

ZeroCO₂-Glass – Investigations on Meltability of CO₂-free Glasses

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Tomasz Engemann, Prof. Dr. Christian Roos

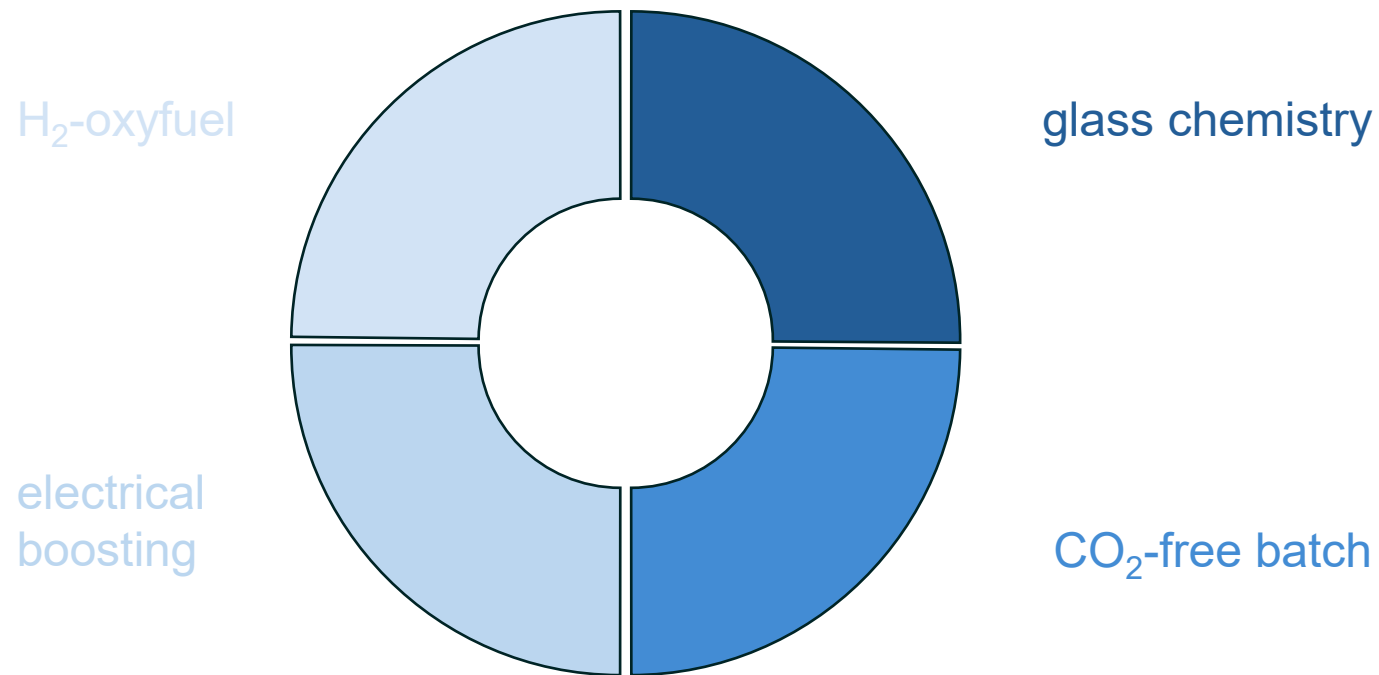
Institute of Mineral Engineering
Chair of Glass and Glass-Ceramic



ZeroCO₂-Glass – Investigations on Meltability of CO₂-free Glasses

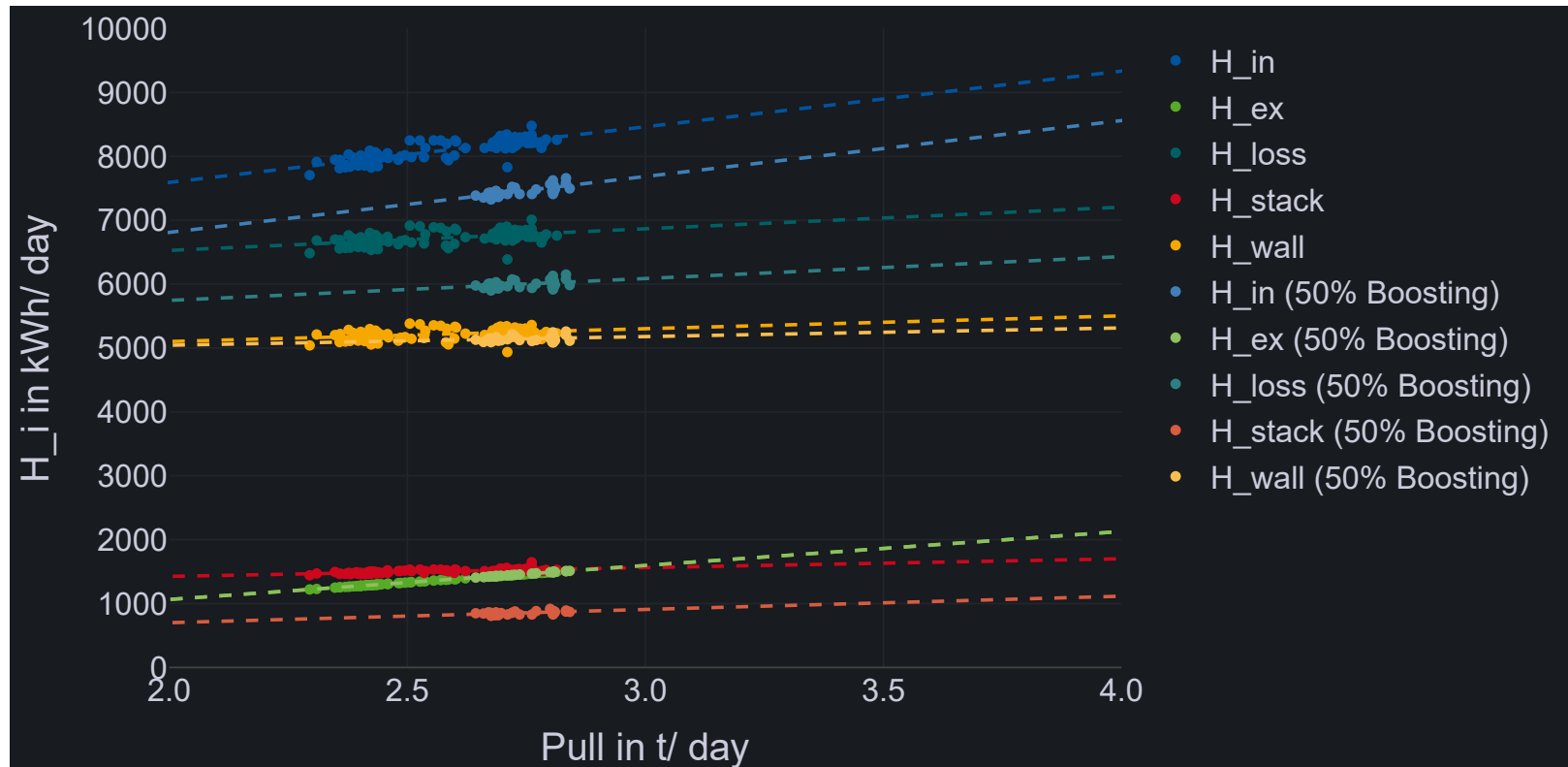
Motivation – ZeroCO₂Glas

- All-encompassing approach to **melt** and form **container glass** in a **CO₂-neutral way** and with **considerable energy savings**



Evaluation of electrical boosting increase

Electrical Boosting increase – Furnace Performance



gas + boosting input

batch reaction + heatup energy

$$H_{loss} = H_{in} - H_{ex}$$

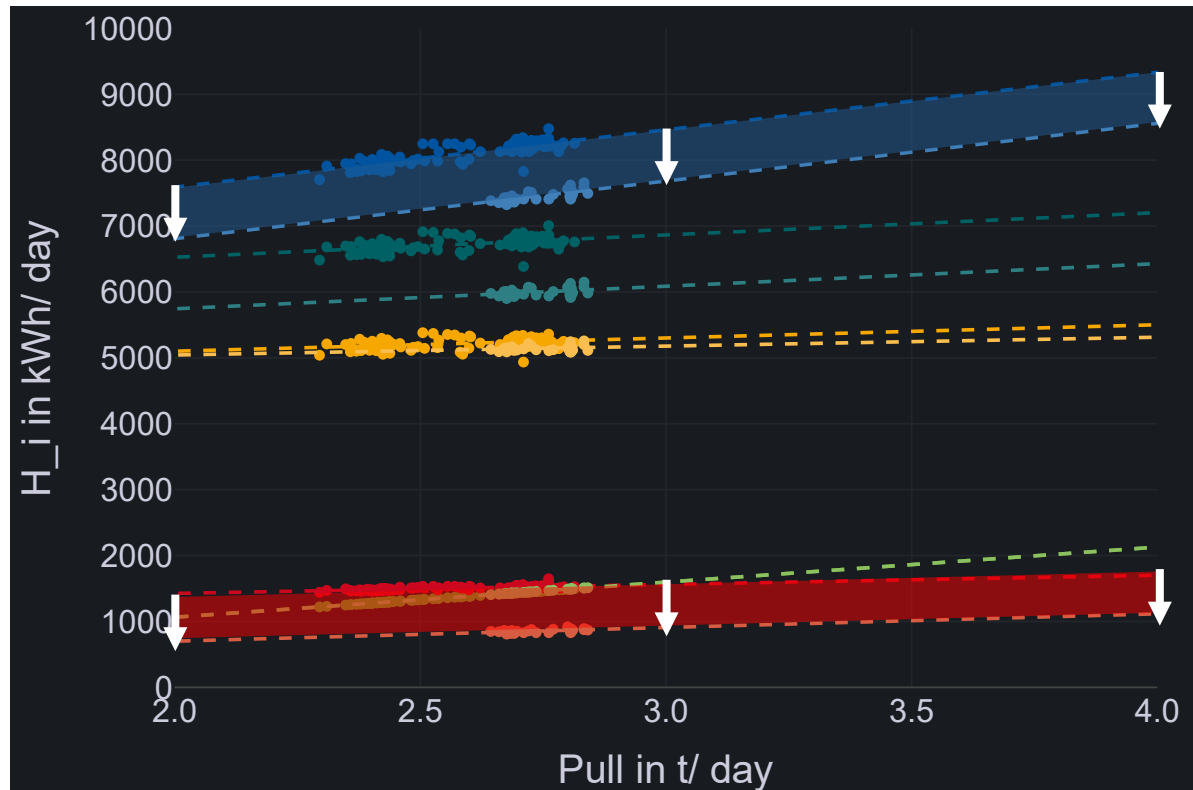
energy loss through chimney

$$H_{wall} = H_{loss} - H_{stack}$$

energy loss over walls/structure/cooling etc.

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Electrical Boosting increase – Furnace Performance



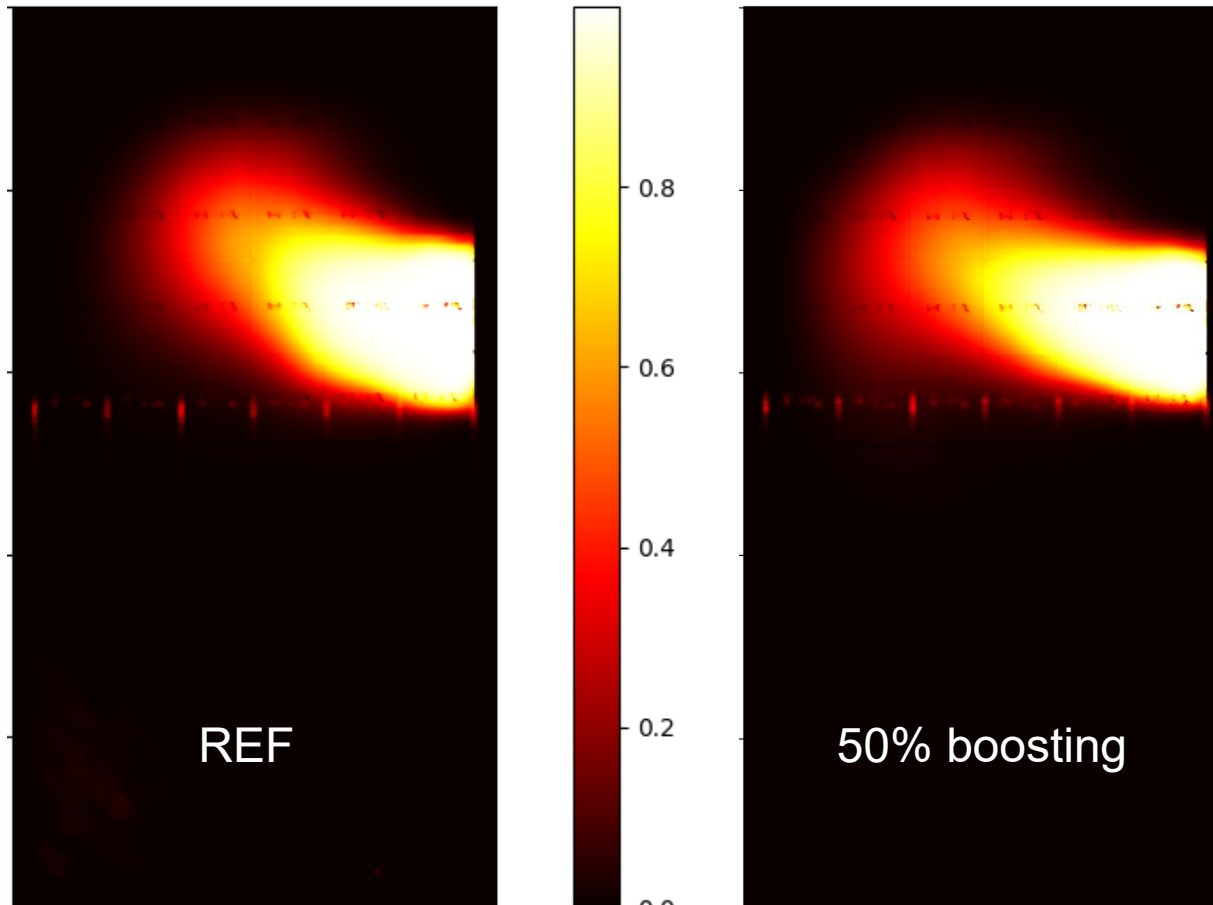
Energy consumption decrease by >10%

Wall losses stable or slightly decreasing
-> Energy consumption decrease even higher on larger furnace due to lower proportion of wall losses

Energy loss through waste gas cut by half

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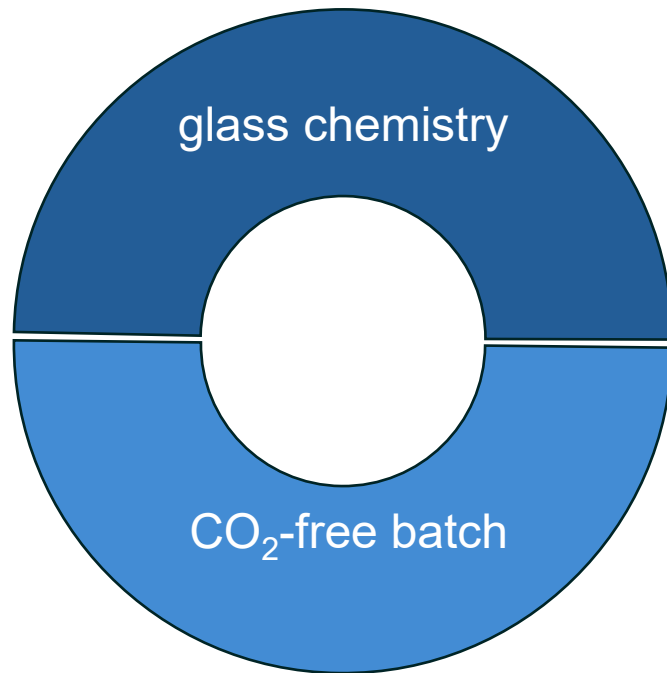
Electrical Boosting increase – Batch coverage



No significant increase in batch coverage despite 70°C lower crown temperature.

Motivation – Alternative Chemistry and Melting

- All-encompassing approach to melt and form container glass in a CO₂-neutral way and with considerable energy savings



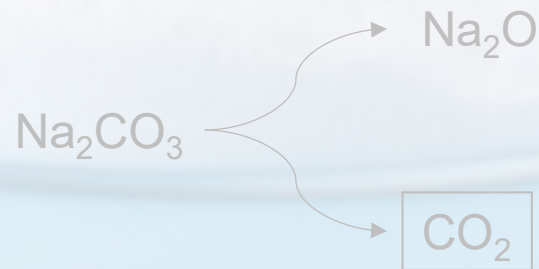
- approx. 300 kg of **CO₂ emission** per ton of glass, 100 kg from the batch
- new glass chemistry with reduced reaction enthalpy enables **energy savings** up to 10%
- **melting strategy** can be adapted to the batch



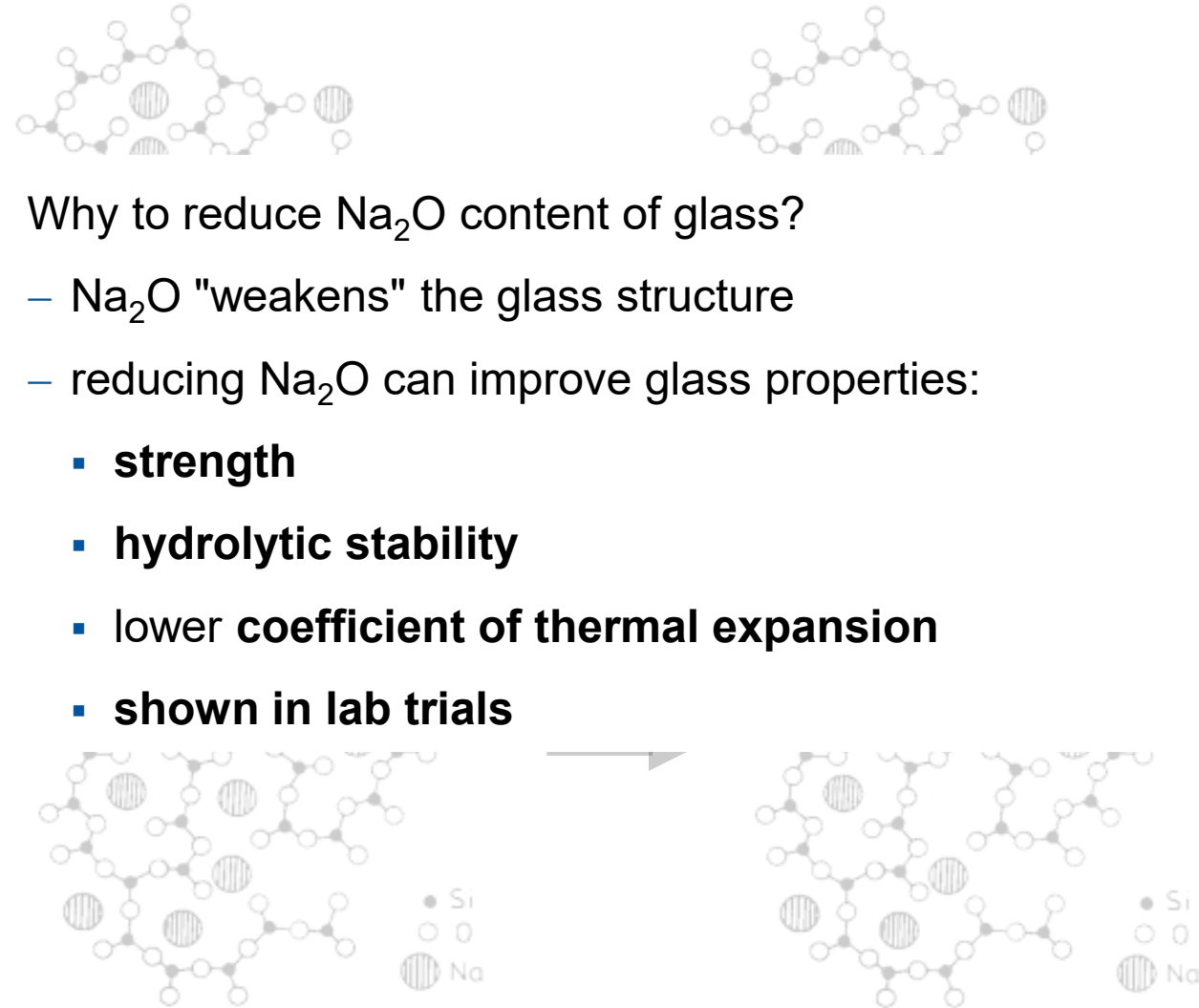
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Motivation – Alternative Chemistry and Melting

- Why to remove soda from batch?
 - **synthetic** raw material
 - **most expensive** raw material
 - soda **releases CO₂** during decomposition in the melting tank

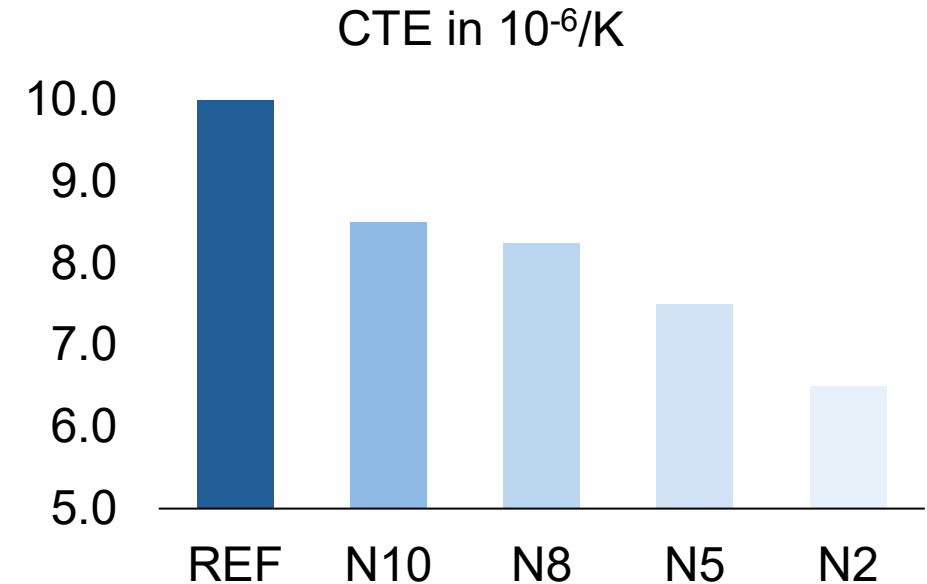
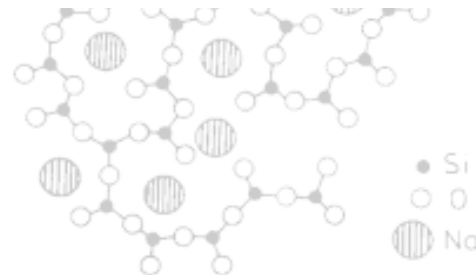
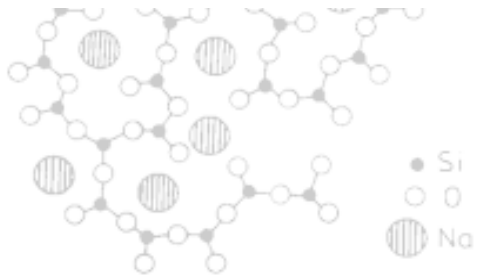


- Why to reduce Na₂O content of glass?
 - Na₂O "weakens" the glass structure
 - reducing Na₂O can improve glass properties:
 - **strength**
 - **hydrolytic stability**
 - lower **coefficient of thermal expansion**
 - **shown in lab trials**



Motivation – Alternative Chemistry and Melting

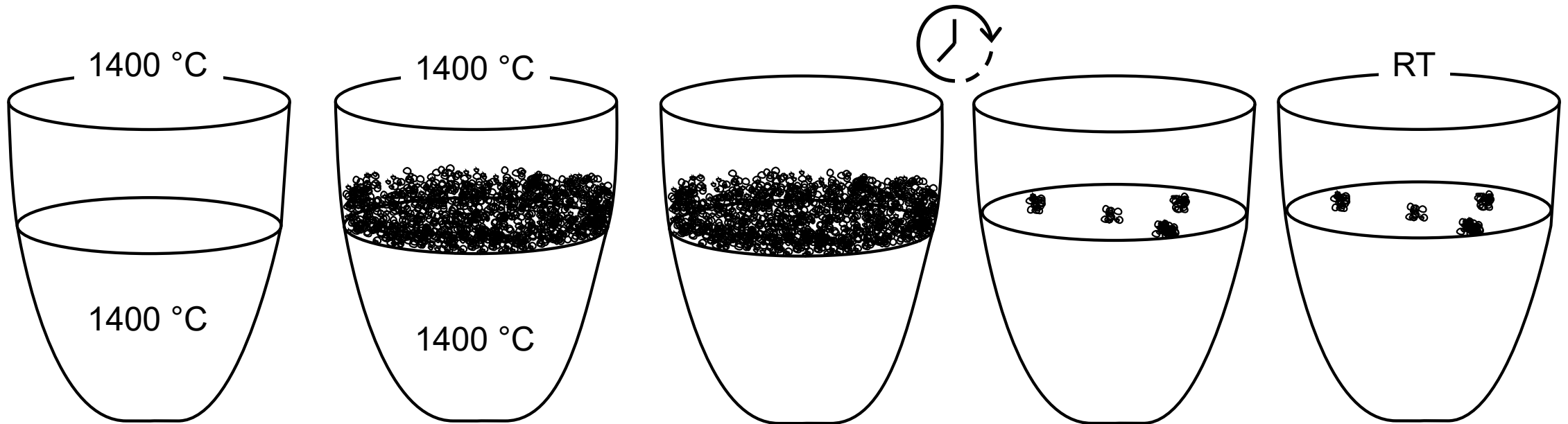
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 - Na₂O "weakens" the glass structure
 - reducing Na₂O can improve glass properties:
 - **strength**
 - **hydrolytic stability**
 - lower **coefficient of thermal expansion (CTE)**
 - **shown in lab trials**



Evaluation of batch melting

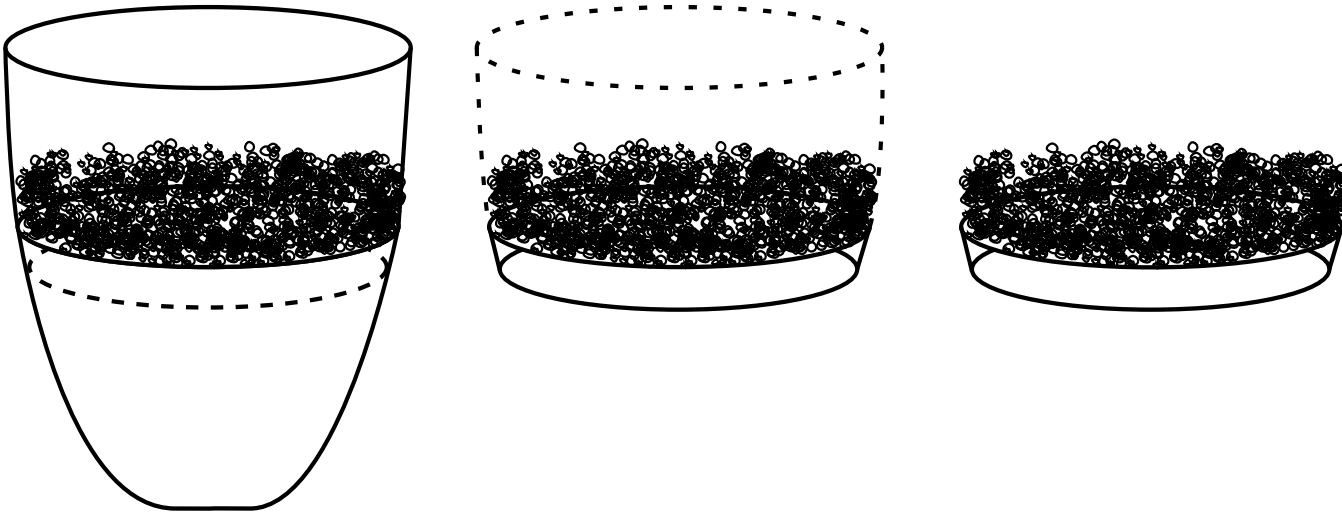
Evaluation of batch melting

- 50 g batch charged on 250 g of melt at 1400 °C **inside furnace** to avoid cooling of melt reservoir
- fixed dwell time
- **air-quenched to RT** to prevent further batch reactions



Evaluation of batch melting

- Separate batch blanket
- Milling <125 µm
- XRD Rietfeld analysis with K-factor method to determine quantity and type of unmelted batch



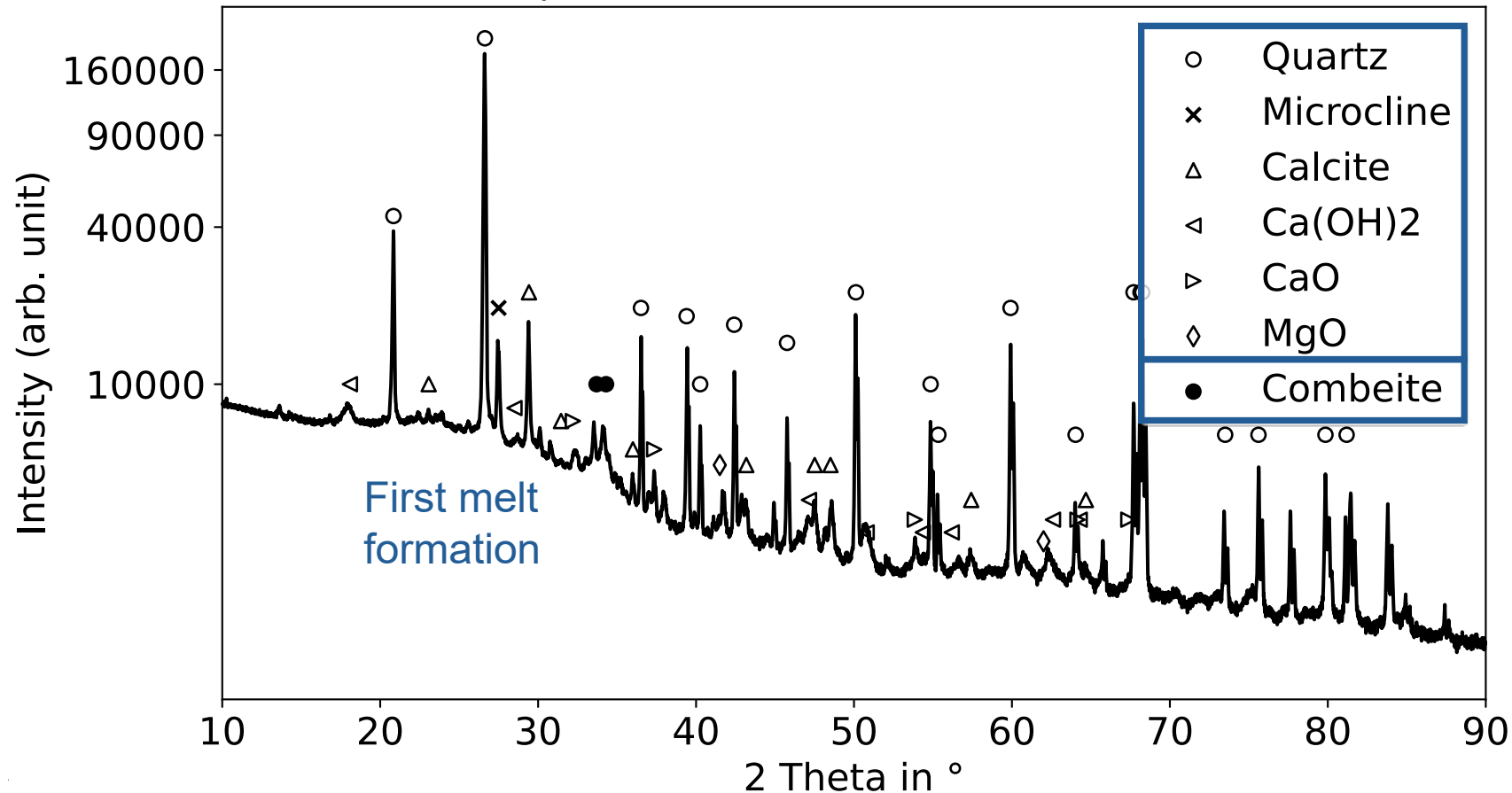
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Evaluation of batch melting



Evaluation of batch melting – Rietveld refinement

XRD pattern of batch at 1400°C, dwell 30 s

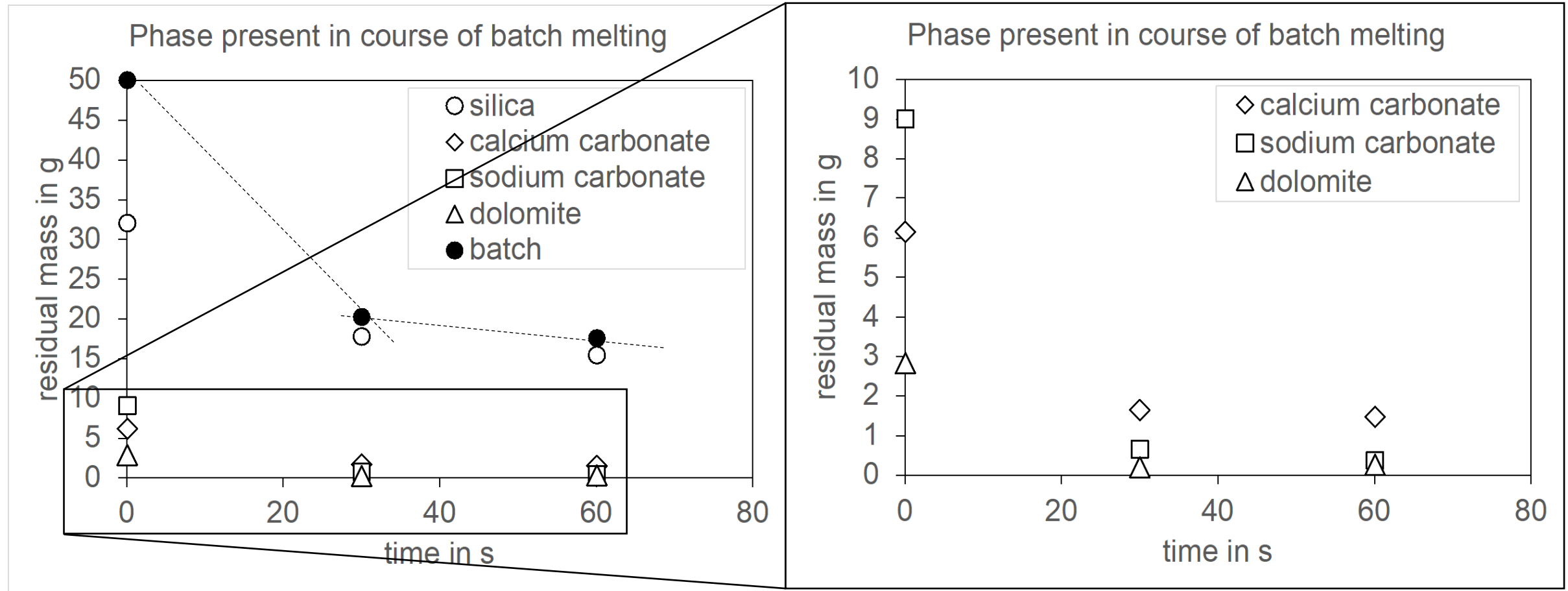


Sand
Limestone
Dolomite
Soda

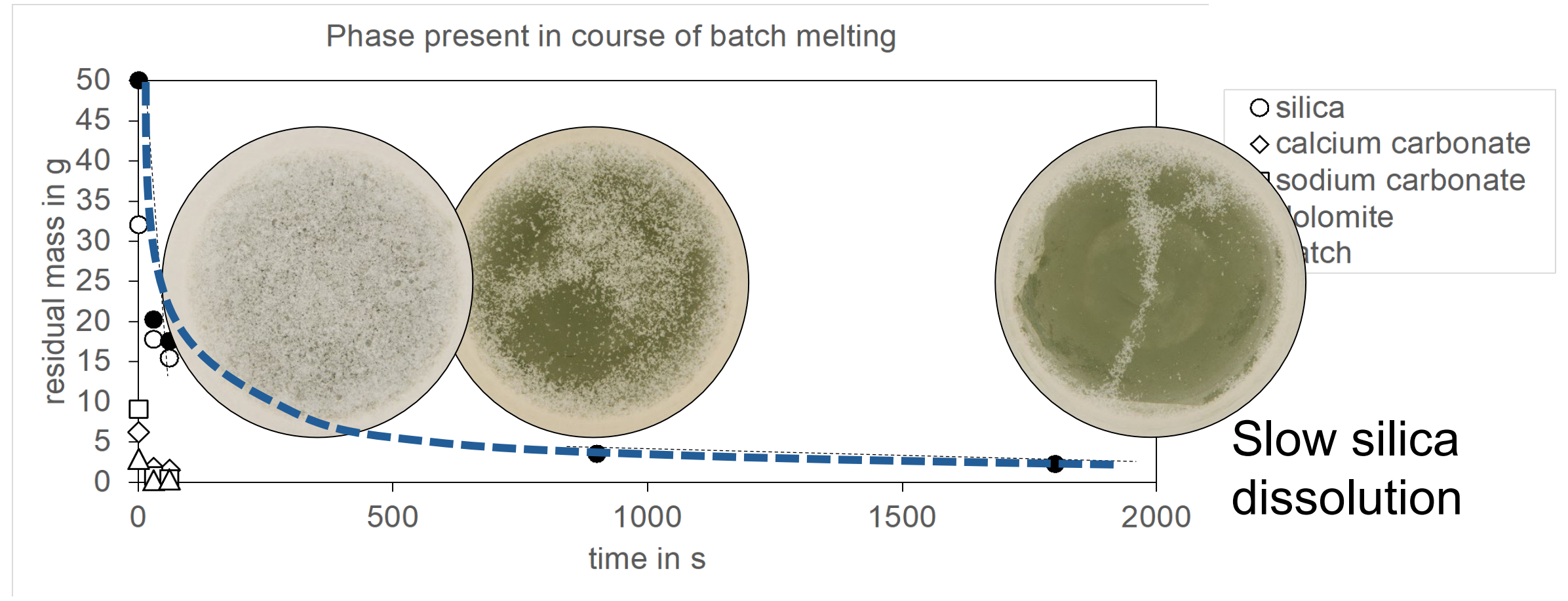
} Raw Materials

$\text{Na}_4\text{CaSi}_3\text{O}_9$ Solid state
 $\text{Na}_2\text{Ca}_2\text{Si}_3\text{O}_9$ reactions

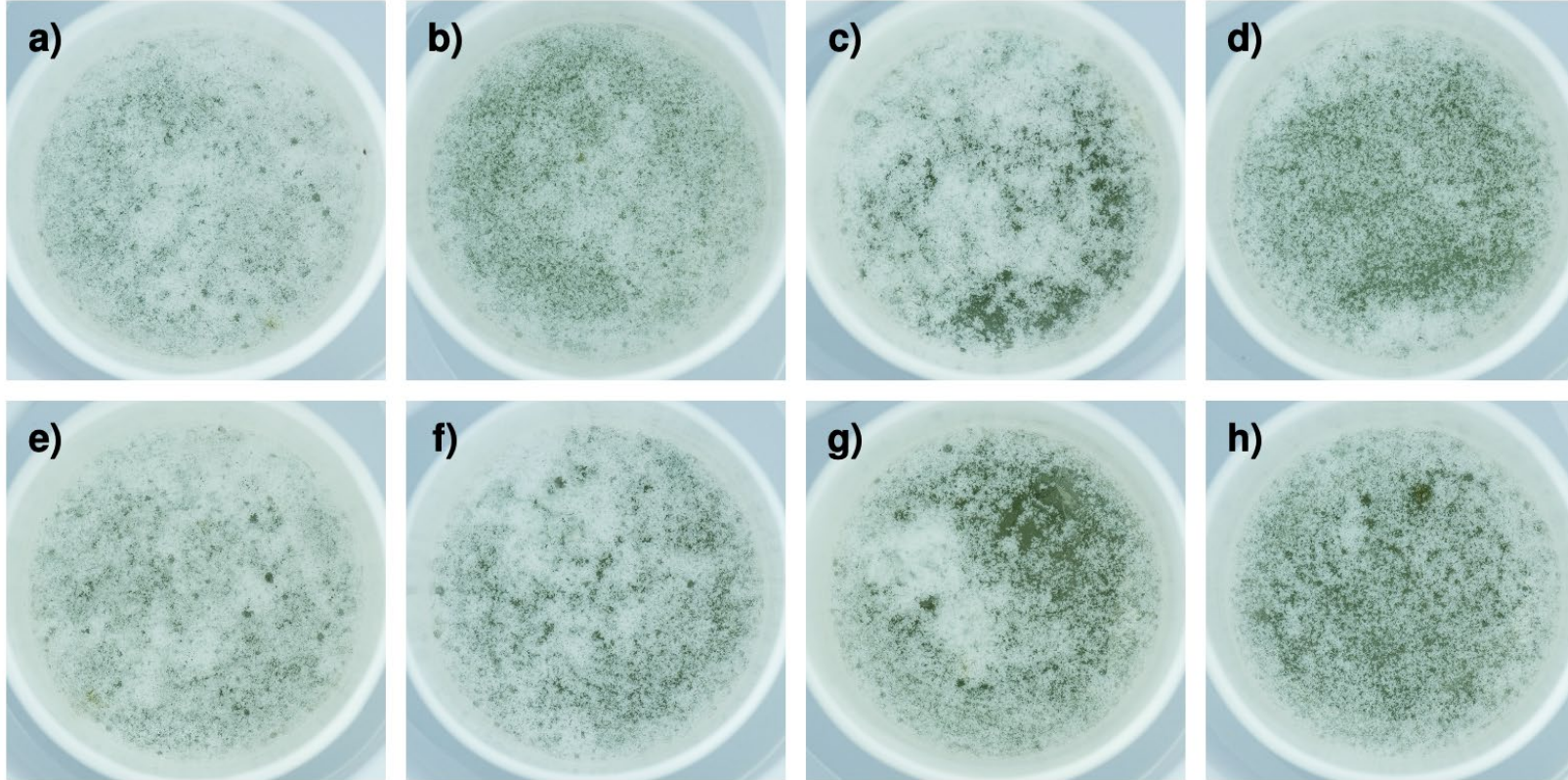
Evaluation of batch melting – SLS



Evaluation of batch melting – SLS



Evaluation of batch melting – SLS



$t = 10 \text{ min}$

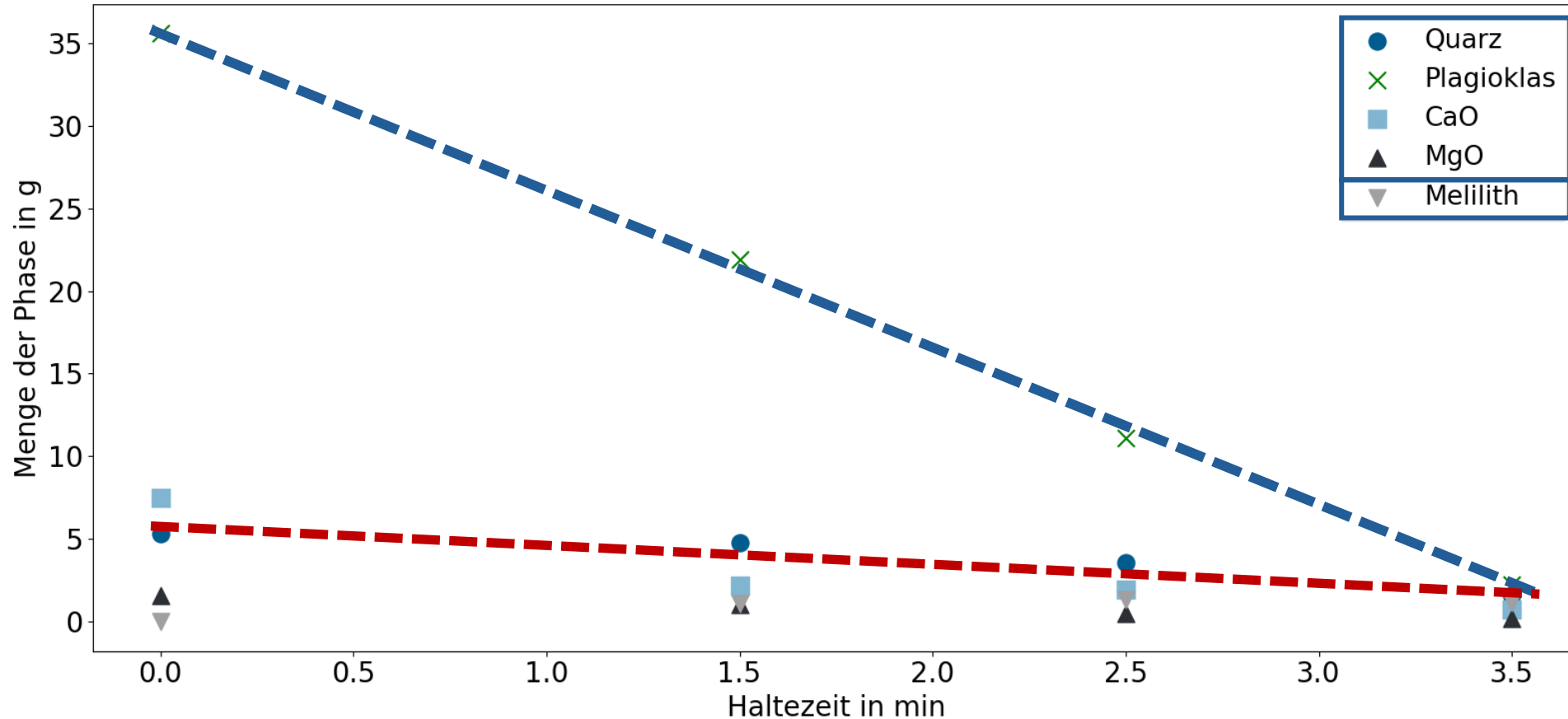
$t = 15 \text{ min}$

$t = 20 \text{ min}$

$t = 25 \text{ min}$

Slow silica
dissolution

Evaluation of batch melting – N8



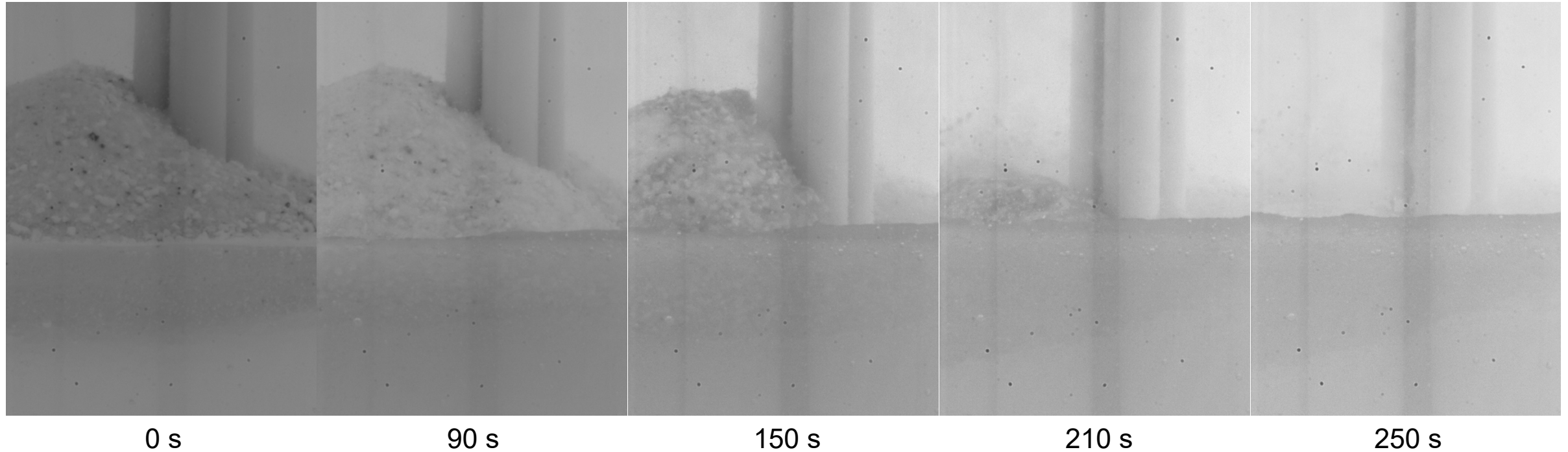
Raw Material

Melilite formation
uncritical due to
liquidus lower than melt
temperature

Avoiding sand/silica
accelerates melting-in

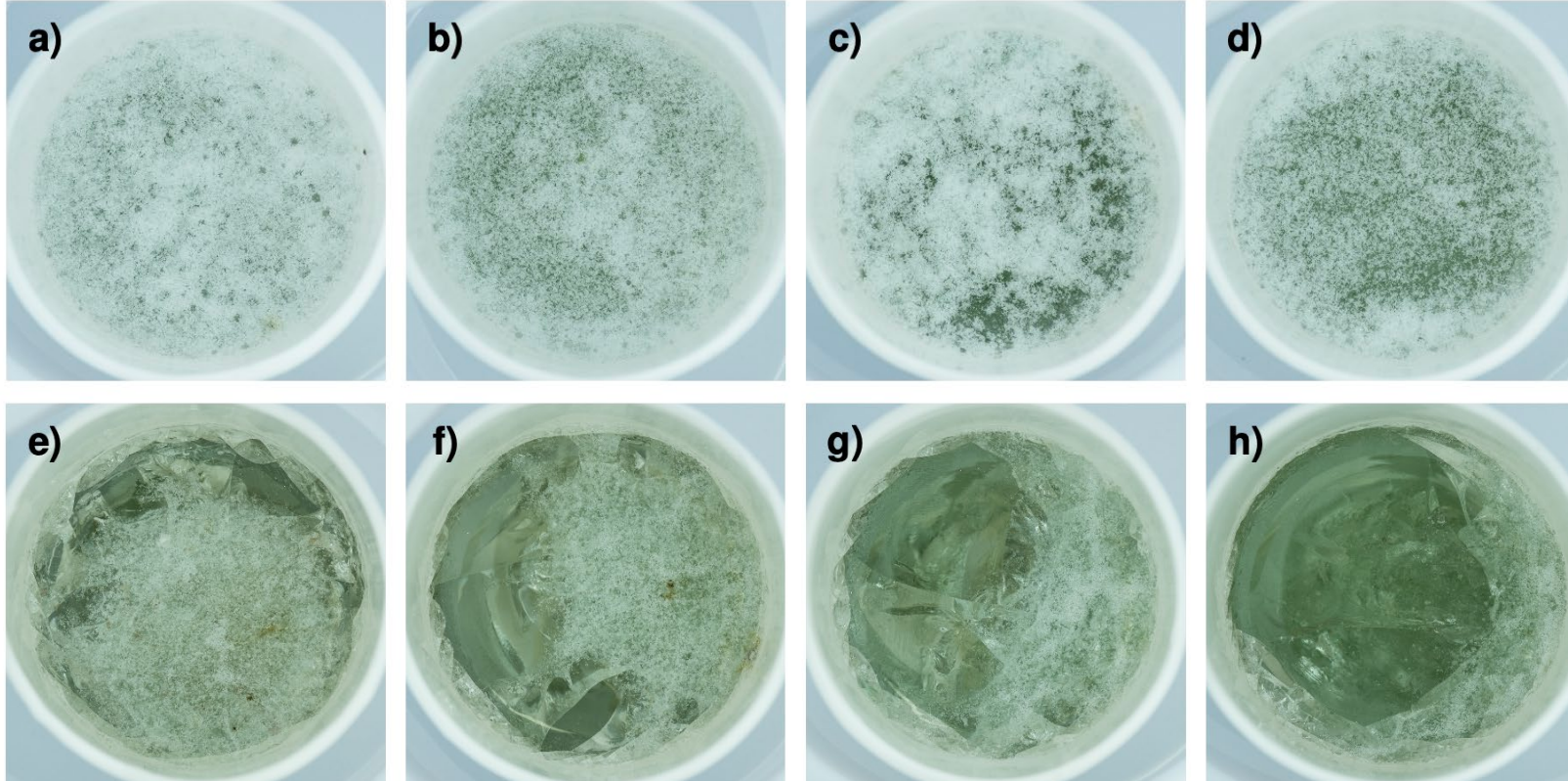
Silica from impurities
remains problematic

Evaluation of batch melting – N8



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Evaluation of batch melting – N5



SLS reference batch

soda-ash free batch
5 % Na₂O by weight

$t = 10 \text{ min}$

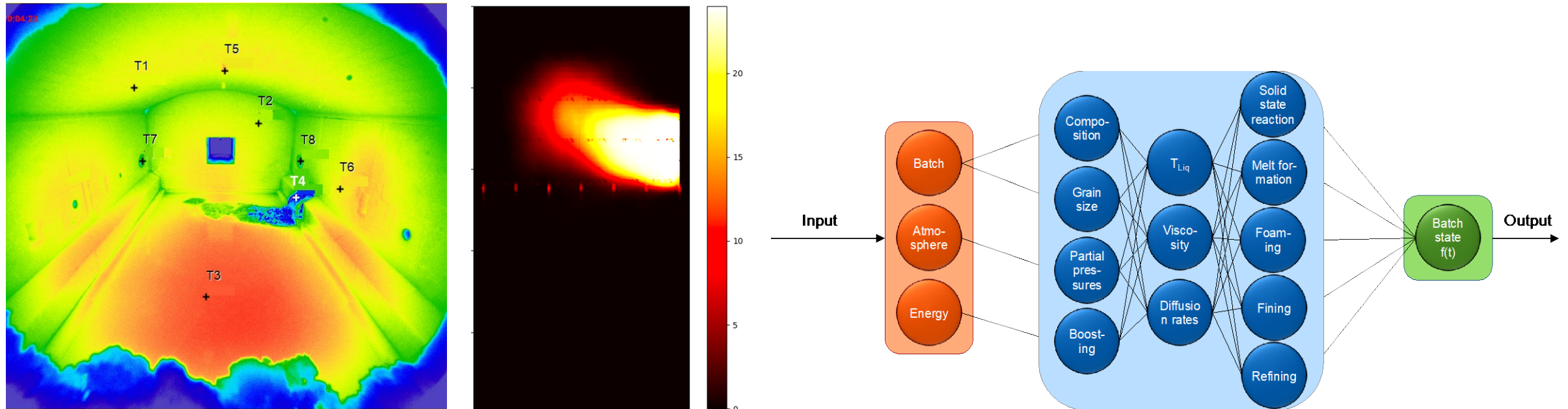
$t = 15 \text{ min}$

$t = 20 \text{ min}$

$t = 25 \text{ min}$

Outlook — Understanding the batch melting

- Use furnace camera and batch monitoring system to evaluate batch melting in 2.5 tpd pilot plant
- The aim is to gain a **profound understanding** of the **melting and fining behaviour** based on **batch and glass properties** in **interaction with the energy input and furnace atmosphere**.



Thank you for your attention



Tomasz Engelmann, M. Sc.
RWTH Aachen University

Institut für Gesteinshüttenkunde
Lehrstuhl für Glas und Glaskeramik

Tel.: +49(0)241/80-98344
E-Mail: t.engelmann@ghi.rwth-aachen.de



RWTHAACHEN UNIVERSITY