Water and Other Volatiles

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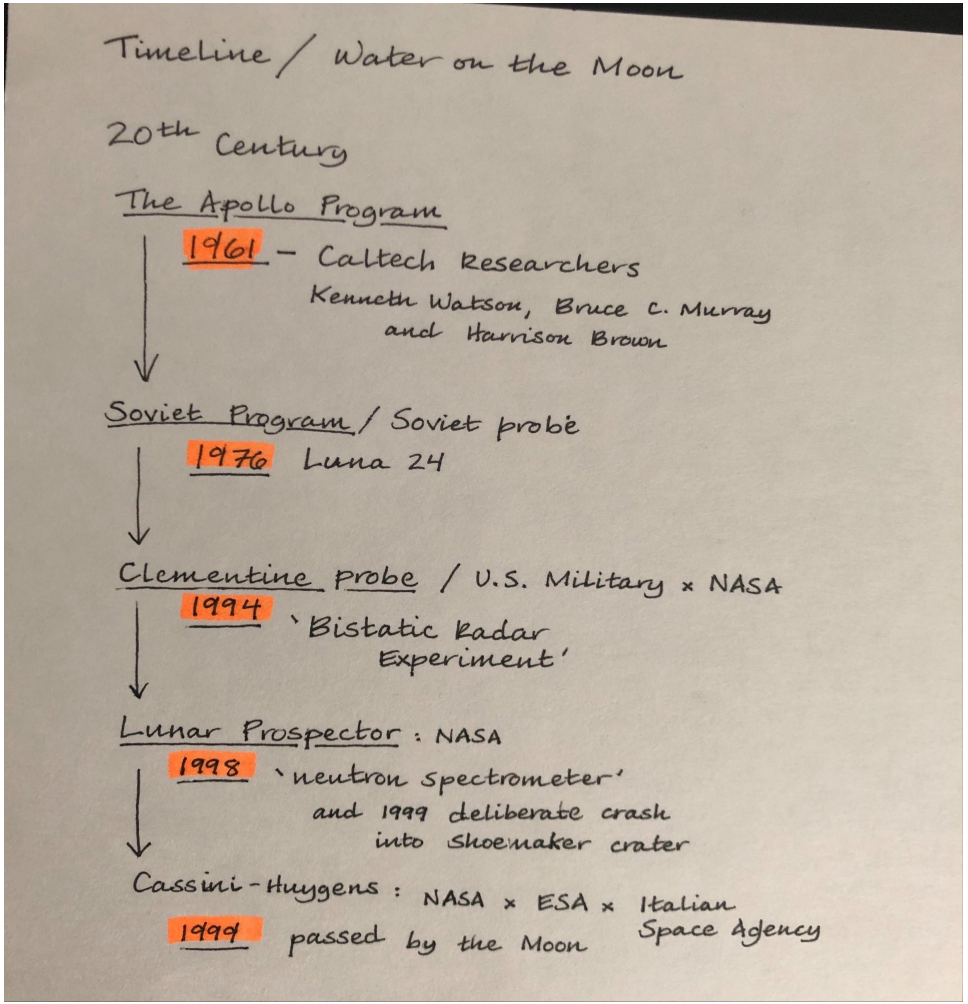
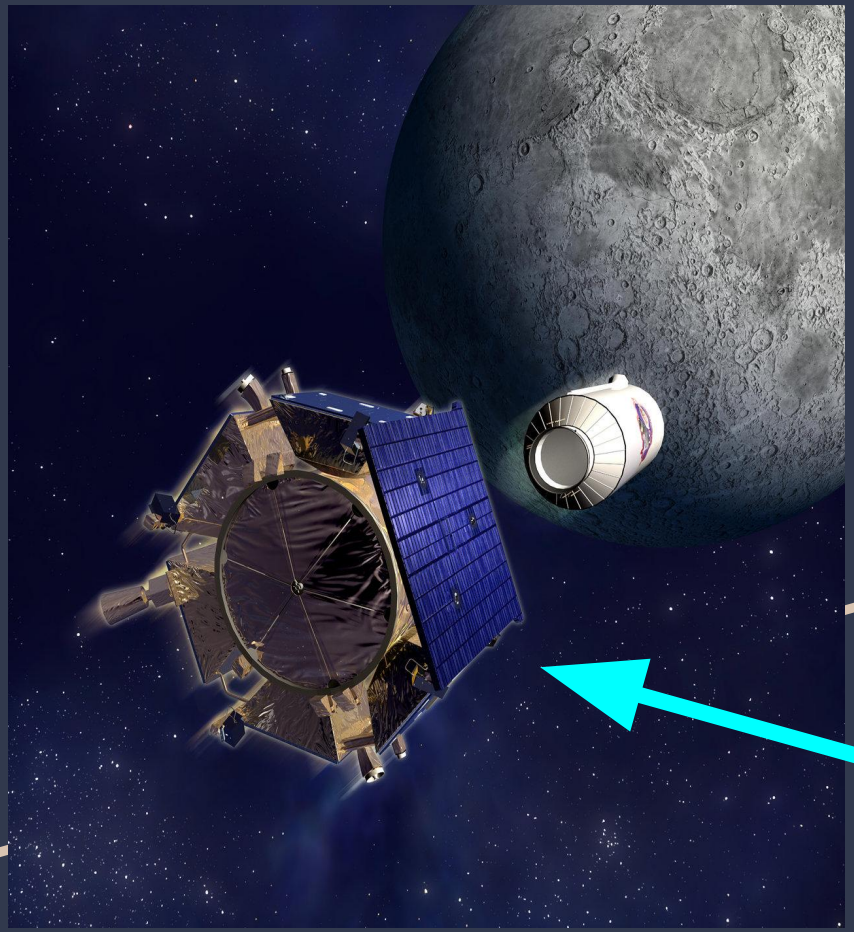
Lunar H_2O History

From the 20th century into the 21st





21st Century

Deep Impact : NASA

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2005 Clementine, Lunar prospector > inconclusive

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Kaguya : AKA 'SELENE' Japanese

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2007 'Gamma Ray Spectrometry'

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Chang'e 1 : Peoples Republic of China

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2007 : detailed photographs of polar areas (water ice location)

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Chandrayaan-1 : India – ISRO

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2008 : Moon Impact Probe – Shackleton Crater @ Lunar South Pole

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LRO / LCROSS

2009 : Cabeus crater impact Ejecta research

Where can it be found?

And How?

CHACE (CHandra's Altitudinal Composition Explorer) on **MIP** (Moon Impact Probe)

M^3 (an imaging spectrometer)

Synthetic Aperture radars

Focus: India / ISRO / Chandrayaan-1

In the *EXOSPHERE*

On the *SURFACE*

SUB-SURFACE

Who has taken charge?

- NASA with Lunar Crater Observation and Sensing Satellite (LCROSS) & Volatiles Investigating Polar Exploration Rover (VIPER)
- India with Chandrayaan-2
- China with Chang’e missions

Potential H_2O Uses

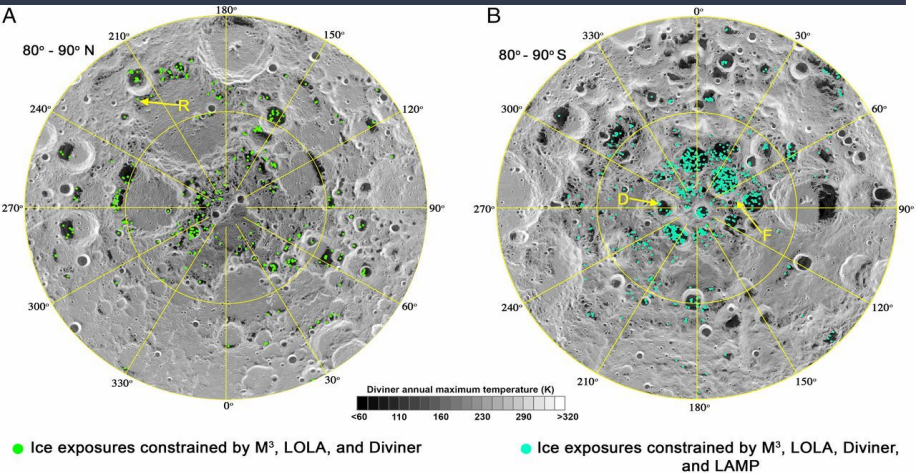
- ★ Domestic Uses for Lunar Base
- ★ Rocket fuel
- ★ Potential source for drinking water
- ★ Provide breathable air

Sustainability

- ★ According to Jim Green, NASA's chief scientist, current estimates suggest somewhere between one hundred million to two hundred million tons of water ice exist in the moon's dark craters

- ★ No accurate measurements to the amount of lunar ice, just estimates

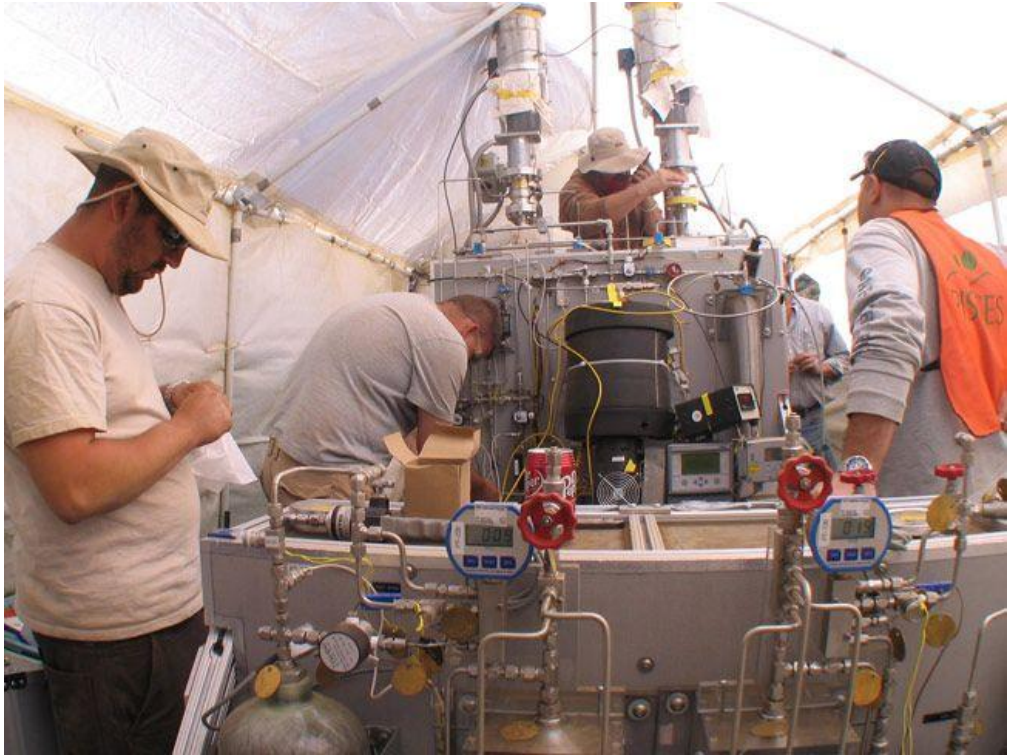
Safety



- ★ Further examinations are yet to be conducted on quality of lunar ice
- ★ Unknown dust levels from asteroid & comet impacts
- ★ Also contains metals, Sulfur oxides, Ammonia, rock, glass, and other possible organic materials
- ★ Realistic and safe separation method is not yet developed

Methods of Extraction

- Hydrogen reduction reactors
  - electrolysis

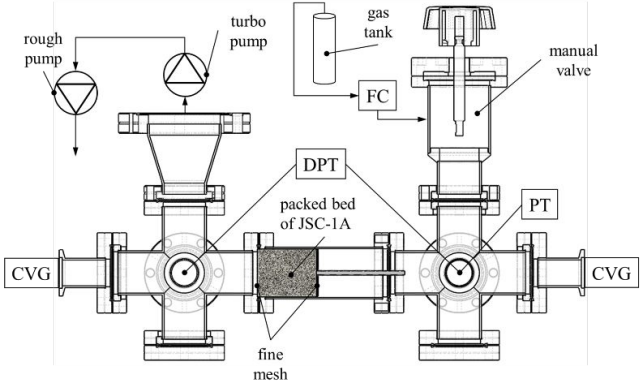


Methods of Extraction

- Microwave
  - Beaming microwaves on lunar permafrost could vaporize 98 percent of water ice, and capture 99 percent of the extracted water in gas form

Possible Obstacles

- Differences in atmospheric conditions could lead to excess volatile escape during sampling and collecting phase of lunar mission.



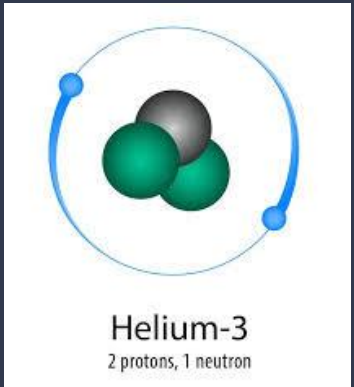
Schematic depiction of the experimental apparatus for measuring transport properties in a regolith packed bed

Possible Obstacles

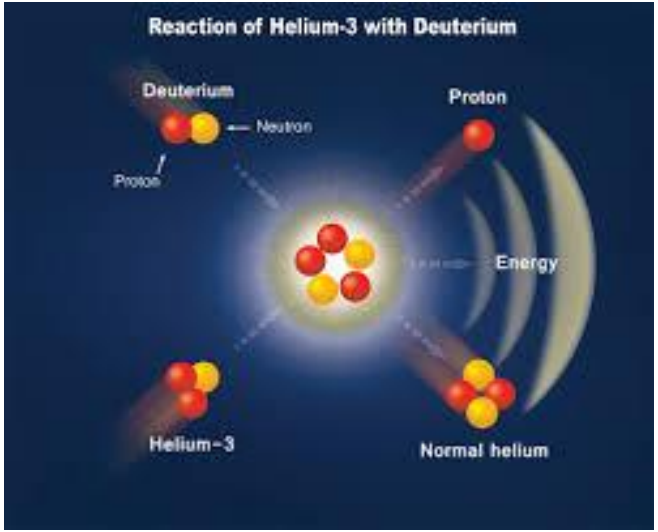
- Difficult to determine the precise microwave frequency for Water extraction

Band designator	Frequency	Wavelength in free space
	GHz	cm
L	1–2	30–15
S	2–4	15–7.5
C	4–8	7.5–3.8
X	8–12	3.8–2.5
Ku	12–18	2.5–1.7
K	18–27	1.7–1.1
Ka	27–40	1.1–0.75
V	40–75	0.75–0.40
W	75–110	0.40–0.27

Other Volatiles



- Helium 3
  - isotope could provide safer nuclear energy in a fusion reactor, since it is not radioactive and would not produce dangerous waste products.



Conclusion

- Artemis 3 Mission 2024
  - NASA has grander plans for future Artemis missions in the late 2020s—“a sustained lunar presence,”

Presence of lunar water and other volatiles will have potentially profound political/societal implications in the near-future.