Experimental Study on Carbothermal Reduction of Lunar Regolith Simulants for Metal/Metalloid Production

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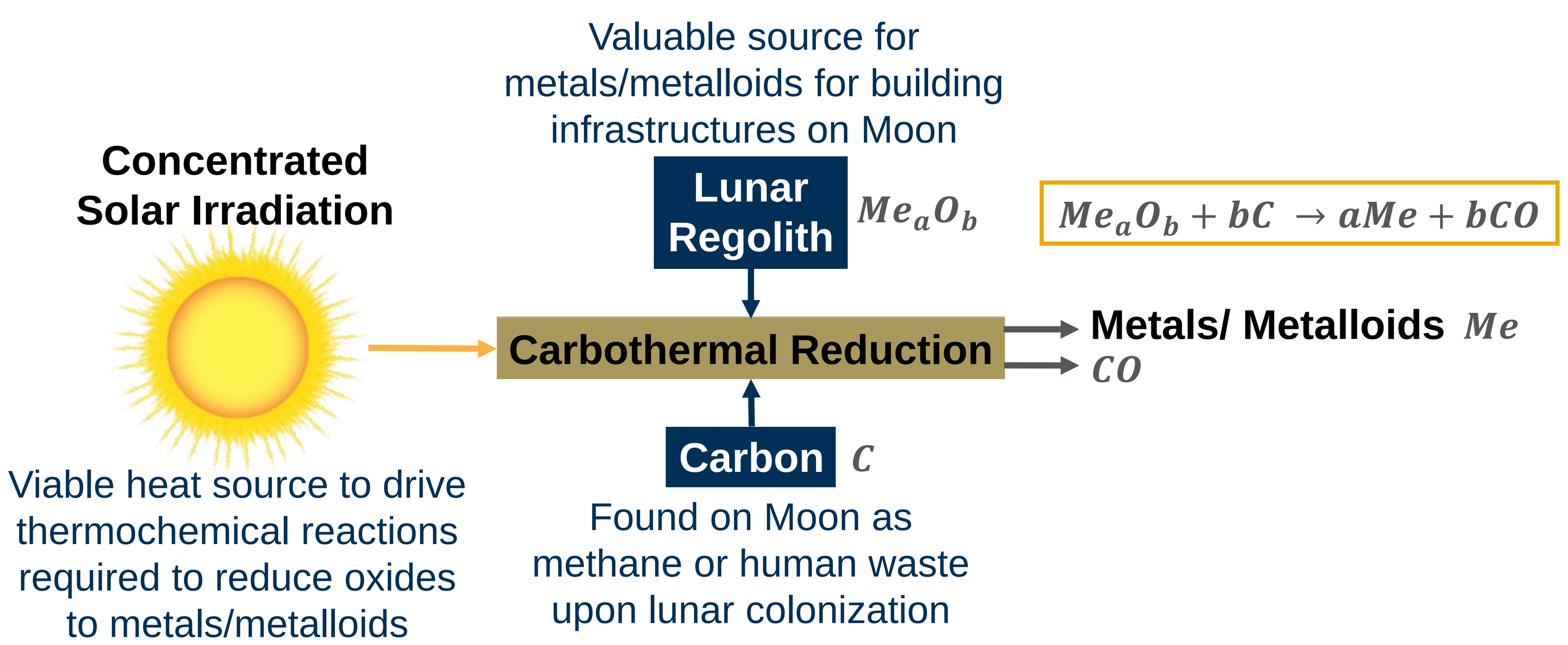
Introduction

In-situ resource utilization is essential for lunar habitation



Investigated simulants

JSC-1A: Mare simulant imitating Apollo sample 14163

LMS-1: Mare simulant

LHS-1: Highland simulant

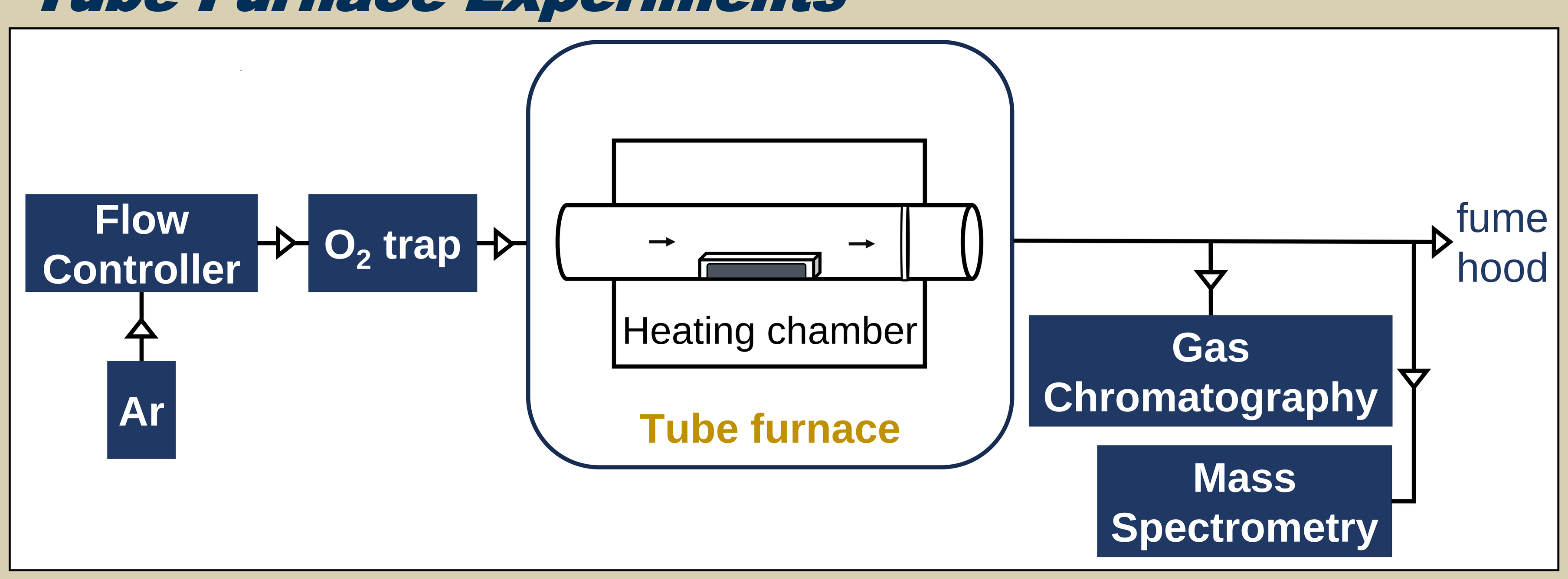
Lunar simulants are mixed with stochiometric amounts of activated carbon

Mixed Sample	C : Simulant
JSC-1A + C	0.332
LMS-1 + C	0.319
LHS-1 + C	0.344

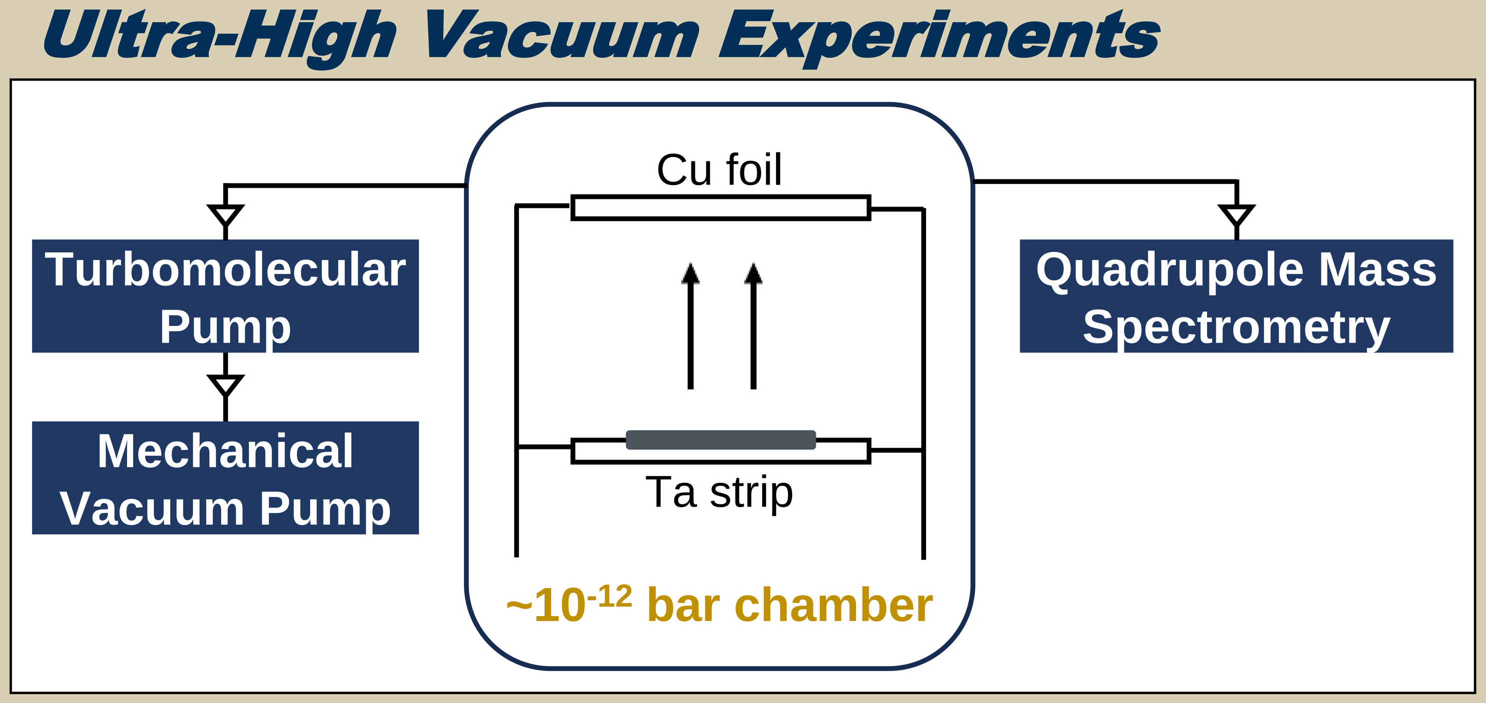
Methodology

Solid-state surface material characterization was conducted on post-experiment samples and volatile collectors

Tube Furnace Experiments



Ultra-High Vacuum Experiments



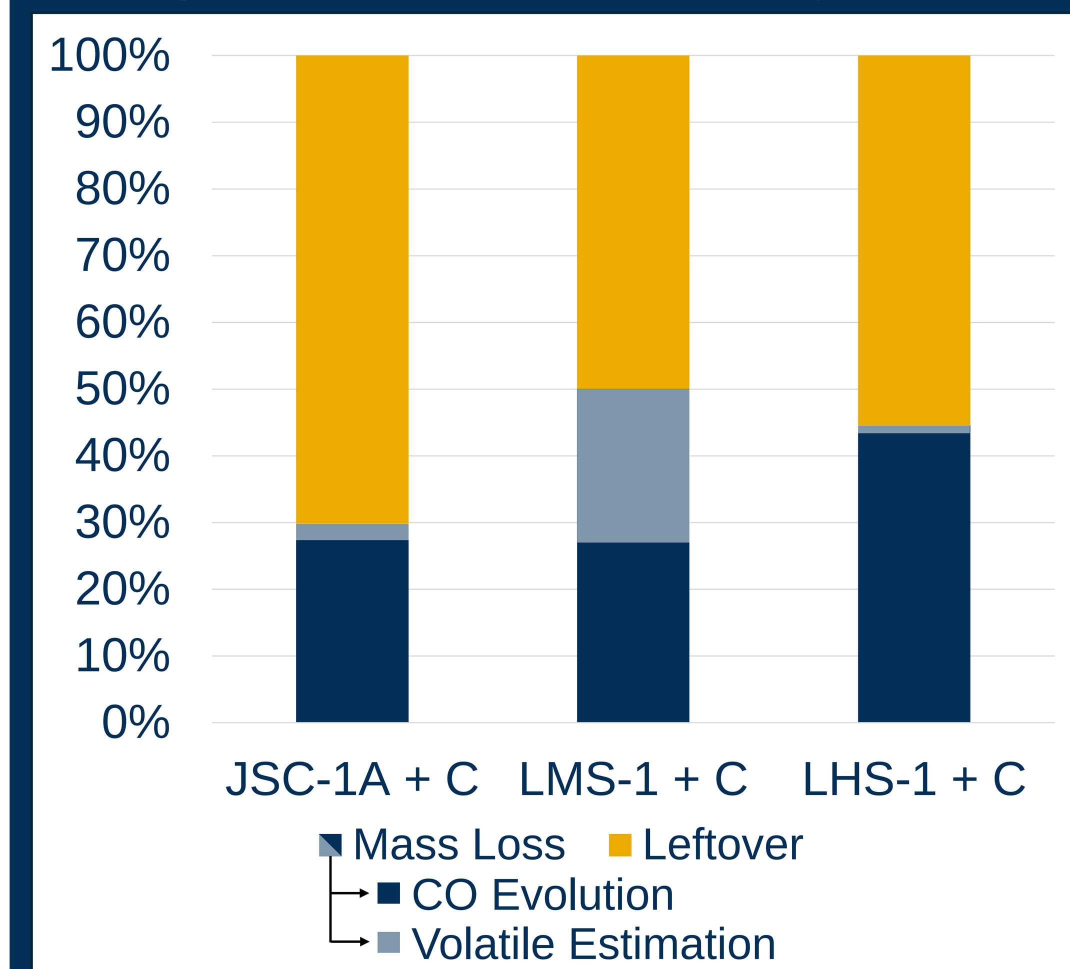
Mo and Cu foils are volatile collectors

Results

Key findings, though not exhaustive

Tube Furnace Experiments

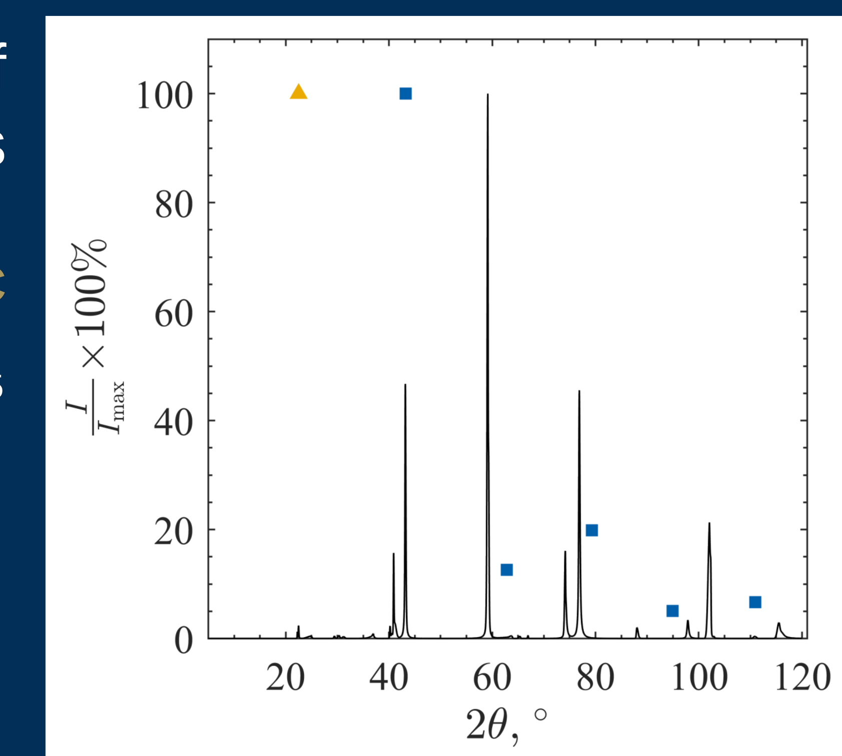
Sample mass balance analysis



X-ray Diffraction patterns of post-experiment samples

JSC-1A + C

$Al_{0.5}Si_{0.75}O_{2.25}$
$Fe_{0.4}Al_{0.6}$

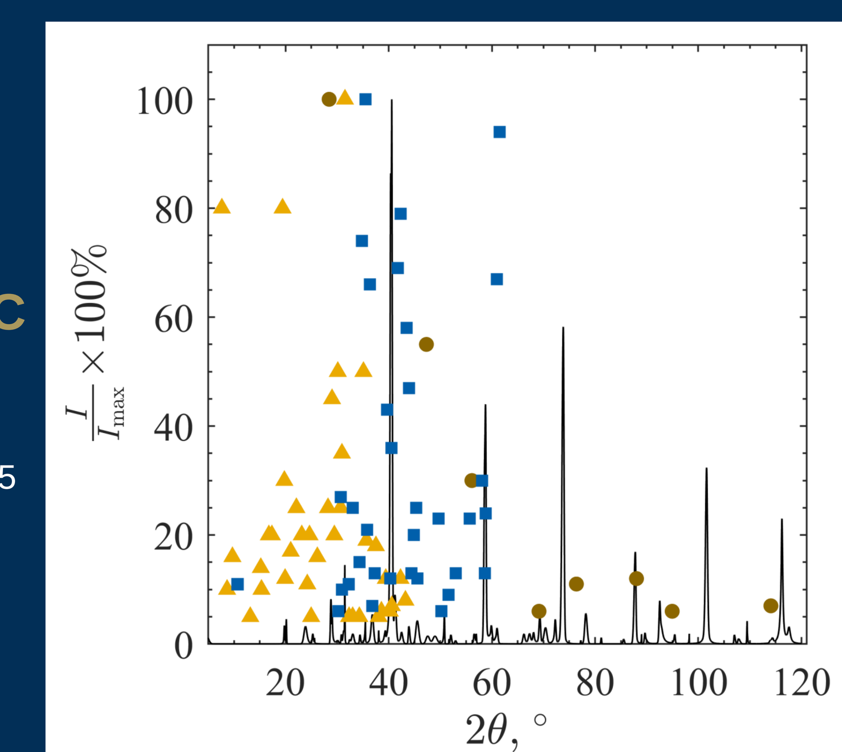


Detected on volatile collectors (Mo foils) by Energy Dispersive Spectrometry (EDS) and X-ray Photoelectron Spectroscopy

SiO_2, SiC, SiO_4, $CaCO_3$, CaO, MgO, Na oxide, Al_2O_3, K

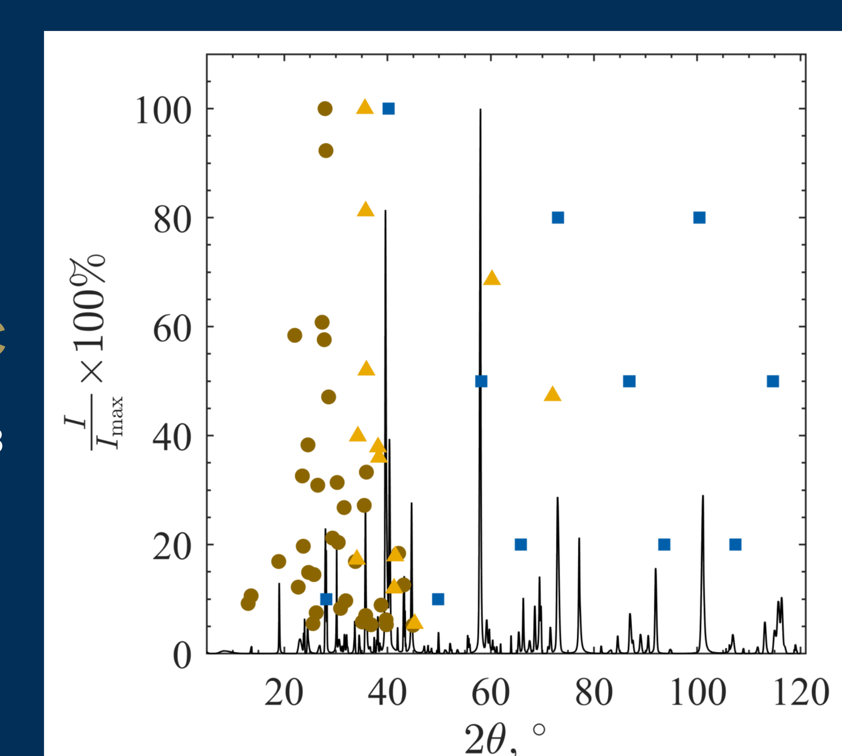
LMS-1 + C

Si
$Ca_3Al_2P_2Si_2O_{15}$
$Ca_2Fe_9O_{13}$



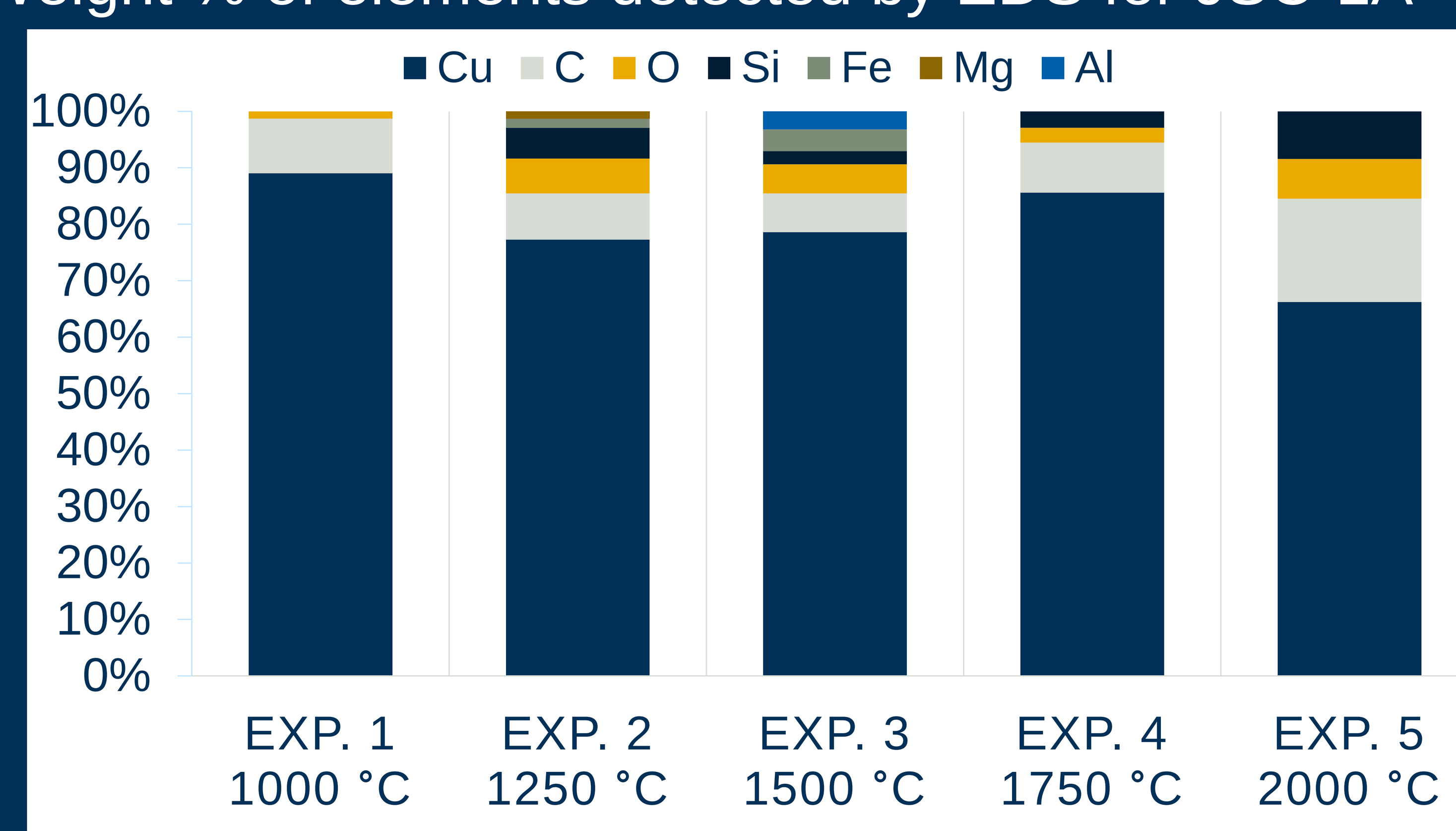
LHS-1 + C

$CaAl_2Si_2O_8$
SiC
$AlMoTi_2$



Ultra-High Vacuum Experiments

Weight % of elements detected by EDS for JSC-1A + C



Conclusions

- Inhomogeneity in post-experiment sample enables constituent separation and production
- Volatile production were quantified and identified as a function of temperature and operating conditions
- Results support thermodynamic predictions and lays foundation for future reactor design and optimization work
- Further work is ongoing with ultra-high vacuum experiments for LHS-1+C and LMS-1+C
- Experimental study with simulated solar irradiation will be conducted in near future

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