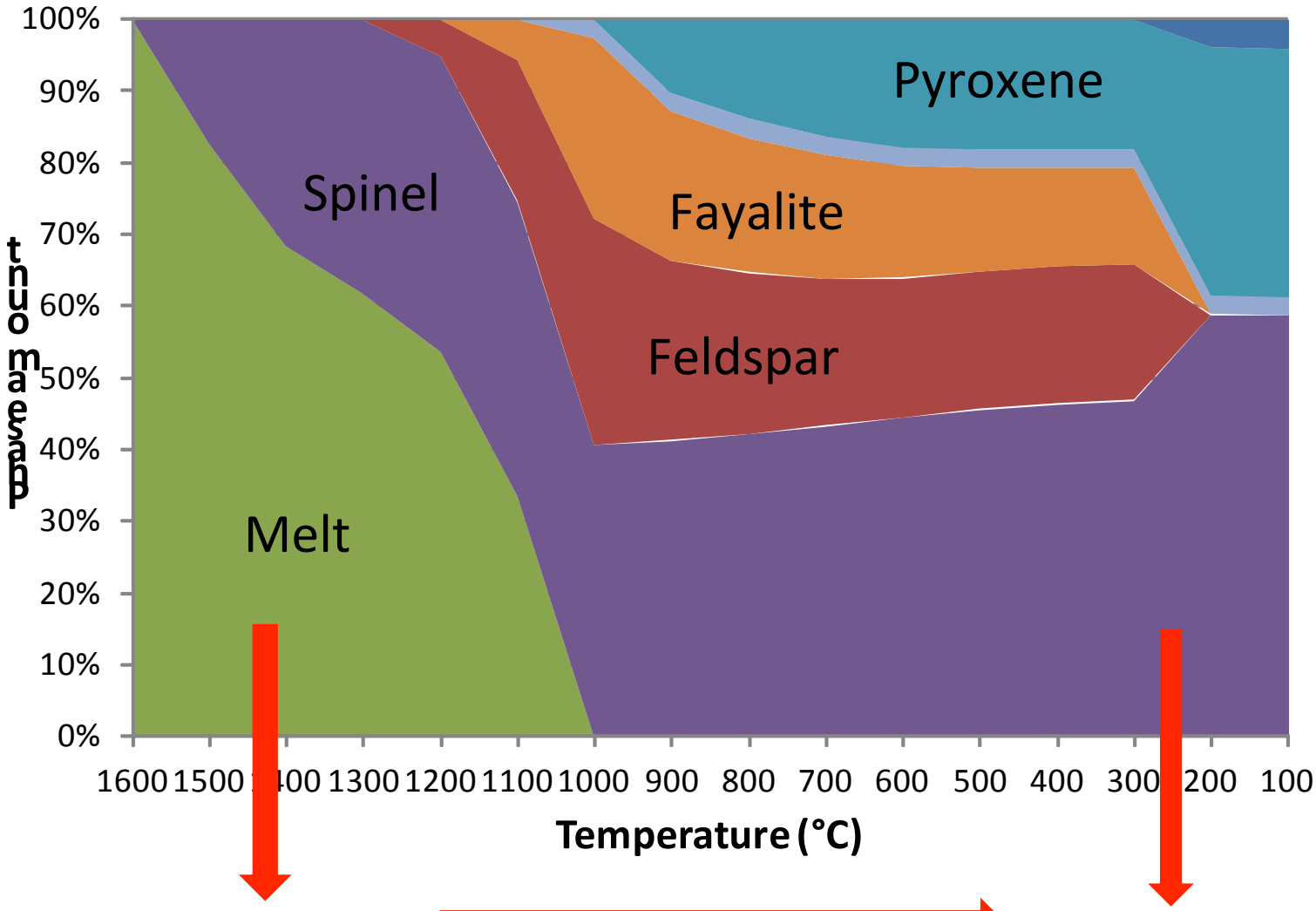


	Mass(%)
Na_2O	18,22
CaO	3,44
Al_2O_3	28,25
FeO	14,67
SiO_2	33,10
Total	99,21

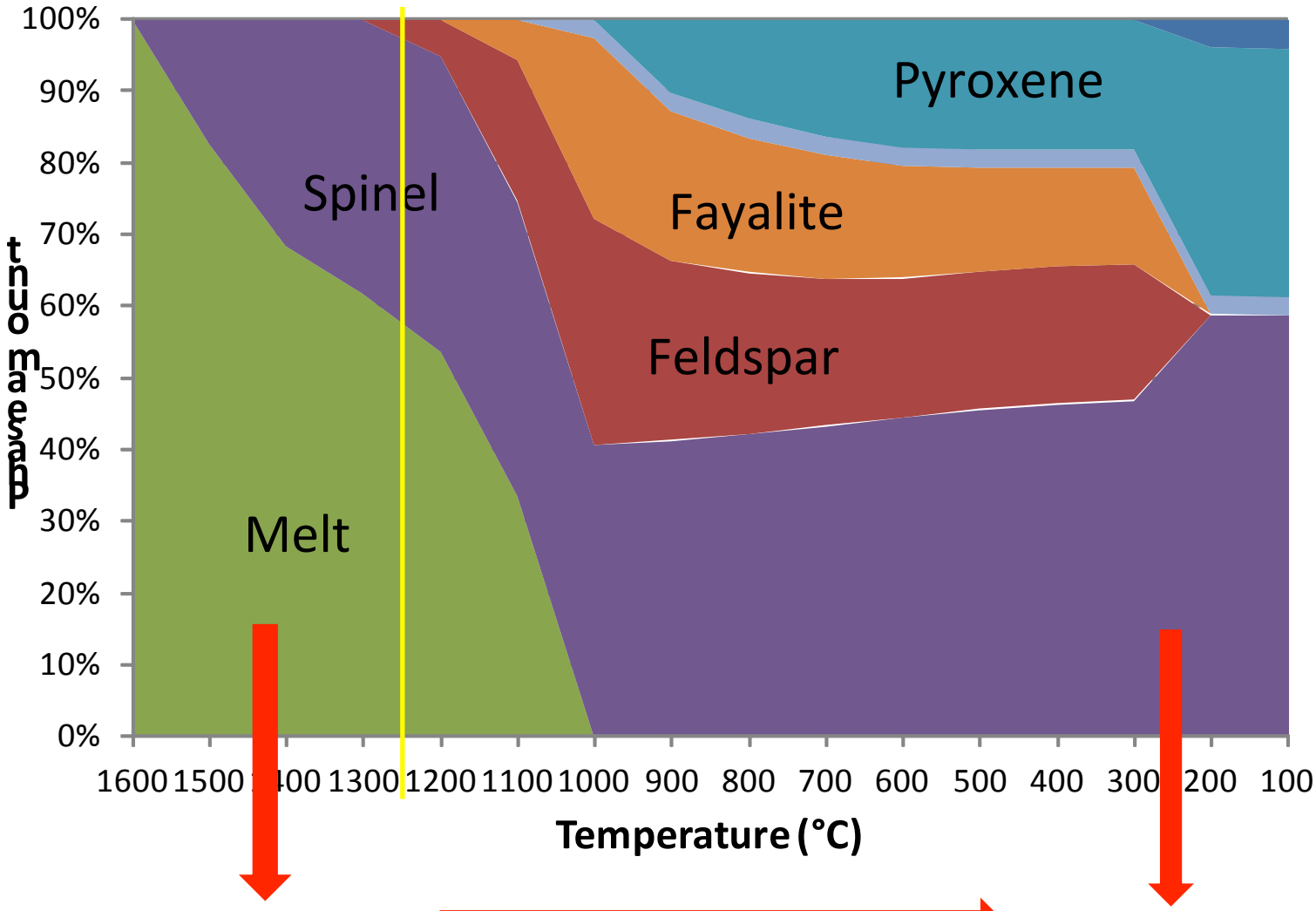




Thermodynamic modelling



Thermodynamic modelling

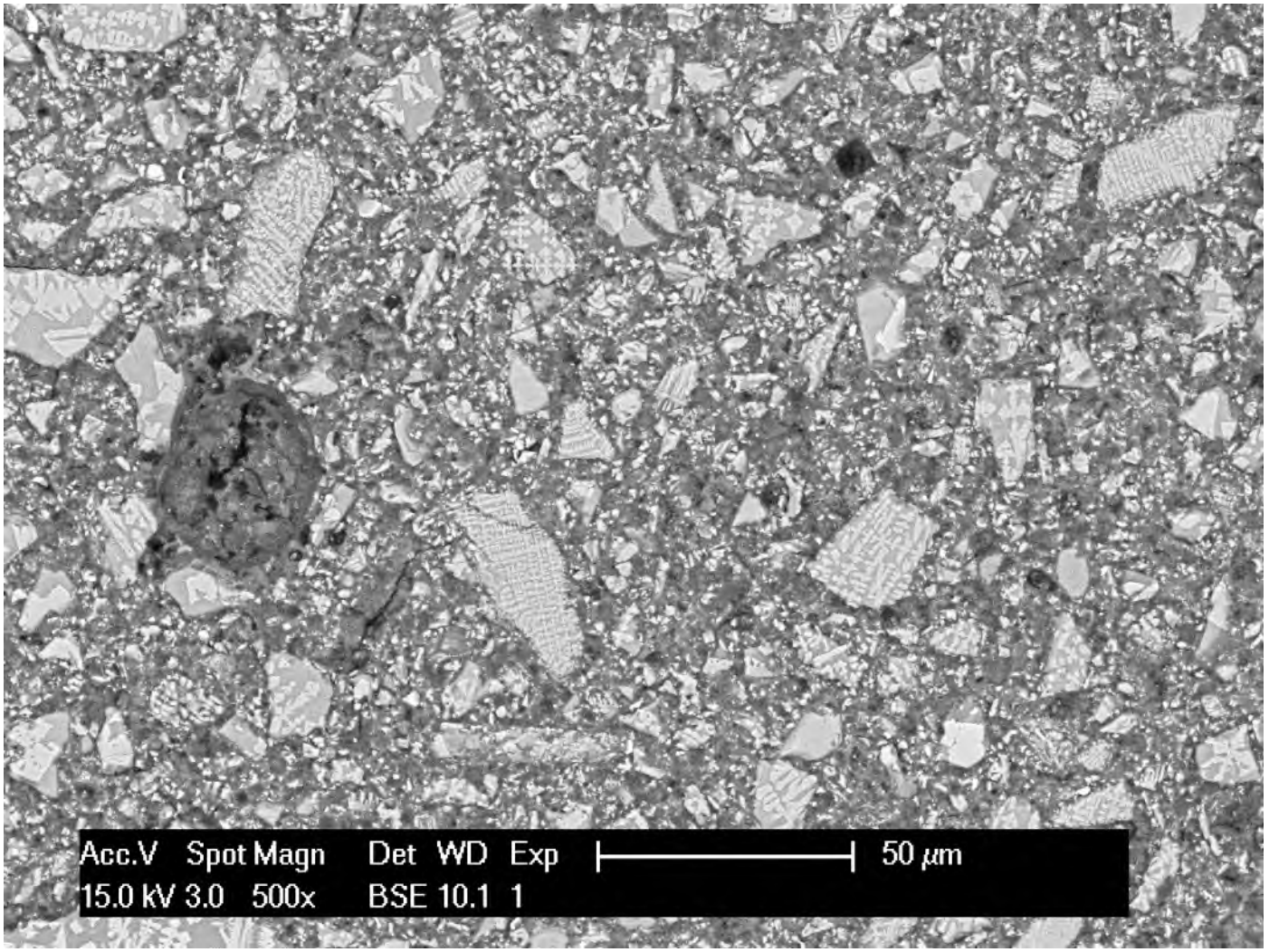


Controlled cooling rate

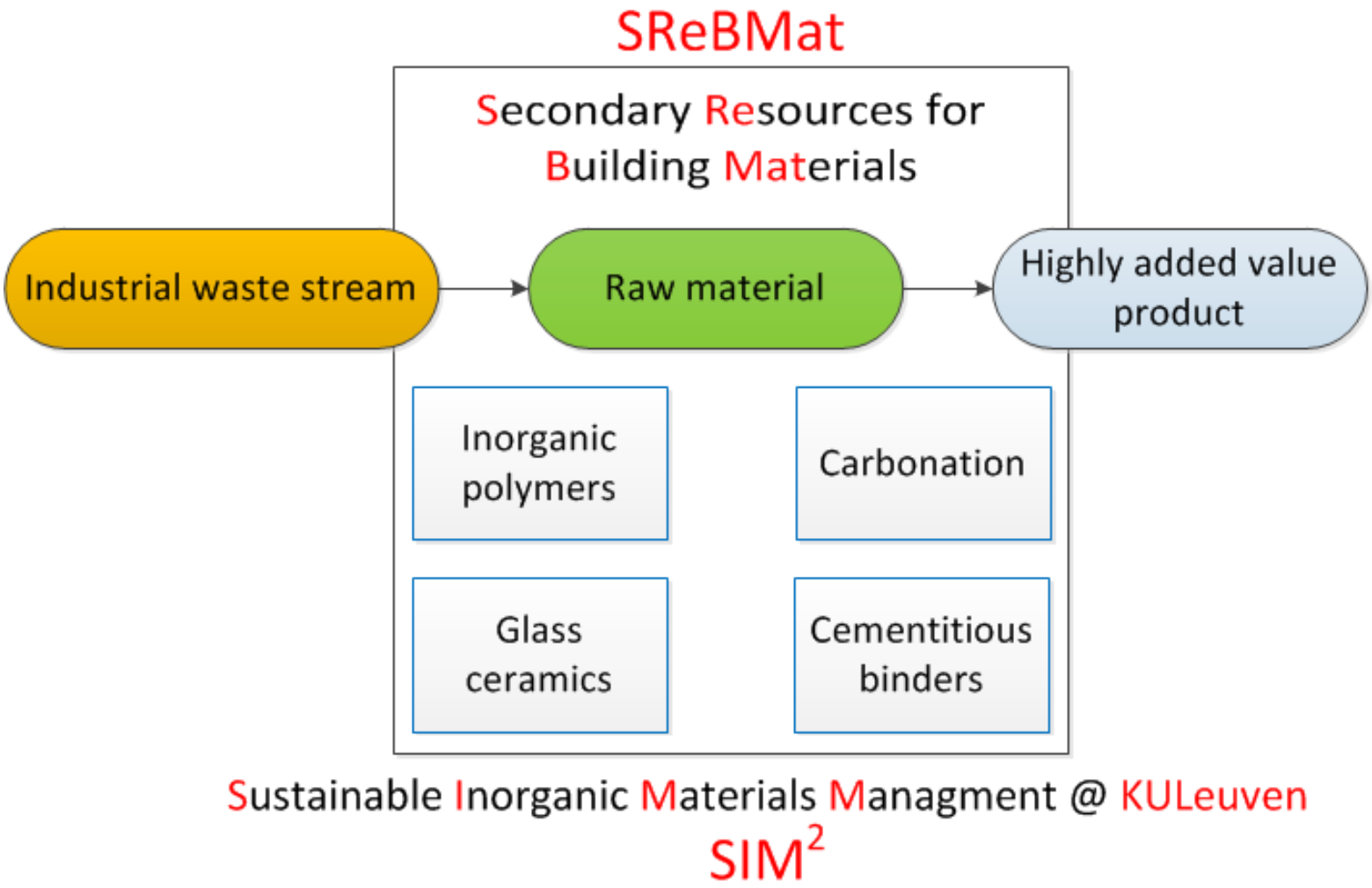
⇒ Determine amount of crystal/glass
⇒ Crystallisation = modification melt chemistry

⇒ Moderate reactivity, hardening in hours
⇒ Strength > 100 Mpa
⇒ No Cracks

Controlled cooling rate = improved properties



Sustainable inorganic materials managment



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Sustainable inorganic materials managment

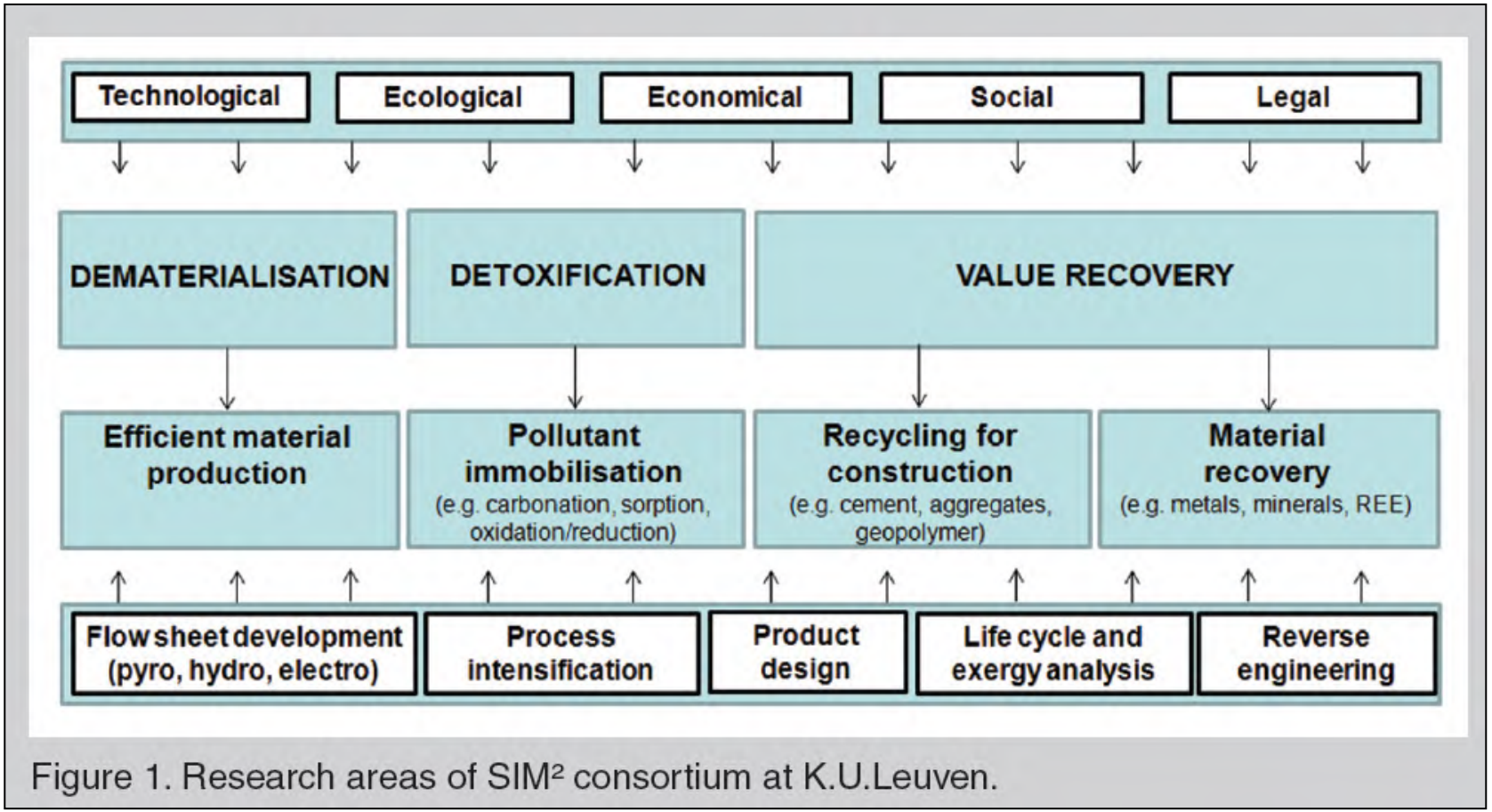

Figure 1. Research areas of SIM² consortium at K.U.Leuven.

Jones et al., JOM, 2011.

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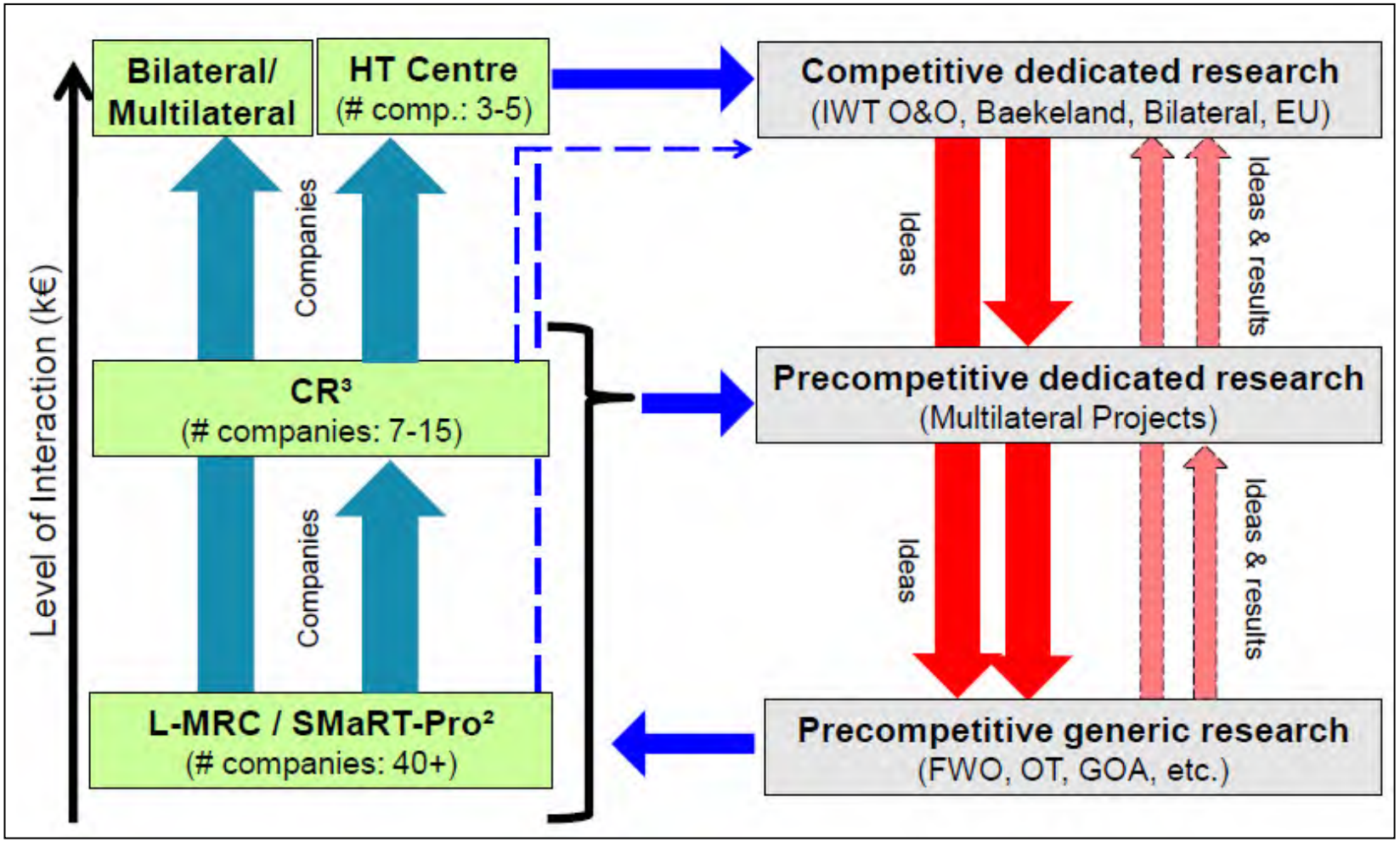
Sustainable inorganic materials managment



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