Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

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COMPARATIVE STUDY OF ALTERNATIVE BINDERS FOR CONCRETE SEALING STRUCTURES IN ROCK SALT

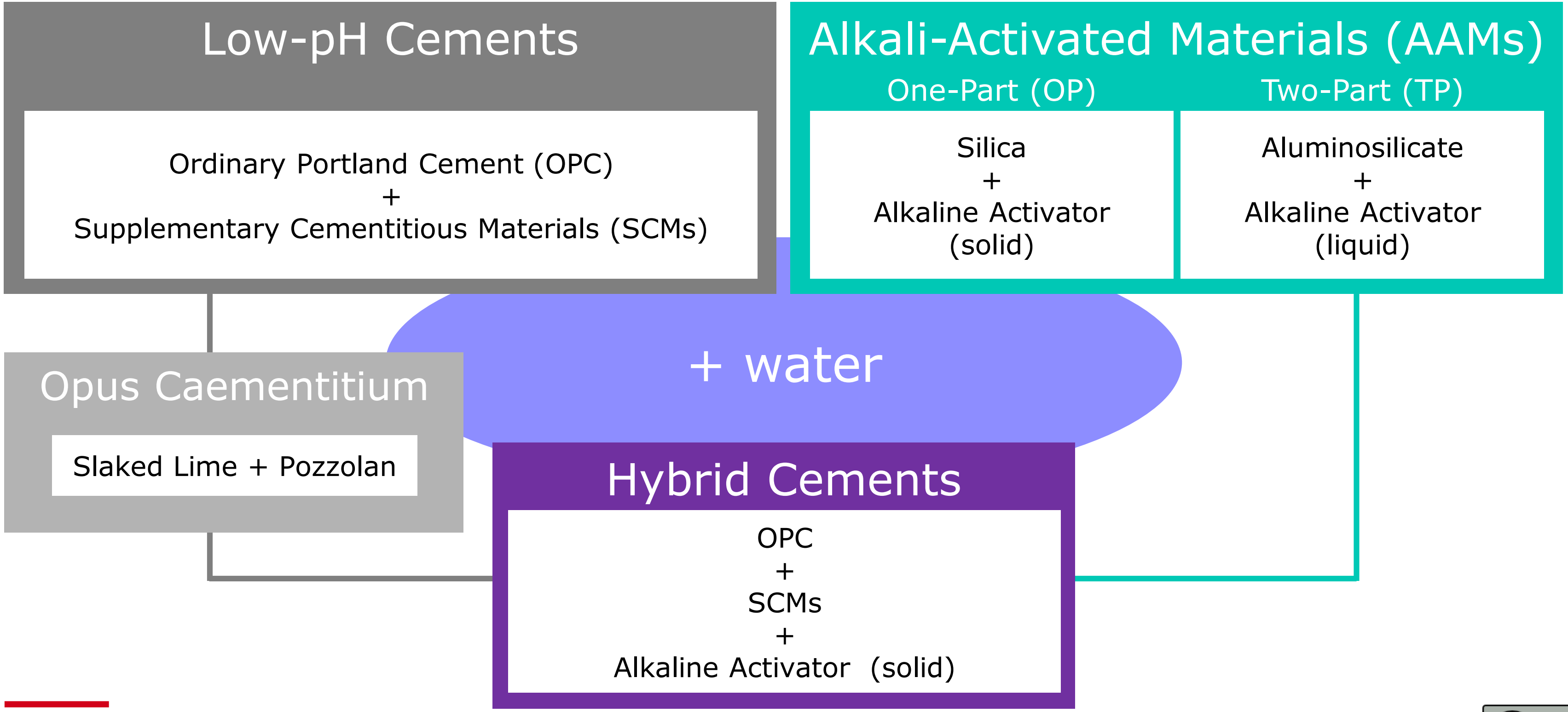
P. Sturm, G.J.G. Gluth, J. Moye, S. Garel, H.-C. Kühne

Background

The save disposal and long-term management of radioactive wastes have become key factors for the current society, as well as for future generations. In Germany, especially the salt-containing 'Zechstein' formations are considered to be suitable for this purpose, due to their low permeability. The long-term sealing function of a barrier is mainly determined by stress-strain interactions between the host rock and the sealing structure, especially at early ages after construction, as well as the permeability with respect to gases and liquids at later ages.

Despite significant progress that has been made with research on specific cements (e.g. magnesium oxychloride cement (MOC) and blended Portland cements (low-pH cements), there is still room for improvement, e.g. in terms of **heat evolution** during hydration and shrinkage.

Studied Binder Systems



Starting Materials and Sample Nomenclature

Class	TP AAM	OP AAMs		Low-pH	Opus	Hybrid	OPC
Sample	F1	O1	O2	M2 (REF)[1]	R1	H1	OPC
Solids (b)	Fly Ash (FA)	Silica Fume; Sodium Aluminate		OPC; Slag; FA	Slaked Lime; Trass	OPC; Slag; Na_2CO_3	OPC
Liquids (b)	Sodium Silicate-sln; NaOH-sln						
Water (w/b)	0.55*	0.5	0.4	0.41	0.63	0.4	0.4
Aggregates (A)	Rock Salt						

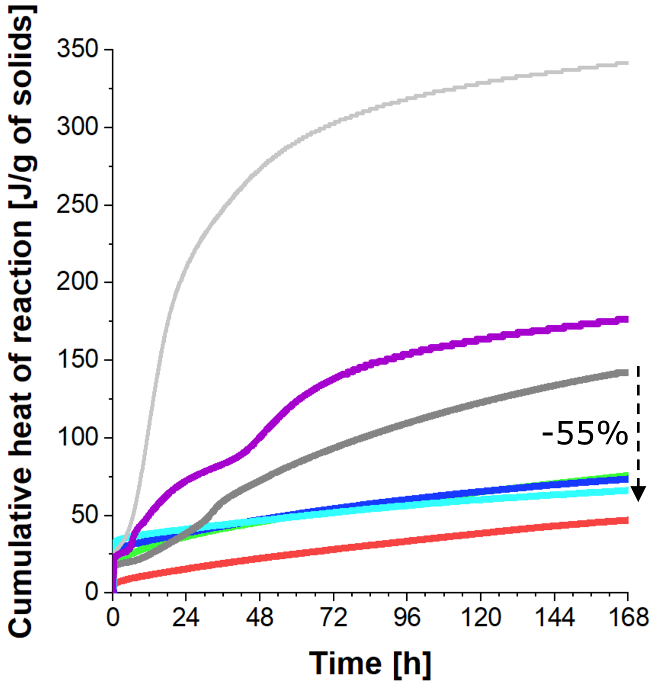
*(liquids(b)+w)/solids(b)

w+b=paste w+b+A=mortar

[1] *DBE 2004 (Unterlagen-Nr.: P 192)*

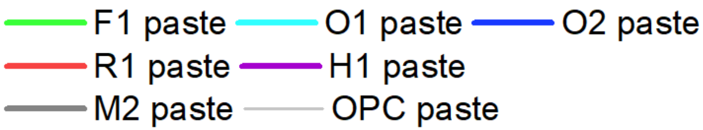
Isothermal Calorimetry (pastes)

(20°C)



Class	Sample (pastes)	Heat of reaction (7d)
AAMs	F1	54.9
	O1	45.9
	O2	48.4
Opus	R1	38.9
Hybrid	H1	154.3
low-pH (REF)	M2	125.4
OPC	OPC	317.6

Low Heat ≤ 270 J/g (DIN EN 197-1)



Isothermal Calorimetry (pastes)

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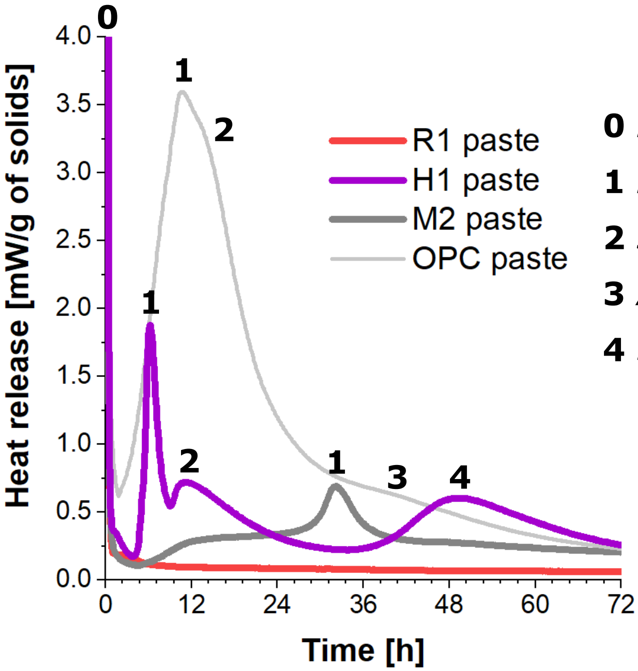


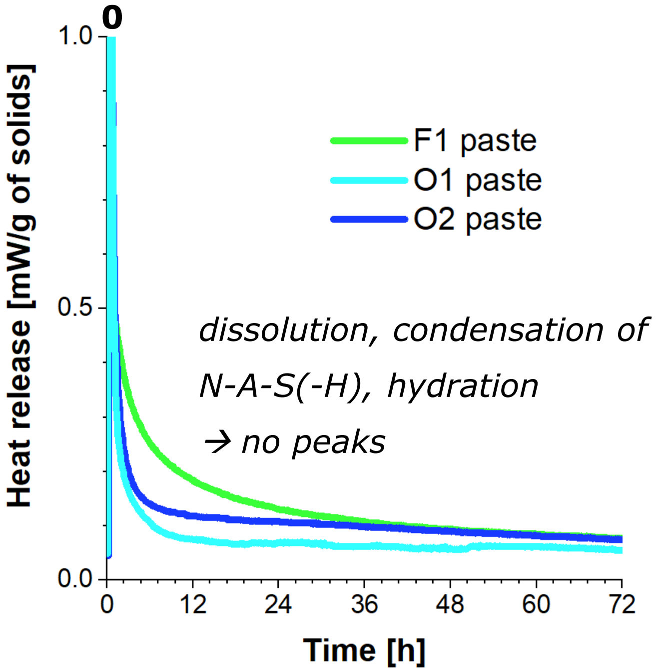
0 *initial dissolution*

1 *main hydration (CSH; CH)*

2 *sulfate depletion*

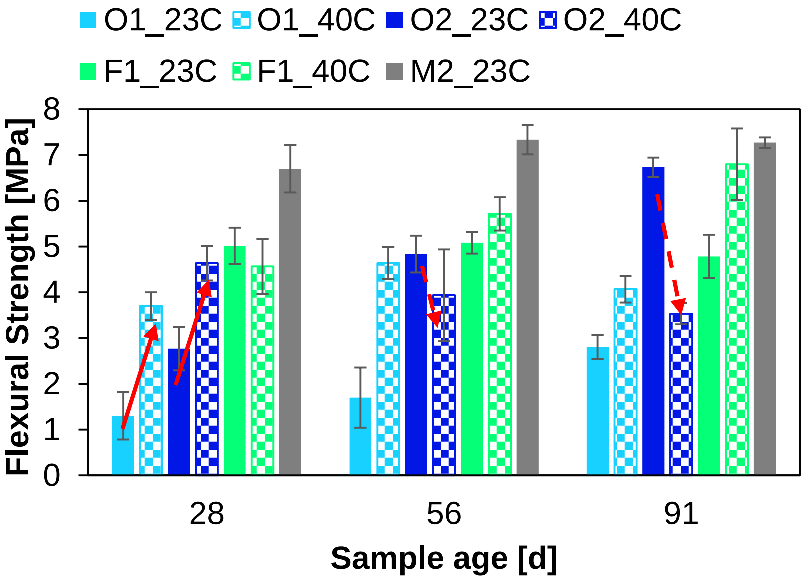
3 *AFt to AFm transformation*

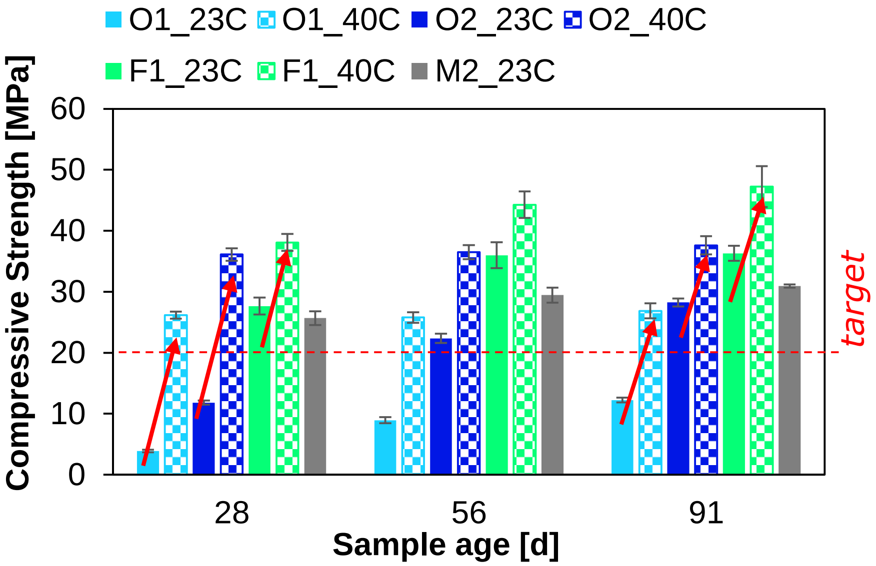
4 *SCM reaction*



Strength Development of the AAM-based Mortars

(Curing at 23°C/50% r.H. or 40 °C/35% r.H.)

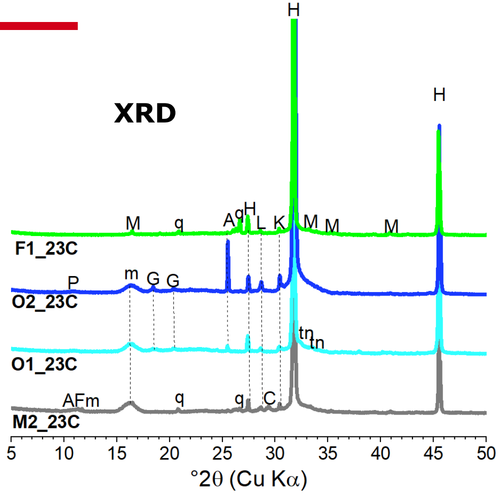




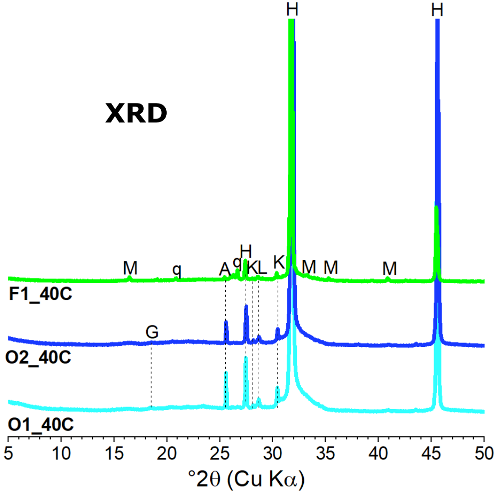
- *at 23 °C comparably low early strength of the AAMs, but highest final compressive strength for F1*
- *at 40 °C acceleration (early strength) and increase of the final compressive strength*
- *at 40 °C decrease of the final flexural strength for O2*

Microstructure of the AAM-based Mortars

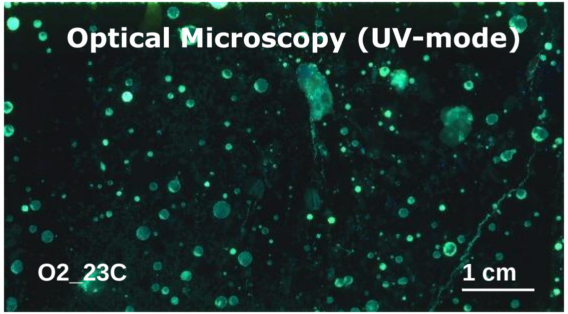
(Curing at 23°C/50% r.H. or 40 °C/35% r.H.)



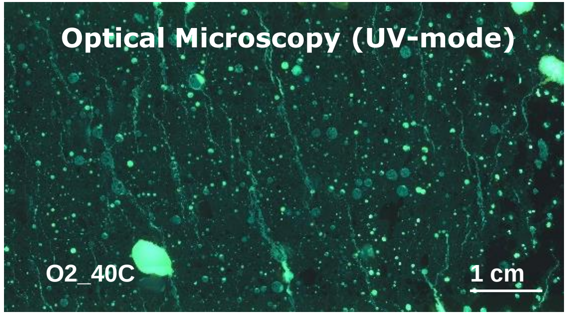
H=halite	**A**=anhydrite
q=quartz	**M**=mullite
C=calcite	**P**=polyhalite
G=gibbsite	**tn**=thermonatrite
M=mirabilite	**AFm**=Friedel`s salt



No major differences, except a slightly increased dissolution rate of the rock salt impurities



Introduction of cracks due to increased drying shrinkage (air humidity),
→ decreased flexural strength (O2)



Conclusions and Future Work

BAM

- Calorimetry (low heat of reaction) and strength development of the AAMs indicate promising reaction kinetics at room temperature
- Improved compressive strength of the AAMs at 40 °C demonstrates an accelerated reaction and presumably an increased degree of reaction (higher dissolution rate of the solid starting materials of the paste)

Next steps:

→Isothermal calorimetry of the AAMs at elevated ambient temperature

→Temperature increase (semi adiabatic calorimetry) and shrinkage of the AAMs under sealed conditions, as expected in-situ

→Adjustments of the hybrid cements with respect to the heat of reaction, chemical durability of the AAMs and hybrid cements (Ph.D. project)

THANK YOU FOR YOUR KIND ATTENTION