



Ablative Arc Mining For In-situ Resource Utilization

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A Giant Leap Forward
volt.utep.edu/cSETR

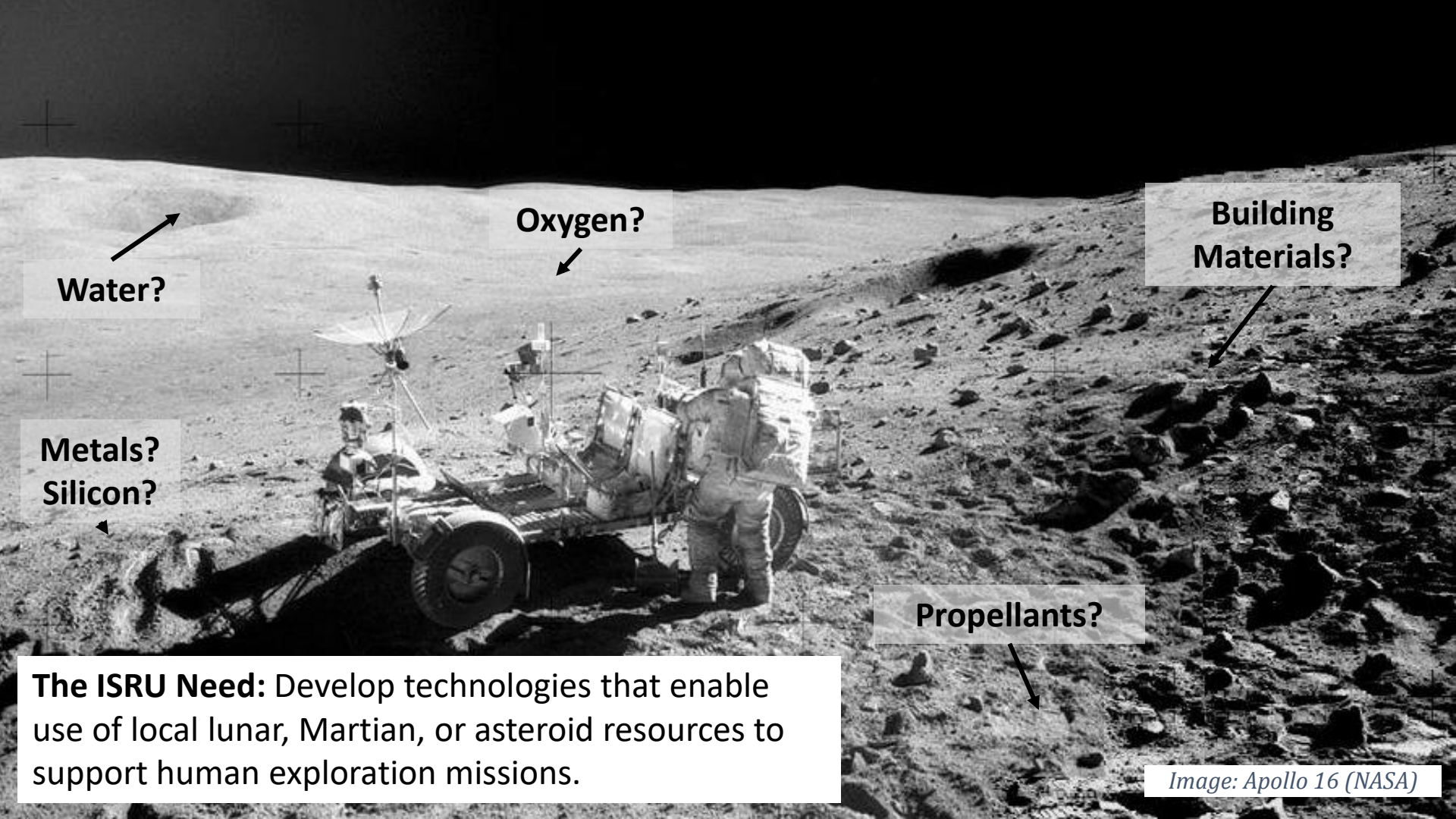




Humans need active lunar settlements to advance science, technology, and human capabilities.

To build them, there are two options

- 1) Bring everything from Earth
(cost prohibitive)
- 2) Find new and creative ways to use whatever is already there, through ***in-situ* resource utilization (ISRU)**



Water?

Oxygen?

Building
Materials?

Metals?
Silicon?

Propellants?

The ISRU Need: Develop technologies that enable use of local lunar, Martian, or asteroid resources to support human exploration missions.

Image: Apollo 16 (NASA)

Lunar Regolith

Lunar regolith contains many different elements.

Oxygen (O)

Silicon (Si)

Aluminum (Al)

Calcium (Ca)

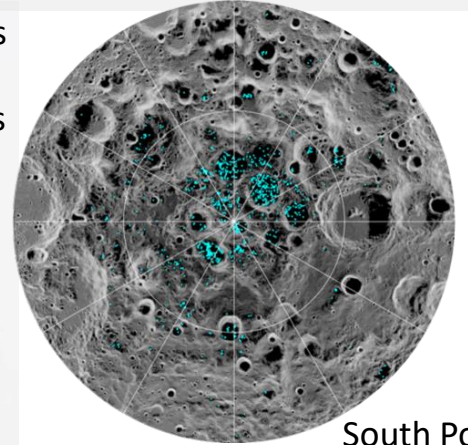
Magnesium (Mg)

Titanium (Ti)

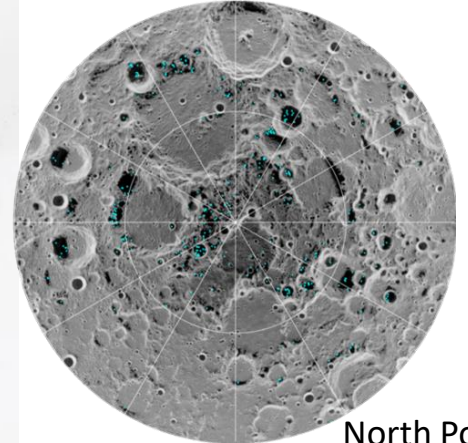
And more...



Lunar Water Deposits (H₂O)



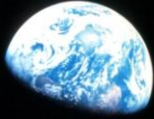
South Pole



North Pole

Launch is expensive and volume limited

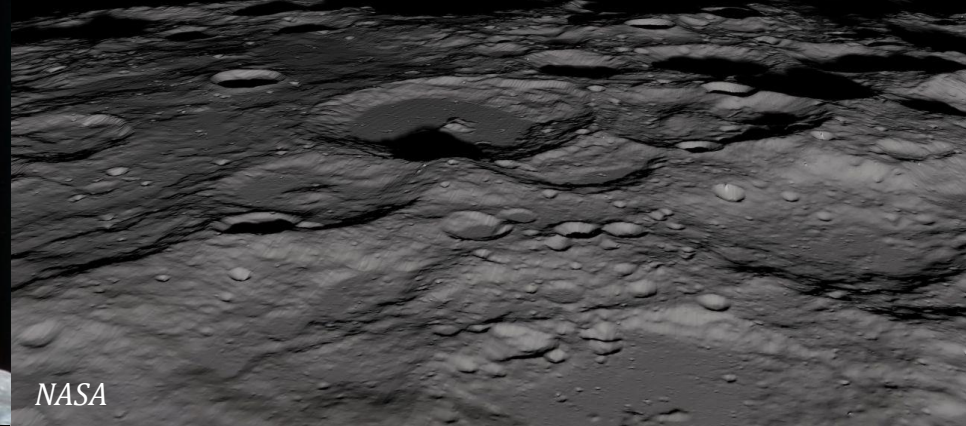
- Systems need to be small and compact



NASA

There is negligible atmosphere and low gravity

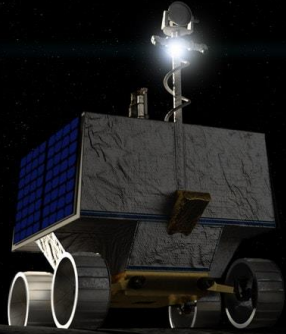
- Large gas and vapor losses through natural diffusion



NASA

Most water found in permanently shadowed regions near the lunar poles

- It's really cold!
- It's really dark!



NASA

The Moon is really dusty, and it sticks to everything!

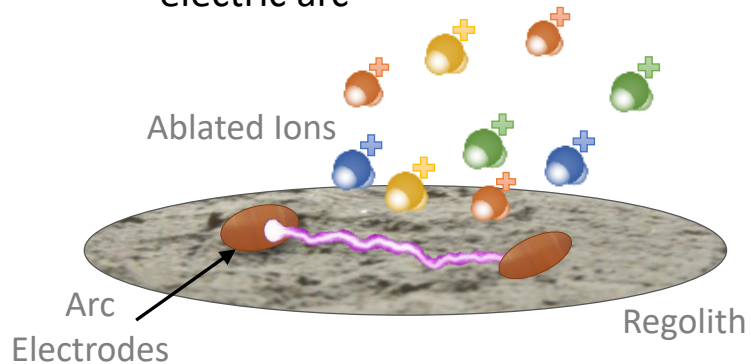
- Minimize moving parts



NASA

The Arc Mining Innovation

1) Ablate and ionize
regolith using an
electric arc



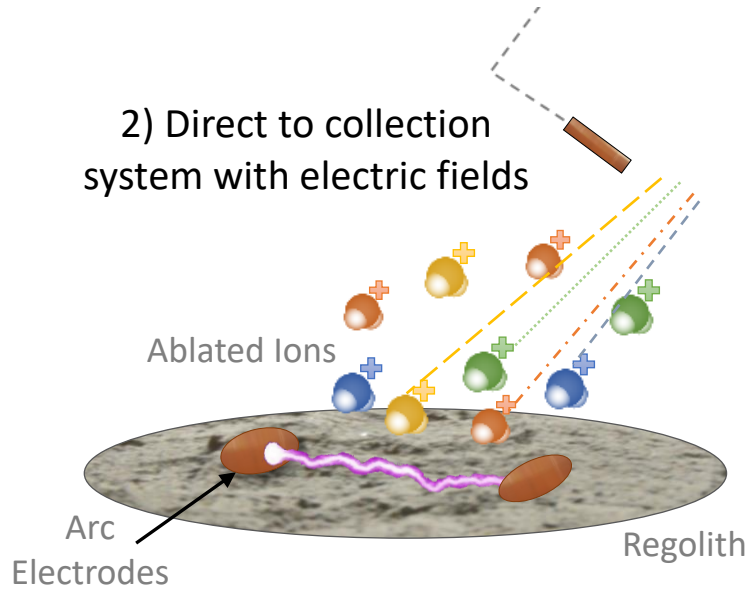
Extracts multiple elements simultaneously

*Ablated as charged ions ready for
electromagnetic transport and handling*

Arc requires no moving parts

The Arc Mining Innovation

2) Direct to collection system with electric fields

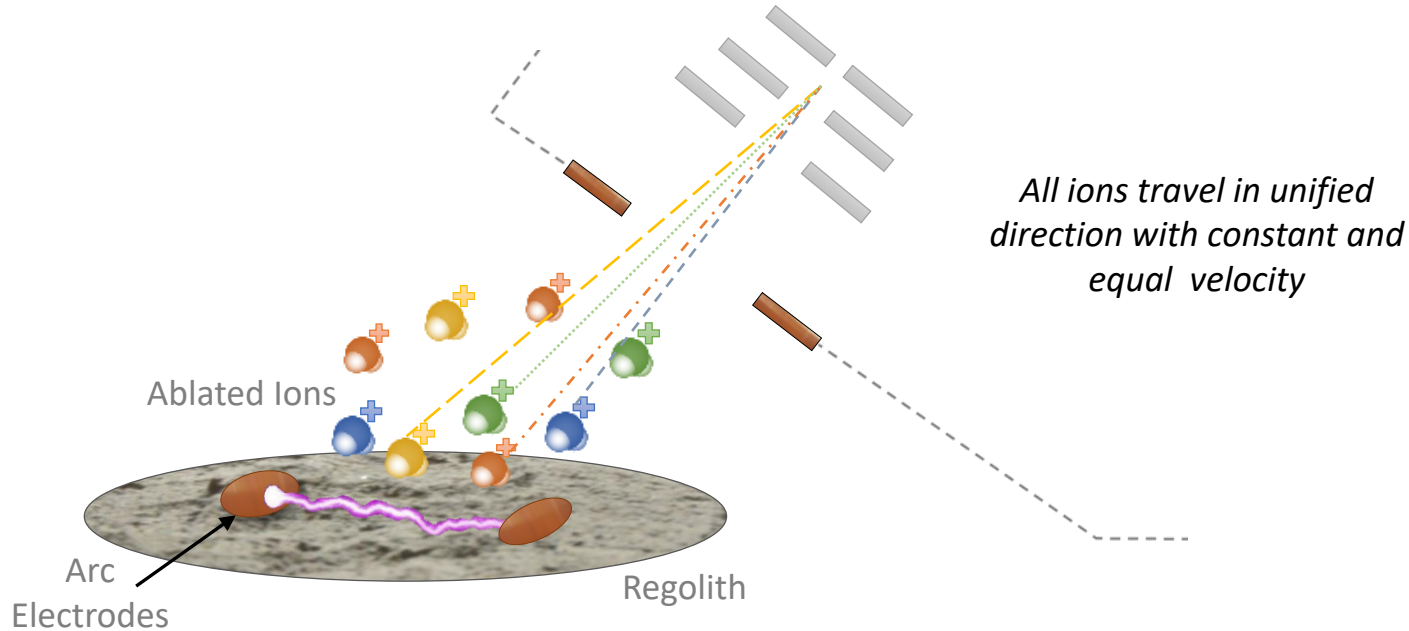


*Minimizes losses from natural diffusion
No reliance on gravity-related forces*

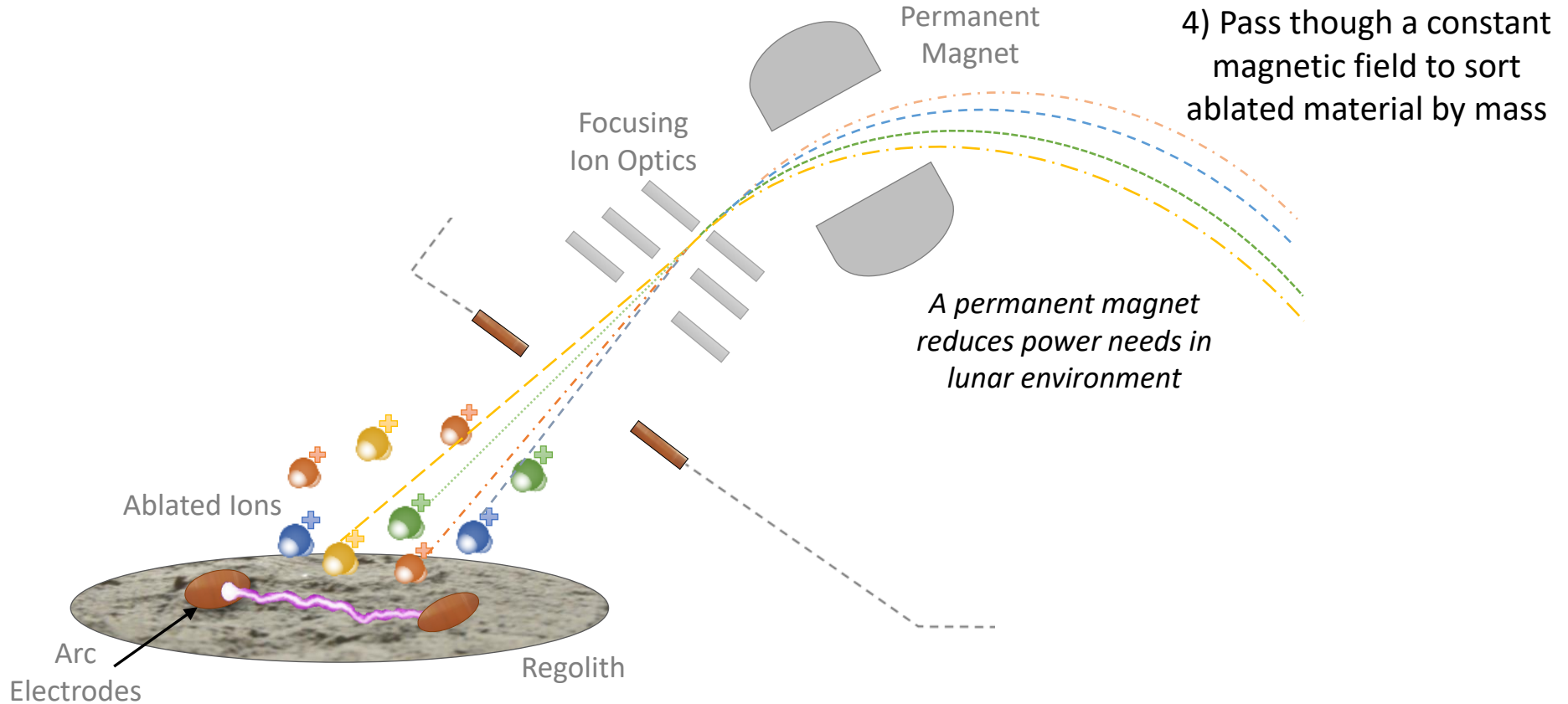
The Arc Mining Innovation

3) Focus the ablated regolith into a collimated ion beam using ion optics

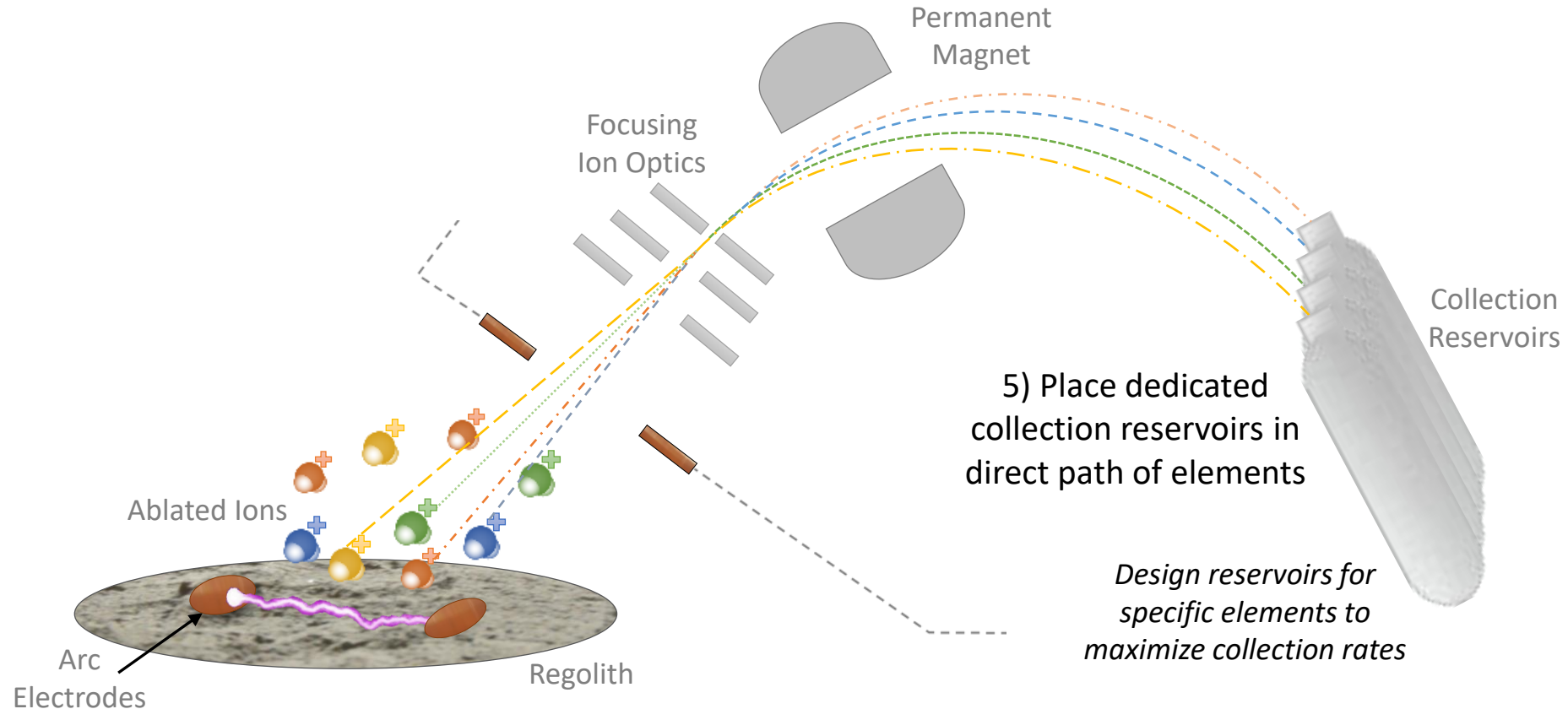
Focusing Ion Optics



The Arc Mining Innovation

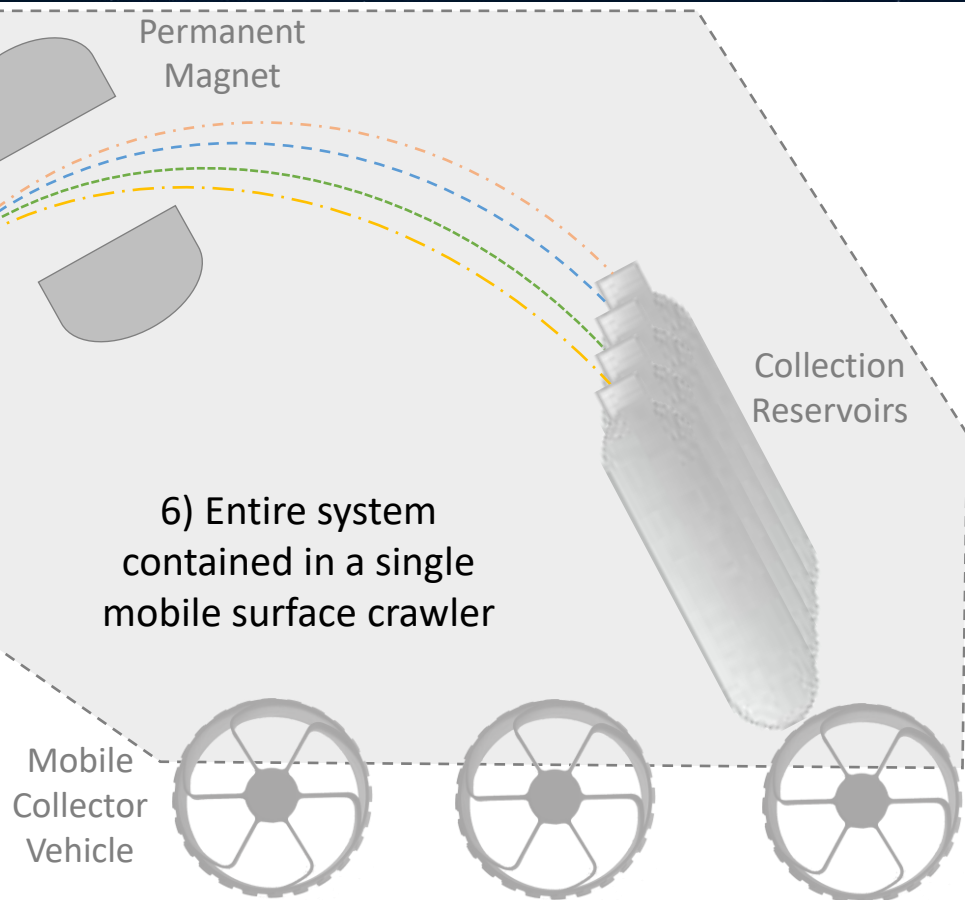
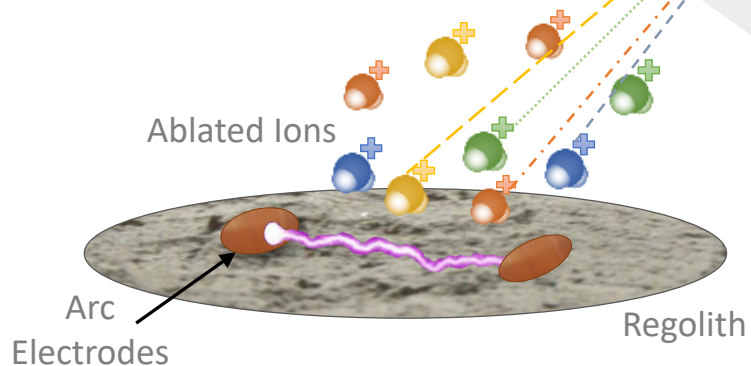


The Arc Mining Innovation



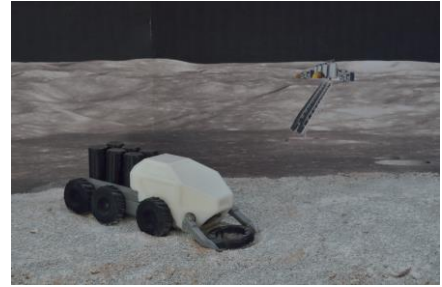
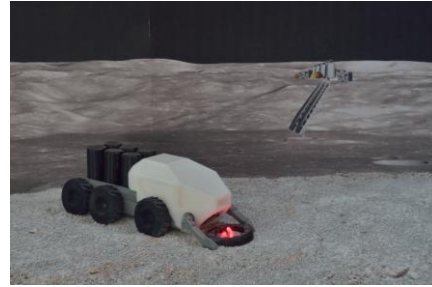
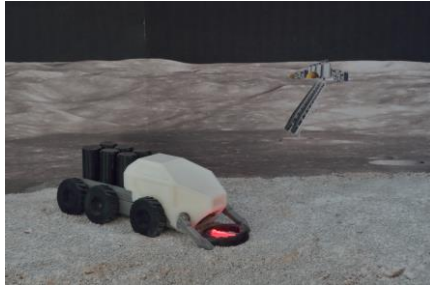
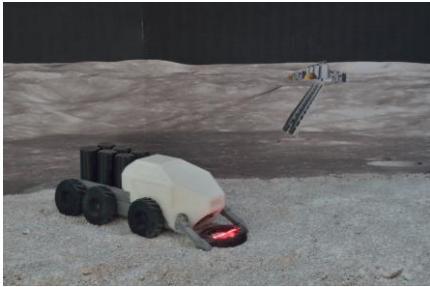
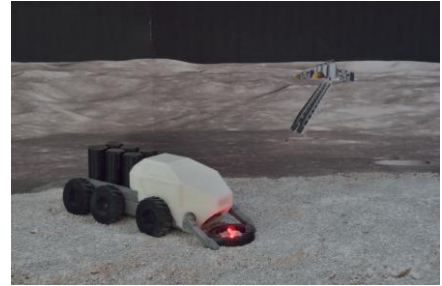
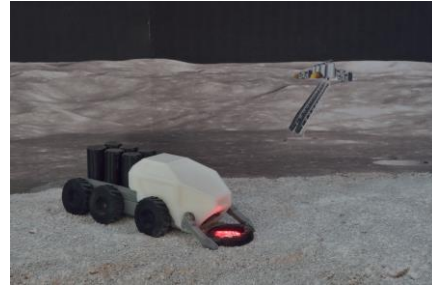
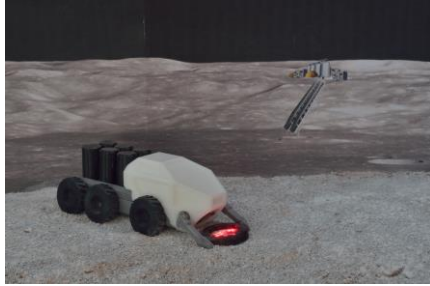
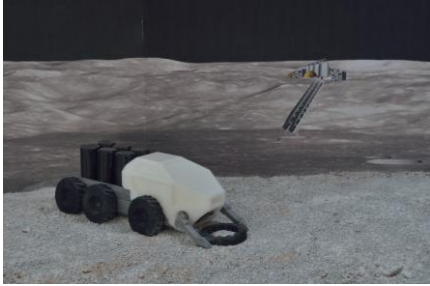
The Arc Mining Innovation

Multiple elements collected simultaneously
One compact surface unit for collection and sorting
Wide-area mining coverage



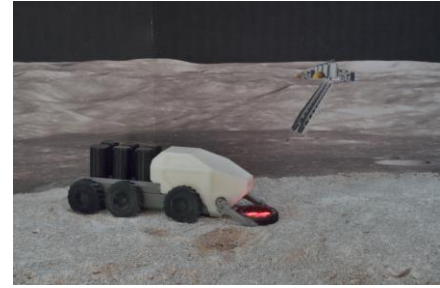
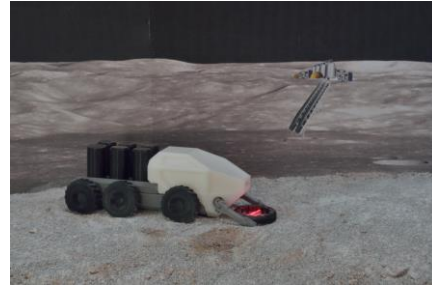
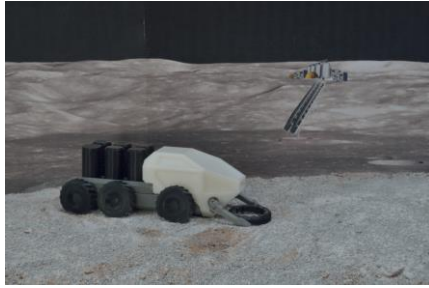
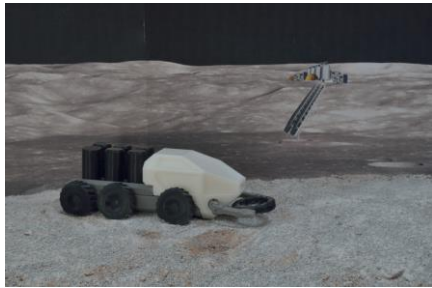
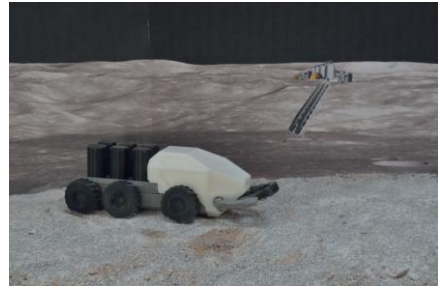
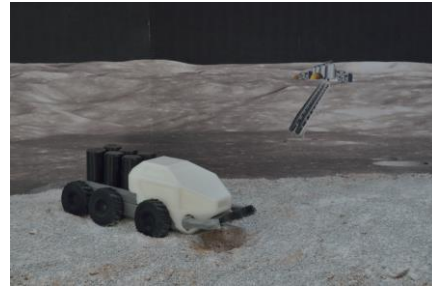
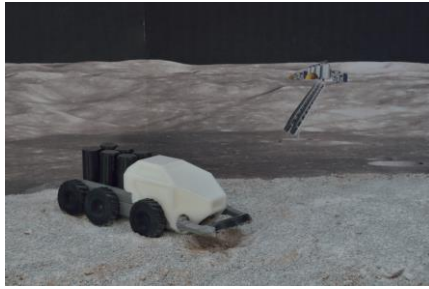
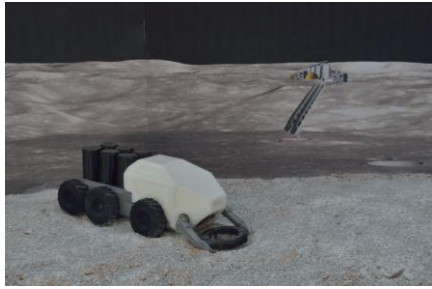
Lunar Mining Operations:

- Deploy crawler into water-rich crater near lunar south pole
- A ring with 12 electrodes on the front of the crawler is placed on the ground
- Arcs alternate through electrode pairs, ablating away a circular region under the ring



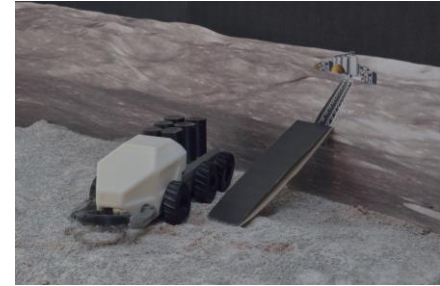
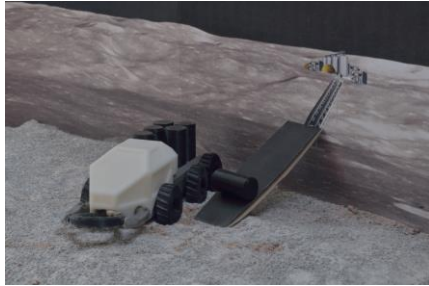
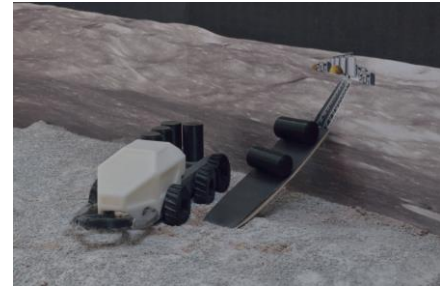
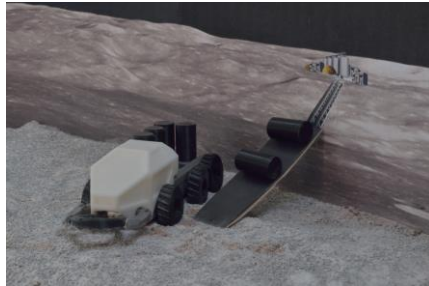
Lunar Mining Operations:

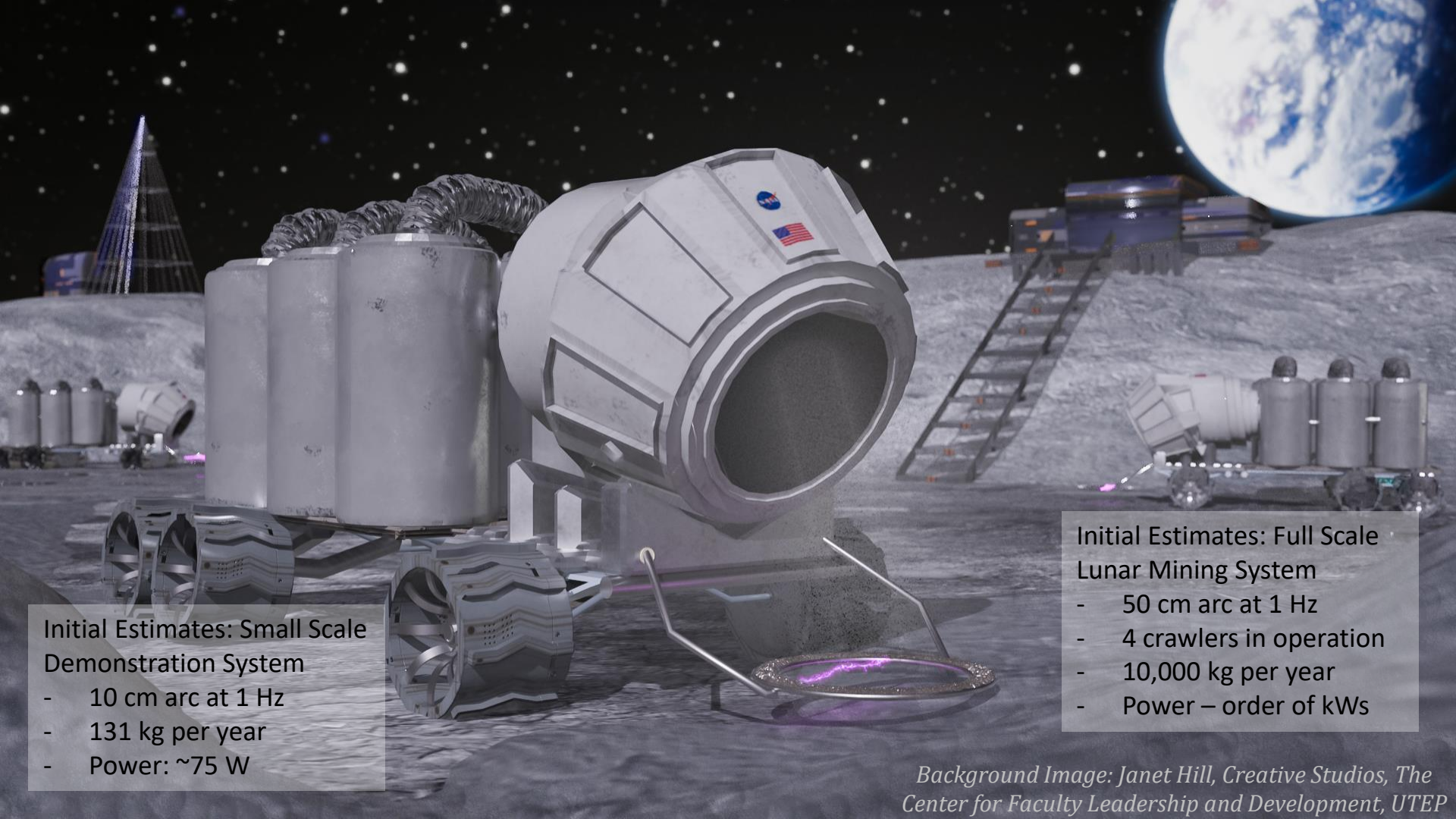
- Once region is exhausted, raise ring and move crawler to a new location to start arcing again



Lunar Mining Operations:

- Exchange full cylinders with empty cylinders through a transfer interchange with a processing plant





Initial Estimates: Small Scale Demonstration System

- 10 cm arc at 1 Hz
- 131 kg per year
- Power: ~75 W

Initial Estimates: Full Scale Lunar Mining System

- 50 cm arc at 1 Hz
- 4 crawlers in operation
- 10,000 kg per year
- Power – order of kW

Background Image: Janet Hill, Creative Studios, The Center for Faculty Leadership and Development, UTEP



The biggest unknown is how lunar regolith behaves under the influence of an electric arc.

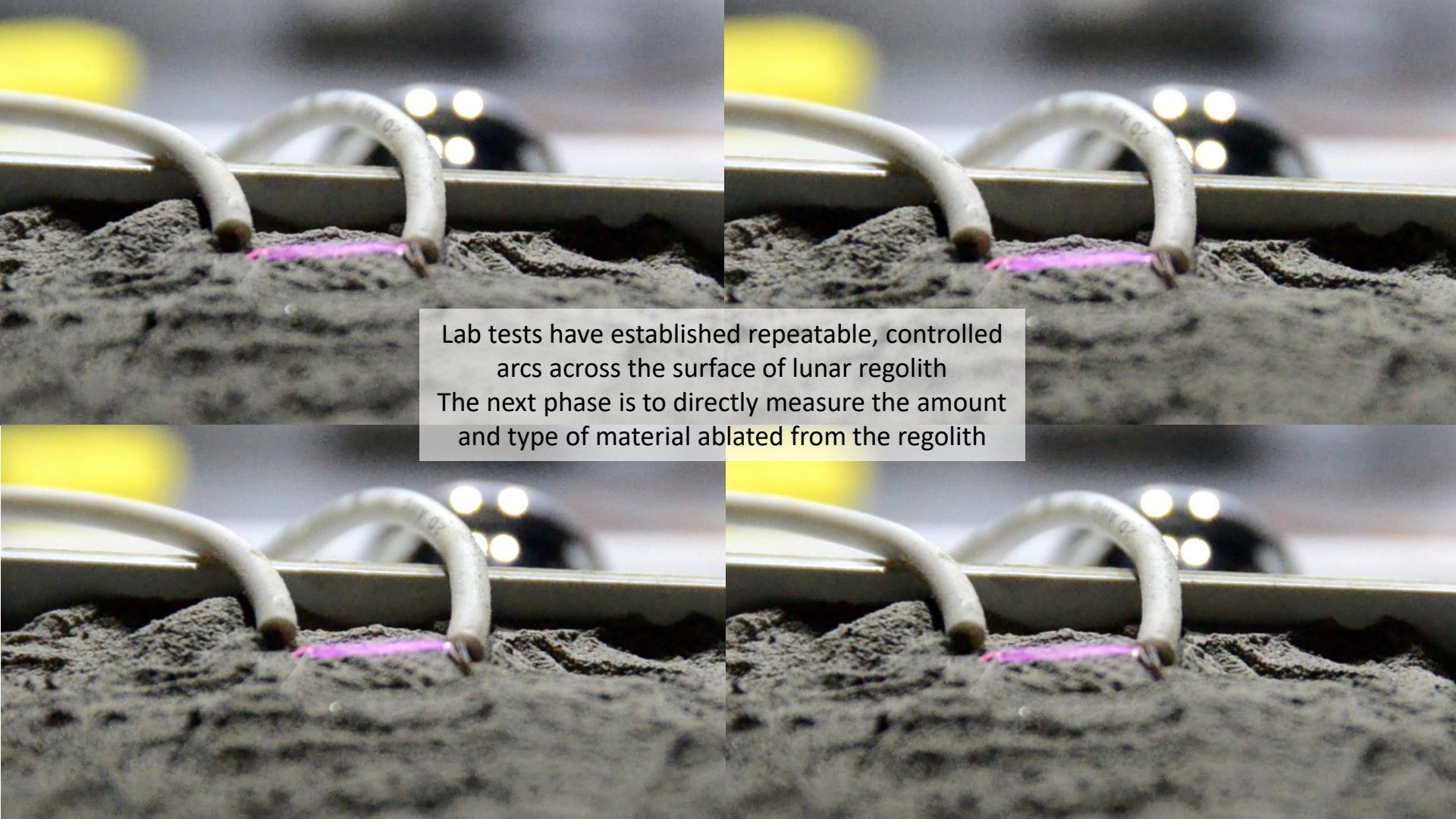
Experiments to study the effect of arcs on regolith in simulated lunar conditions are underway.

These values will be used to update collection rate and power estimates for comparison to other proposed lunar mining techniques



00:17.10






Lab tests have established repeatable, controlled arcs across the surface of lunar regolith
The next phase is to directly measure the amount and type of material ablated from the regolith



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