Phase Equilibria in the "$CuO_{0.5}$"-CaO-$AlO_{1.5}$ Ternary System in Equilibrium with Metallic Copper

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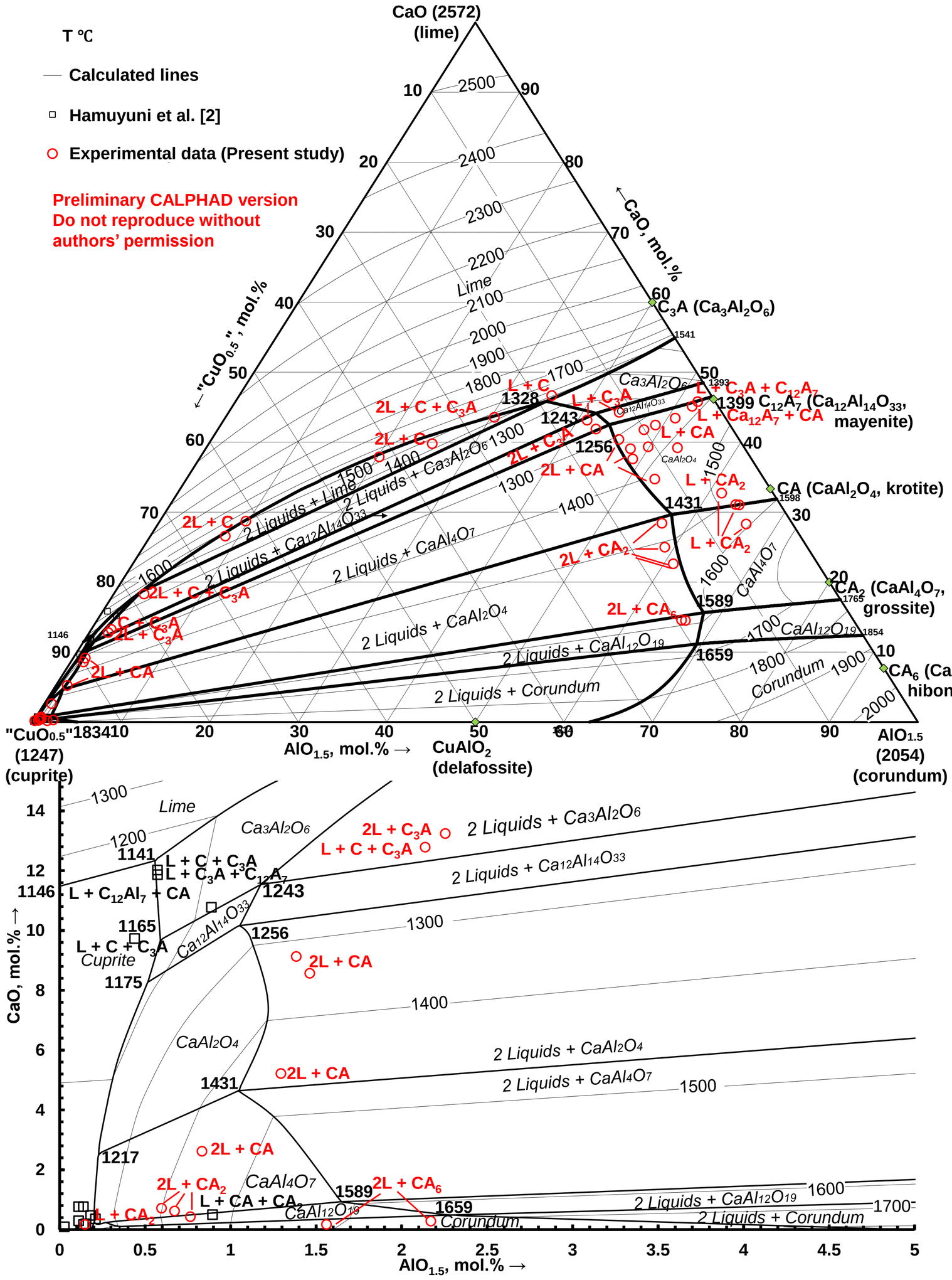
Background

- $CuO_{0.5}$, $AlO_{1.5}$ and CaO (along with FeO_x, MgO and SiO_2) form the basis of the primary and recycling copper production slags [1].
- Calcium aluminate slag is a promising recycling medium for waste electrical and electronic equipment (WEEE).
- The data on phase equilibria and other thermodynamic properties of metallurgical slag systems are extremely important for understanding ways to improve production and refractory performance.
- The phase diagram of the "$CuO_{0.5}$"-CaO-$AlO_{1.5}$ system in equilibrium with metallic copper was not found in literature.

Aims of Work

- Construct the liquidus surface of the system.
- Support the thermodynamic calculations with experimental data on phase equilibria.



Calculated phase diagram of the "$CuO_{0.5}$"-CaO-$AlO_{1.5}$ system in equilibrium with metallic copper: full liquidus surface and zoomed "$CuO_{0.5}$"-rich area of the diagram.

Measured copper oxide concentrations in calcium aluminates (L-line used for Cu instead of K-line).

Phase	"$CuO_{0.5}$", mol.%
$CaAl_{12}O_{19}$	0.06 ± 0.04
$CaAl_2O_4$	0.12 ± 0.06
$CaAl_4O_7$	0.08 ± 0.02
$Ca_{12}Al_{14}O_{33}$	<0.11
$Ca_3Al_2O_6$	<0.23

Results

- The system is characterised by a wide immiscibility gap between "$CuO_{0.5}$"-rich and "$CuO_{0.5}$"-poor slags.
- Strong positive deviation from ideal solution and high activity coefficients of "$CuO_{0.5}$"
- The concentrations of copper oxide in calcium aluminates are measured using the new technique (L-line of Cu instead of K-line to avoid secondary fluorescence) to be negligible.

Further Work Needed

- The "$CuO_{0.5}$"-rich corner of the diagram needs careful experimental revision.
- The current thermodynamic model of the system needs further optimization.
- The system also needs to be studied under fixed oxygen partial pressures.

Conclusions

- The calculated liquidus surface of the "$CuO_{0.5}$"-CaO-$AlO_{1.5}$ system in equilibrium with metallic copper is presented.
- The thermodynamic model is in a good agreement with experimental data, but needs further optimization to comply with recent experimental data

[1] B. Gorai et al., Resources, Conservation and Recycling, 39 (2003) 299-313.
[2] J. Hamuyuni et al., CALPHAD, 55 (2016) 199-207

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