The Metalysis-FFC process for the efficient extraction of oxygen on the lunar surface

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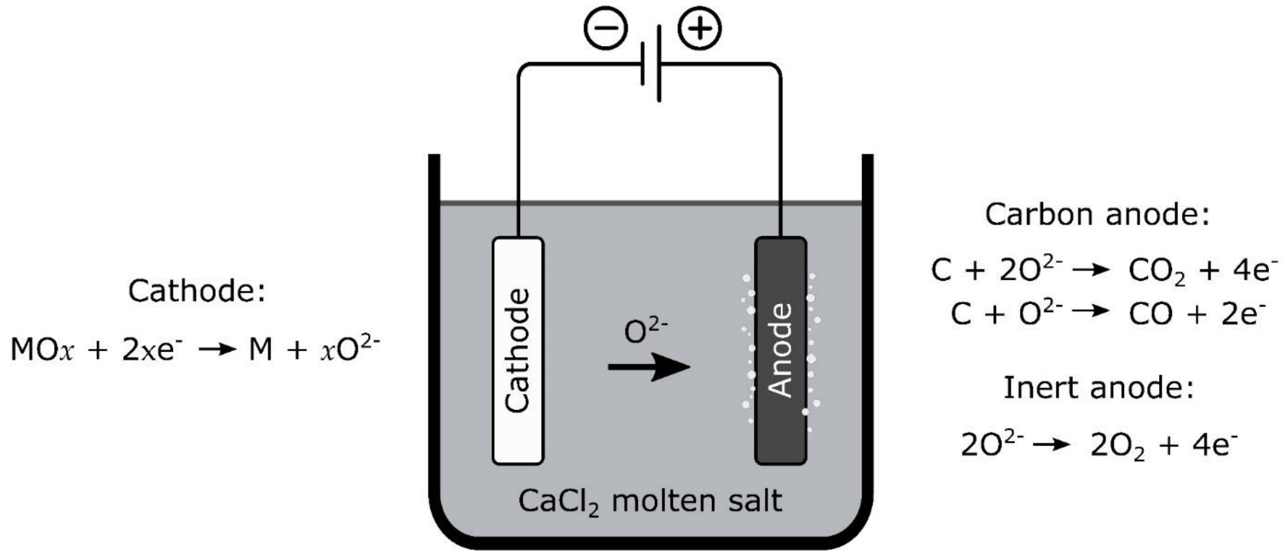

Figure 1: schematic showing the FFC-Cambridge process operating at ~900 °C

- Regolith is a widely available source of oxygen
- All major elements in lunar regolith can be reduced - removes constraints on location
- Simultaneous production of metals highly beneficial

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Results: Oxygen extraction

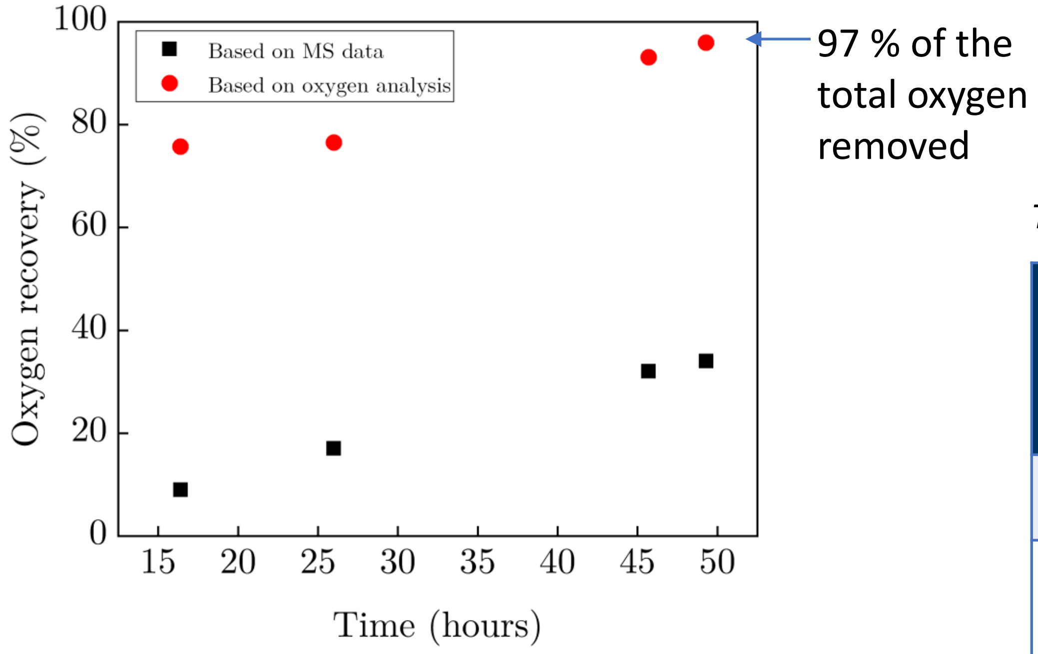

Figure 3: oxygen recovery (% of total oxygen) from JSC-2A simulant vs. time ($CaCl_2$, 950 °C, 4A, inert anode)

- Oxygen detected in gas stream lower due to reactor corrosion (terrestrial cells designed for CO/CO_2)
- Oxygen remaining in product a more accurate indication of process success

Table 1: comparison to other oxygen extraction processes

	Hydrogen reduction	Carbothermal reduction	Molten regolith electrolysis	Metalysis-FFC
Temp.	~900 °C	>1600 °C	>1600 °C	~900 °C
Oxygen yield*	1-2%[1]	10-20%[1]	20-30%[1]	40-45%

1. Sanders, G.B. and Larson, W.E., 2012, *Journal of Aerospace Engineering*, *26*(1), pp.5-17.

*Yield (%) = kg oxygen/kg regolith

Results: Metal/alloy production

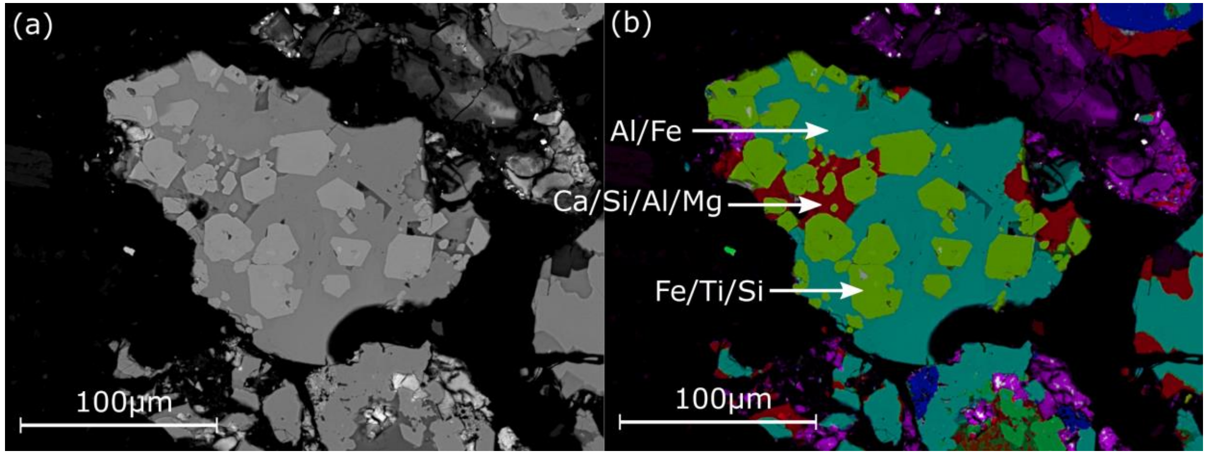

Figure 4: SEM/EDX image of a fully reduced metallised JSC-2A grain

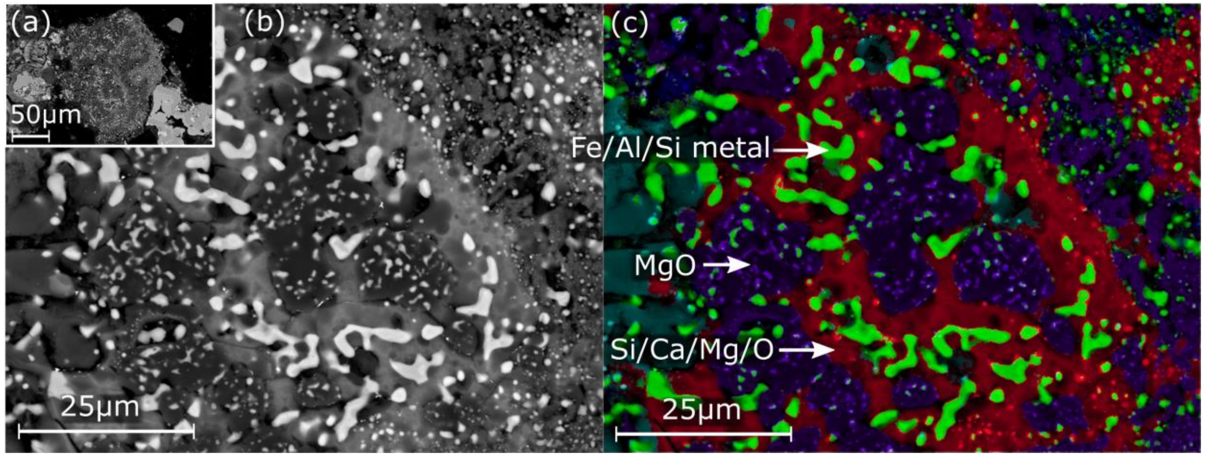

Figure 5: SEM/EDX image of a partially reduced JSC-2A grain

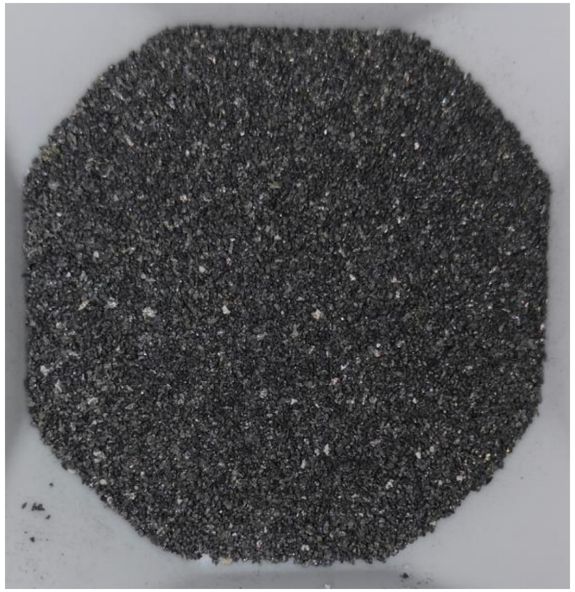

Figure 6: metal powder produced by the reduction of powdered JSC-2A lunar regolith simulant

- Mixed alloy from bulk lunar regolith – potentially useful?
- Possibility of metal/alloy separation based on electrolysis parameters

- Terrestrial technology is focused on pure metal and alloy production from various oxides
- Off-Earth technology development for lunar oxygen can feed into Mars metal production capabilities

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Future directions

- Optimise process parameters
- Identify the sweet spot between oxygen yield vs. processing time/energy input
- Understand the reduction behaviour of individual minerals, how this relates to different regolith deposits and regions, and how this could potentially lead to metal/alloy separation

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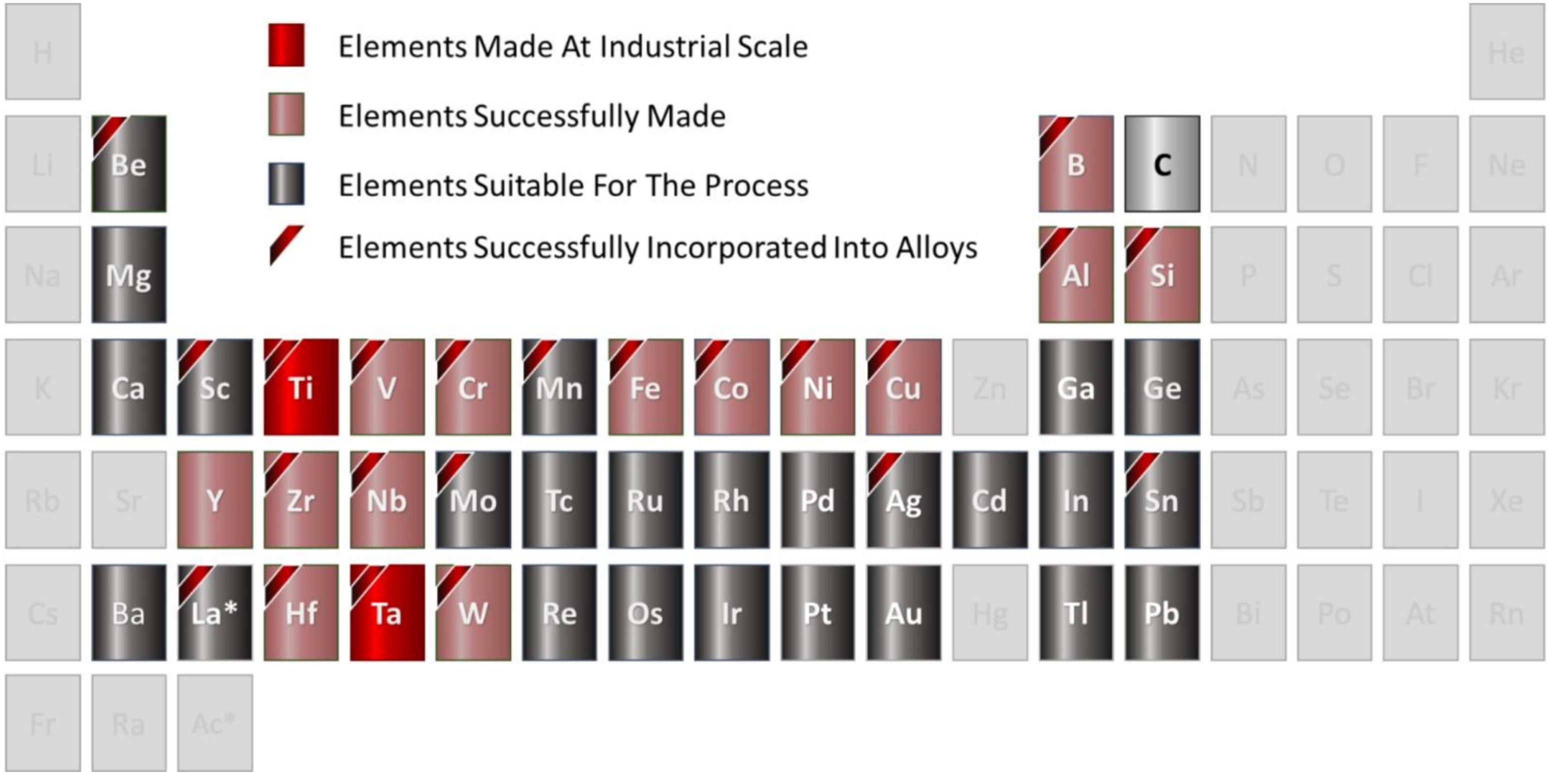

Figure x: elements produced and scaled up by Metalysis as of 2018