CALCIUM SULFOALUMINATE CEMENT CLINKERING

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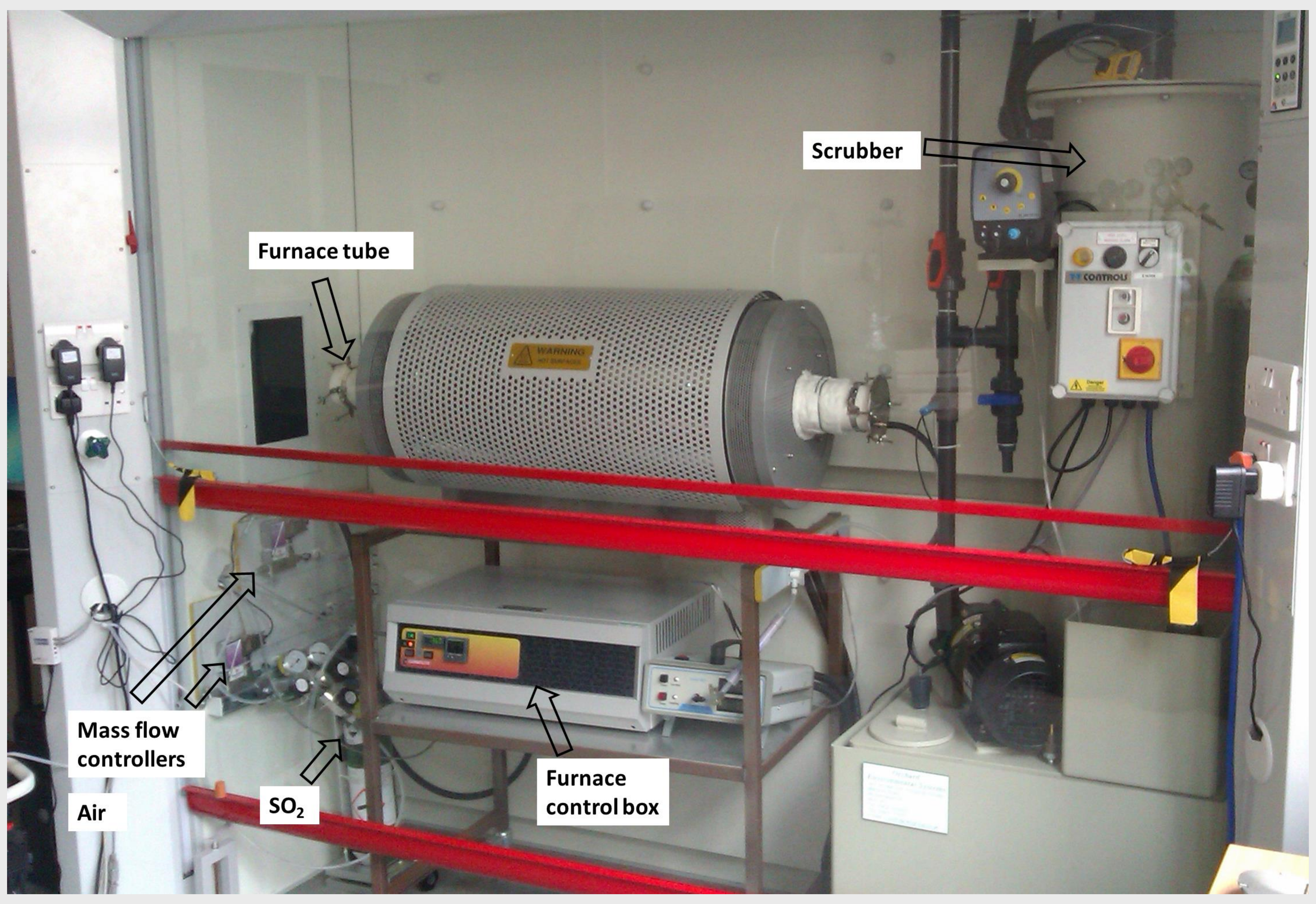
The aim of these studies was to gain understanding in the phase development of calcium sulfoaluminate cements, together with their resulting properties. Laboratory experiments, pilot plant trials and thermodynamic calculation were used for the studies.
The results show that phase development is affected not only by temperature and composition but also by the partial pressures of SO_2 and O_2 gas in the kiln. The mineralogical contents of the sulfate- containing phases, in coexistence with other silicate and aluminate phases, can be controlled reproducibly.

LABORATORY EXPERIMENTS



Raw materials
SO_2+O_2
Lab grade Al_2O_3, SiO_2, $CaCO_3$, Fe_2O_3, $CaSO_4$
Bauxite, clay, limestone

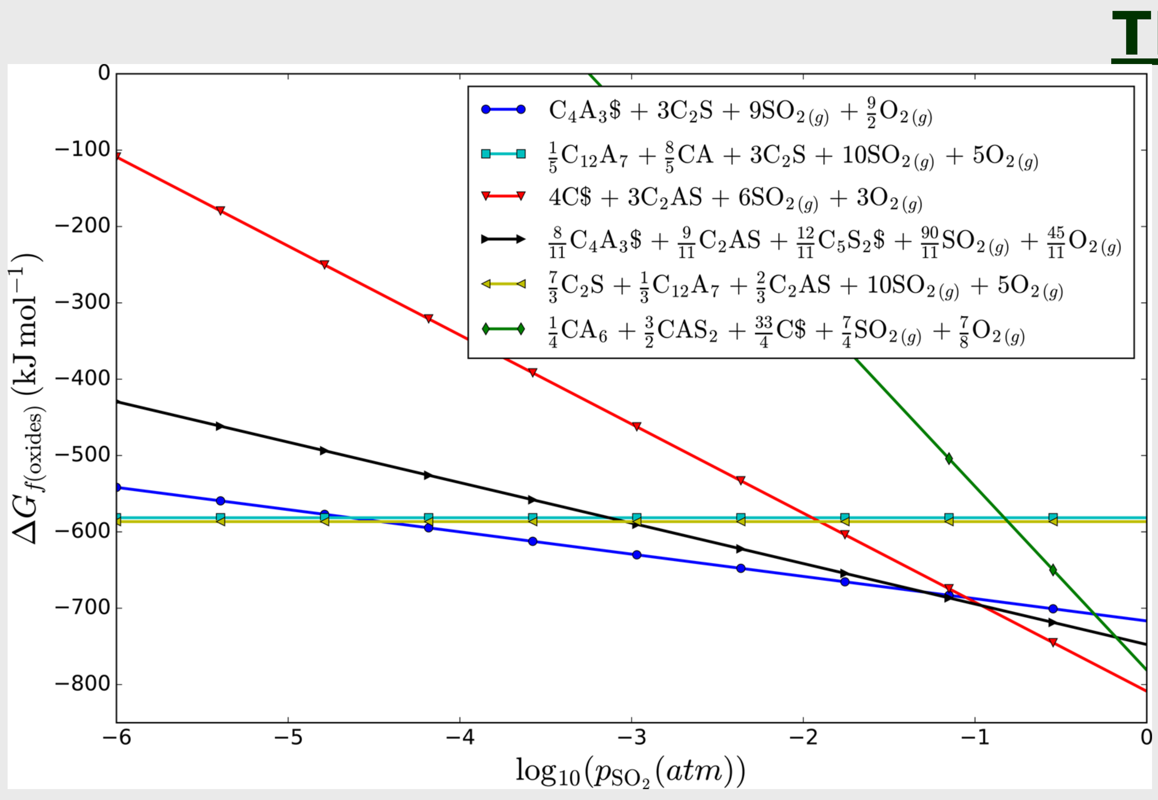
Synthesis
$C\bar{S}$, $C_4A_3\bar{S}$, $C_5S_2\bar{S}$, clinkers ($C_4A_3\bar{S}$-C_2S-C_4AF)
T 1200-1300 °C
Ratio SO_2:air (g/min) 1:2.5–1:100 (0.04:4)
Time 5-240 min
Powders/pellets

Characterisation
XRD-Rietveld

- Rapid transfer of SO_2 and O_2 to clinkering solids to form $C\bar{S}A$ clinkers
- Temperature windows for clinkers with $C_4A_3\bar{S}$ and $C_5S_2\bar{S}$
- SO_2 partial pressure threshold:
  $C\bar{S}$+C_2AS <-> $C_4A_3\bar{S}$+C_2S


Advances in clinkering technology of calcium sulfoaluminate cement, Galan, Elhoweris, Hanein, Bannerman, Glasser, Adv. Cem. Res. 2017, in press

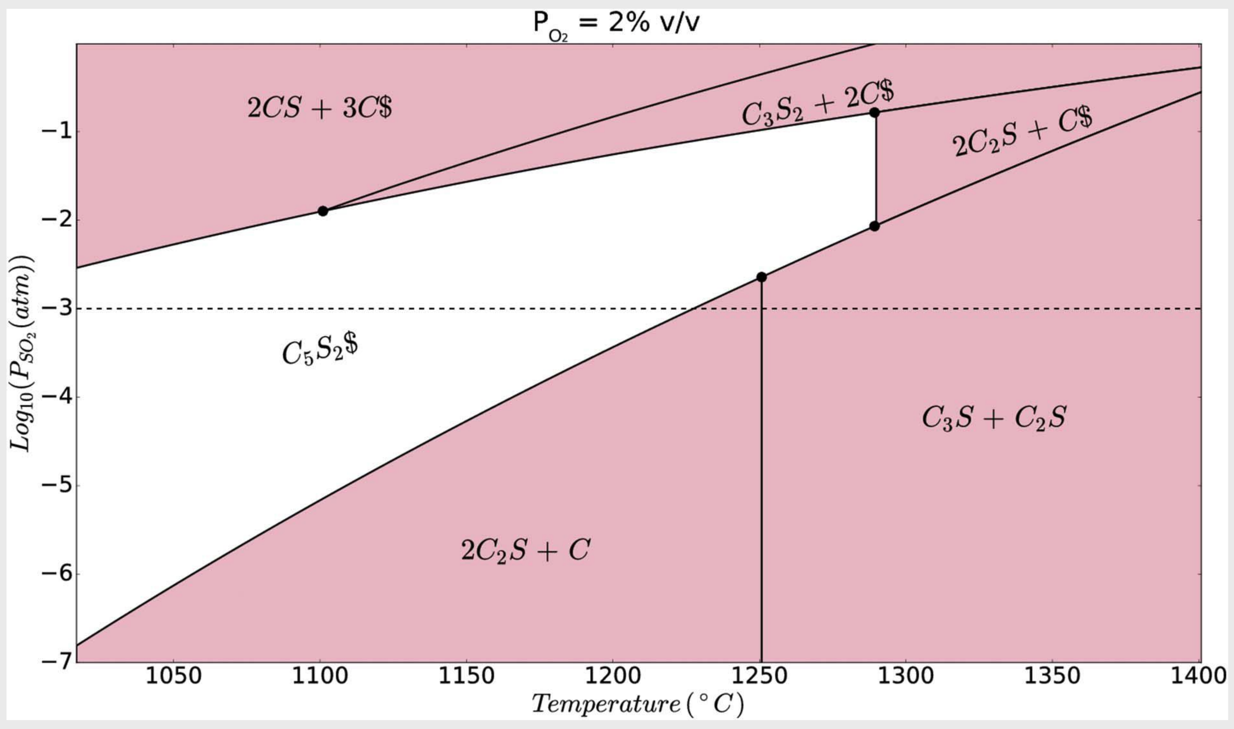
THERMODYNAMIC CALCULATIONS



Phase compatibility in the System CaO-SiO$_2$-Al$_2$O$_3$-SO$_3$-Fe$_2$O$_3$ and the Effect of Partial Pressure on the Phase Stability, Galan, Hanein, Elhoweris, Bannerman, Glasser, Ind. Eng. Chem. Res. 2017, 56

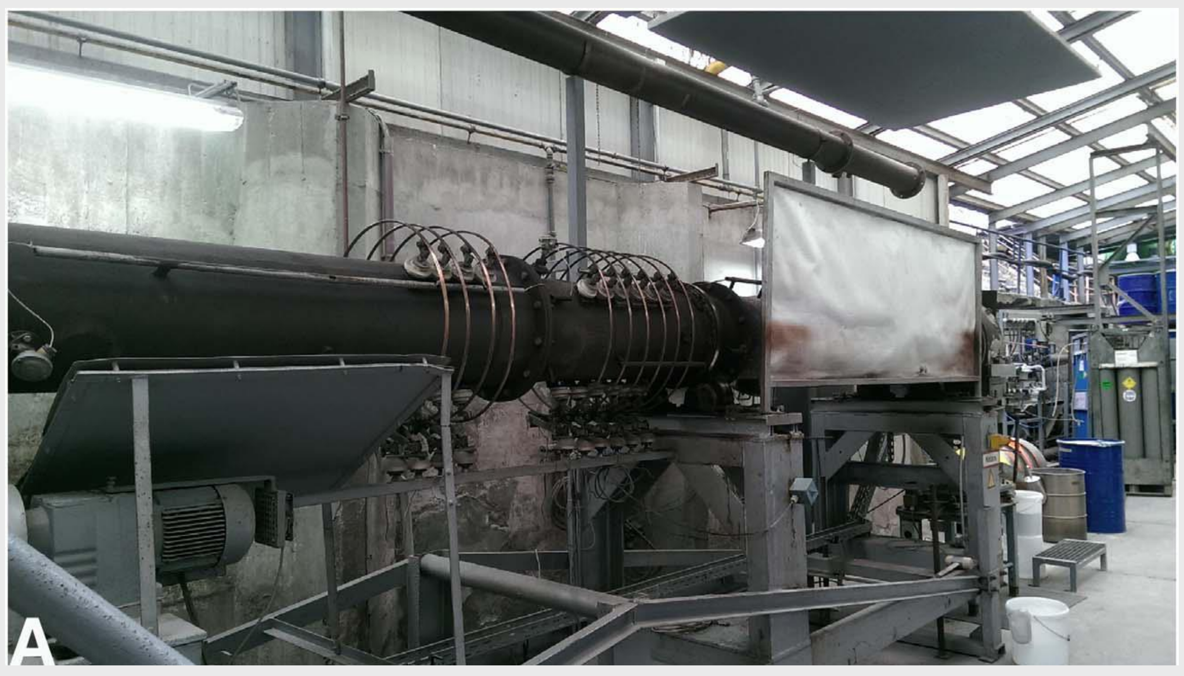
Thermodynamic stability of sulfate-containing phases

Ranges of SO_2, O_2 and temperature where the phases in the C-S-A-$\bar{S}$–F system form and coexist



Stability of ternesite and the production at scale of ternesite-based clinkers, Hanein, Galan, Glasser, Skalamprinos, Elhoweris, Imbabi, Bannerman, Cem. Concr. Res. 2017, 91

PILOT PLANT TRIALS



Kiln: 7.4 m long; 0.3 m diameter
Counter current flow
Natural gas + Sulfur powder (introduced with screw feeder to the burner)

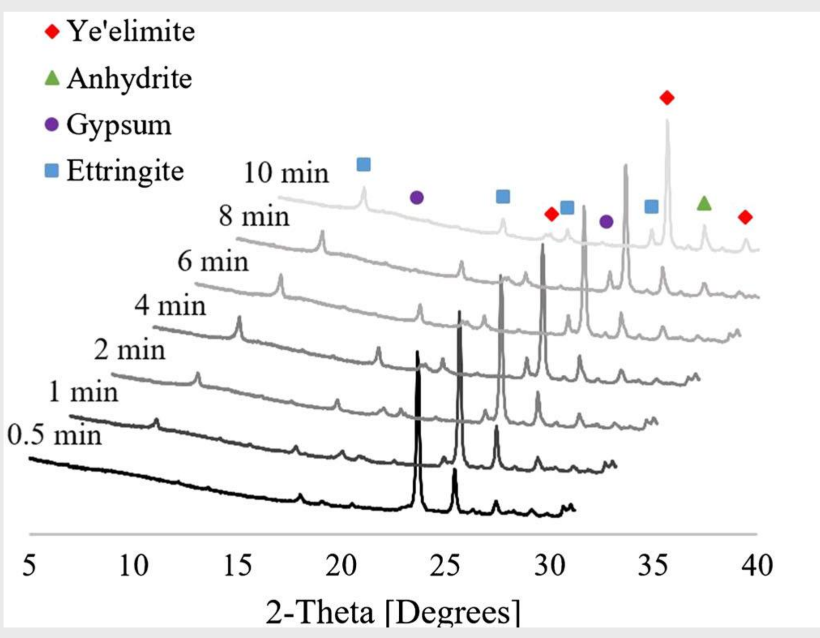
Limestone, bauxite and clay

Average operating conditions:
1260 °C; 7% O_2; 0.4% SO_2; rpm 2

Produced clinker
36% $C_4A_3\bar{S}$ 28% β-C_2S 15% α'-C_2S
10% $C\bar{S}$ 4% C_2AS 2% C_4AF
2% CT, 2% C

Production of belite calcium sulfoaluminate cement using sulfur as a fuel and as a source of clinker sulfur trioxide: pilot kiln trial, Hanein, Galan, Elhoweris, Khare, Skalamprinos, Jen, Whittaker, Imbabi, Glasser, Bannerman, Adv. Cem. Res. 2016, 28

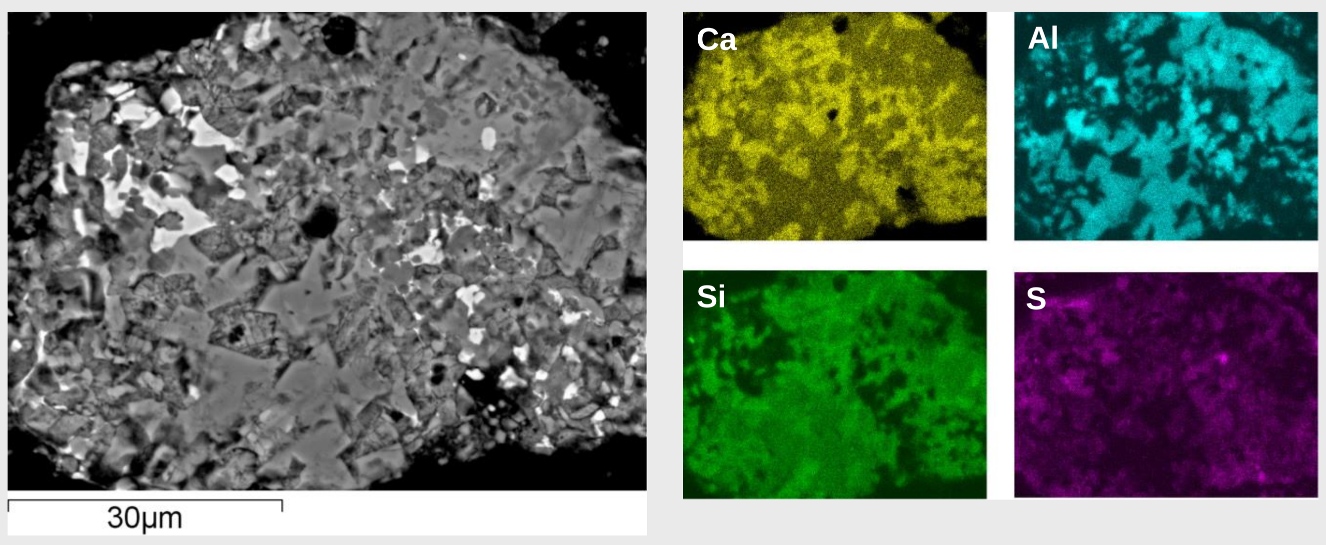
HYDRATION



Experimental clinker: rapid hydration
Intrinsic anhydrite -> ettringite network

Setting time retardation: addition of citric acid + gypsum or additional mixing and higher w/c

Early strength higher without retarder
28d strength higher with retarder



The impact of intrinsic anhydrite in an experimental calcium sulfoaluminate cement from a novel, carbon-minimized production process, Jen, Skalamprinos, Whittaker, Galan, Imbabi, Glasser, Mat. Struct. 2017, 50

CONCLUSIONS

The understanding of the influence of the SO_2 + O_2 partial pressure, together with the temperature, on the formation of phases in the system C-S-A-$\bar{S}$–F has enabled a new approach to clinker design and production.
A new generation of sulfoaluminate compositions are being developed which are readily clinkered using conventional processing. Advantages are: further reduction of CO_2 emissions, re-utilization of a waste material, and strength development improvement by controlling and optimising the mineralogy.