Water From Out of This World

Kady Ferguson, Alex Potts, Zach Rahl, Kevin Reilly

Faculty Advisors: Professor Derren Rosbach and Professor Sharon Wulf

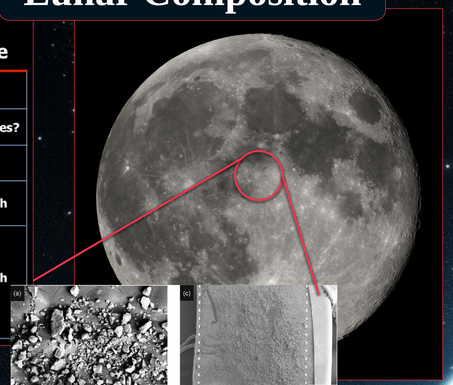
Abstract

The main focus is to create a lunar base by establishing a sustainable water source on the moon. The first reason is to gain access to potential resources that are strained on Earth or not present at all. Another reasoning for the creation of a lunar base is for its potential as a stepping-stone to further space exploration and colonization. The base must provide its own means of life-essential resources and use them to their fullest potential. In terms of water, a closed system must be implemented to maximize efficiency. To establish a sustainable water source, an initial focus would be placed on harvesting the ice deposits located at the moon's poles, and then creating water from its elements using the oxygen from lunar regolith, and hydrogen from the solar winds.

Lunar Energy Mineral Resources

Resource	Use	Occurrence
Helium-3	Energy	Mature regolith
Hydrogen	Propellant, water	Mature regolith, poles?
Oxygen	Propellant, air/water	Global
Nitrogen, carbon	Food and plastics	Breccias/regolith
Metals/bulk regolith Iron Titanium Aluminum	Construction Moon base Shielding Roads Solar power facility	Breccias/regolith

Lunar Composition



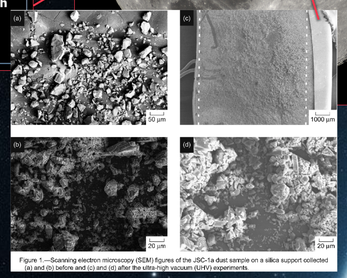
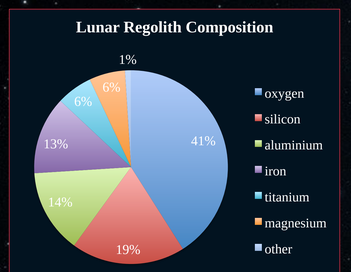


Figure 1.—Scanning electron microscopy (SEM) figures of the JSC-1a dust sample on a silica support collected (a) and (b) before and (c) and (d) after the ultra-high vacuum (UHV) experiments.



Background on the Moon

- No liquid water, no atmosphere, and one-sixth Earth's gravity; the moon is barren landscape compared to Earth
- Impacts of asteroids and comets deposited the current water resources on the moon in the craters.
- Lunar surface is 2m-10m deep of lunar regolith.

Problem Statement

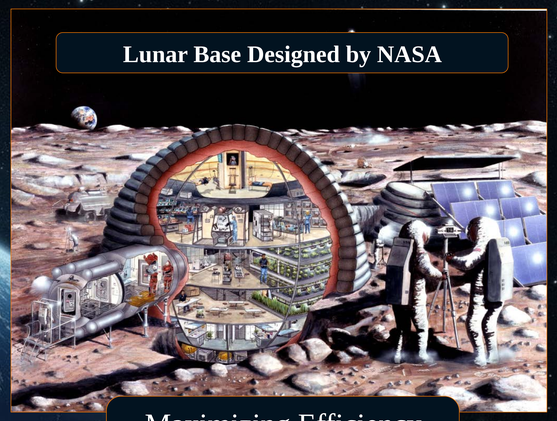
Ideal	Reality
Water on the moon is easily accessible and plentiful.	The unknown, limited water resources on the moon are difficult to extract.

Consequences

If we do not find a way to obtain water efficiently, we will not be able to move forward in space.

Lunar Colony

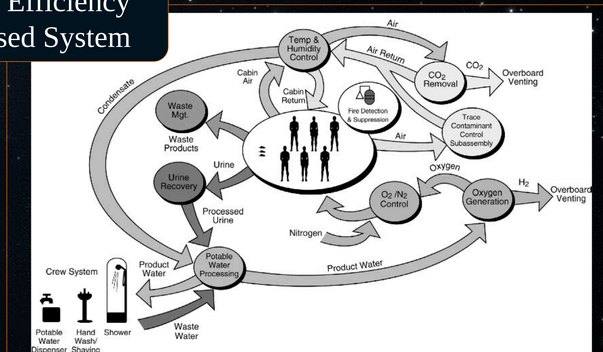
Lunar Base Designed by NASA



How much water does the base need?

Water Requirements	Per Man, Daily (kg)	Total for Crew of 15(kg)
Metabolic Oxygen	-0.9	-13.5
Drinking Water	-3.6	-54.0
Hygiene Water	-5.4	-81.0
Food	-0.6	-9.0
Waste Production (water is gained)		
Carbon Dioxide	+1.0	+15.0
Water Vapor	+2.5	+37.4
Urine	+1.5	+22.5
Feces	+0.16	+2.4
Net Total	**-5.34**	**-80.2**
%Efficiency	**49.1%**	**49.1%**

Maximizing Efficiency Using a Closed System



Solutions

Short Term

Harvest water trapped in the lunar ice caps

Where: polar ice caps
How: lunar rovers to mine the ice to send for treatment
Return Rate: 1000 tons of regolith for 0.5L of water

End Result of **Potable Water**

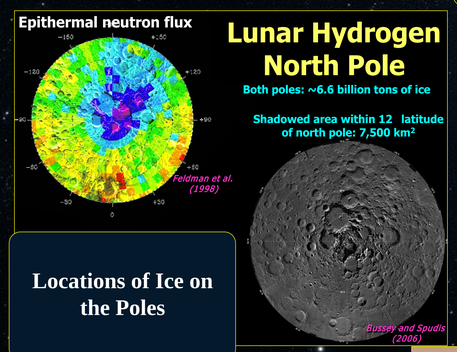
Long Term

Create Water from its elements: H_2O

Gathering Oxygen: Process the lunar regolith through a microwave system to extract oxygen from the metal oxides.
i.e. $Fe_2O_3 \rightarrow 2Fe^{+3} + {}^3/_2\,O_2$

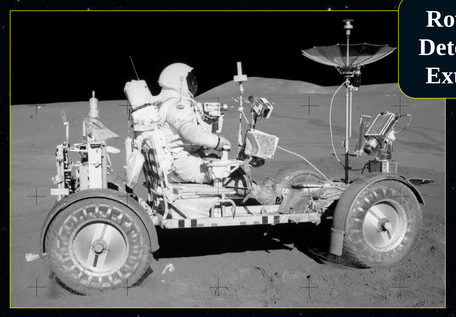
Gathering Hydrogen: Collecting Hydrogen from the Solar Winds
Methodology: Develop a vacuum to collect the solar winds before they hit the surface of the moon causing the hydrogen to evaporate.

React Elements for **Potable Water**
$H_2 + {}^1/_2O_2 \rightarrow H_2O$

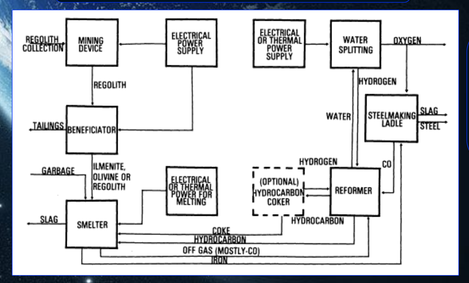


Locations of Ice on the Poles

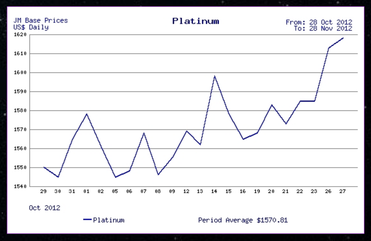
Rovers for Detection & Extraction

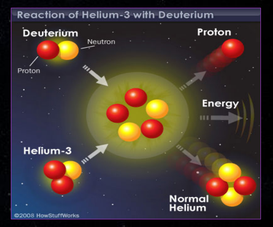


The Process of Mining Oxygen



The Solar Winds





Most Economical Benefits

Resource	Use	Occurrence	Worth
Helium-3	Energy	Solar Winds	1 load (26tons)= $3Billion
Platinum	Industrial, Medicinal	Lunar Regolith	1oz=$1,600

Social Impacts

1. Technological Advancements
2. Potential of Living on the Moon
3. Exploring new ways to make water

End Goals

1. Establish a Lunar Colony
2. Create water using the moon's resources
3. Create an economic gain

References

Ambrose, W. A. (2009). Water Ice on Mars and the Moon. Search and Discovery, (#80055). Retrieved from http://www.searchanddiscovery.comwww.searchand discovery.com/documents/2009/80055ambrose/ndx_ambrose.pdf

Goering, J., Sah, S., Burghaus, U., & Street Jr, K. W. (2008). Adsorption of water on JSC-1A (simulated moon dust samples)—a surface science study. *Surface and Interface Analysis*, *40*(11), 1423-1429. Retrieved from http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080041528_2008042060.pdf

Graps, Amara. (2008). What is the chemical composition of the solar wind?. *Standford Solar Center*. Retrieved from http://solarcenter.stanford.edu/FAQ/Qsolwindcomp .html

Mendell, W.W. (Ed). (1985). *Lunar Bases and Space Activities of the 21st Century*. Houston, TX: Lunar and Planetary Institute.

Pearlman, Howard. (2012). Water Questions and Answers. *U.S Department of the Interior*. Retrieved from http://ga.water.usgs.gov/edu/qa-home-percapita.html

Smith, Yvette. (2009) New Temperature Maps Provide a 'Whole New Way of Seeing the Moon. *NASA*. Retrieved from http://www.nasa.gov/topics/solarsystem/features/ divinerb20090917.html

Spudis, P. D., & Lavoie, A. R. (2011). Using the resources of the Moon to create a permanent, cislunar space faring system. *Spudis Lunar Resource*. Retrieved from http://www.spudislunarresources.com/Bibliography/p/102.pdf

Wilson, Jim. (2007). International Space Station: Environmental Control and Life Support System. *National Aeronautics and Space Administration (NASA)*. Retrieved from http://www.nasa.gov/centers/marshall/pdf/104840main_eclss.pdf