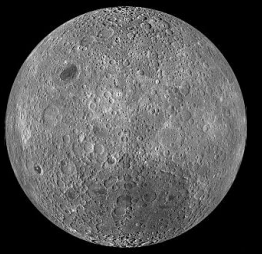
Fostering International Cooperation through Space Resources: The Moon as a Blueprint



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"If God wanted humans to become a space-faring species, He would have given them a Moon"

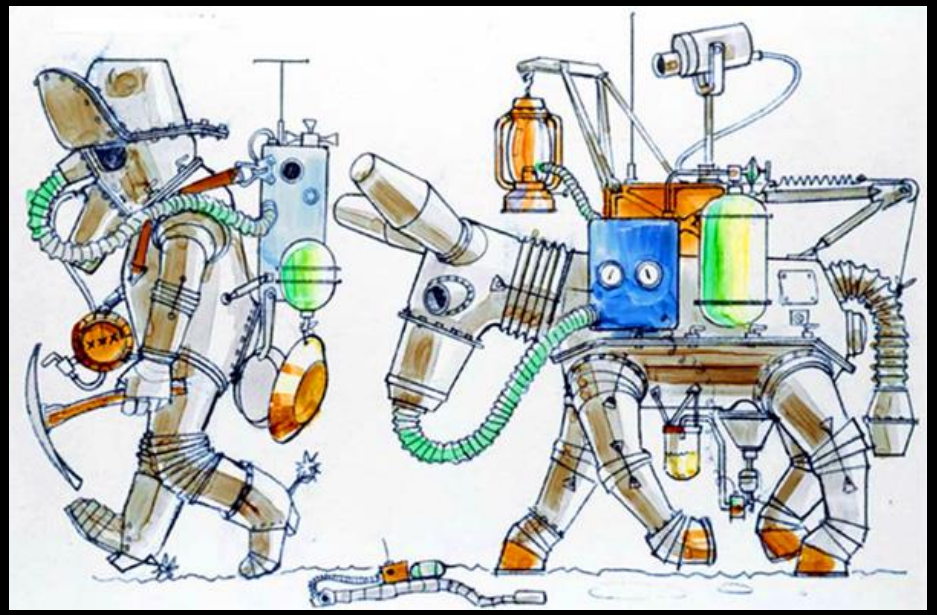
Paraphrased from Krafft Ehricke (1986) Lunar Industrialization & Settlement. In, Lunar Bases & Space Activities of the 21st Century, Mendell W.W., editor, 827-855. Lunar & Planetary Institute, Houston.

Presentation to the Legal Subcommittee of the United Nations Committee On the Peaceful Uses of Outer Space: 6 May 2025

Take Home Messages

Formulating an international framework for lunar/space resources would benefit from the data returned by an international lunar resource prospecting campaign.

Resource prospecting would help inform the Space Resources Working Group by providing data on lunar resources that could:



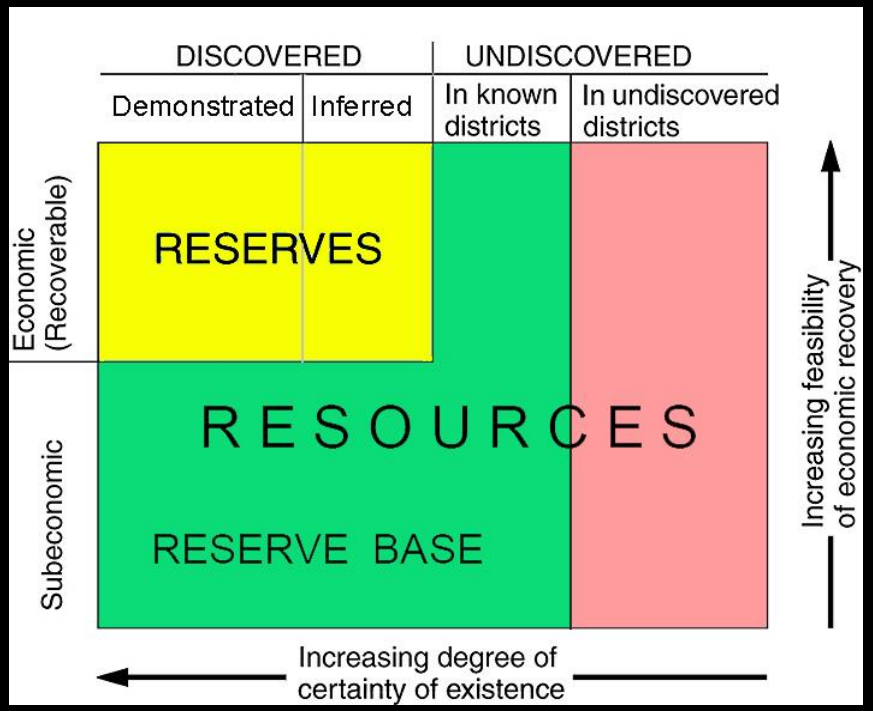
- Nurture international cooperation
- Develop information sharing protocols
- Initiate interoperability requirements
- Conduct science, exploration, & commercial activities at the same time
- Understand the resources in order to responsibly utilize them

When we go to the Moon, Mars & beyond, we should go together

Lunar resources are not ready for extraction/use as their *reserve potential* is unknown

This presentation aims to inform the Space Resources WG of two aspects:

- Finding *resources* is not sufficient to start space resource extraction and use
- For extraction to be considered, the existence of *reserves* needs to be proven



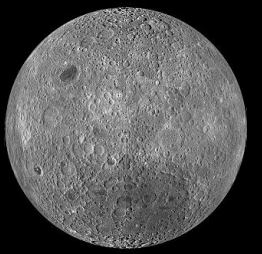
Resource: A concentration of natural materials in/on the crust in such form and amount that economic extraction of a commodity from the concentration is currently/potentially feasible.

Reserve: The recoverable portion of a resource which could be economically & legally extracted or produced at the time of determination.

United States Geological Survey (1980) Geol. Survey Circ. 831.
https://pubs.er.usgs.gov/publication/cir831

As of today, there are no recognized ***reserves*** at the Moon

Prospecting (characterization) campaigns are essential before resource extraction & utilization can occur



The ***reserve potential*** of any resource on the Moon cannot be evaluated – more granular data sets are needed (see Table 1)

- These new data types would need to be obtained via mobile surface assets

Table 1: Datasets for lunar volatile resource evaluation

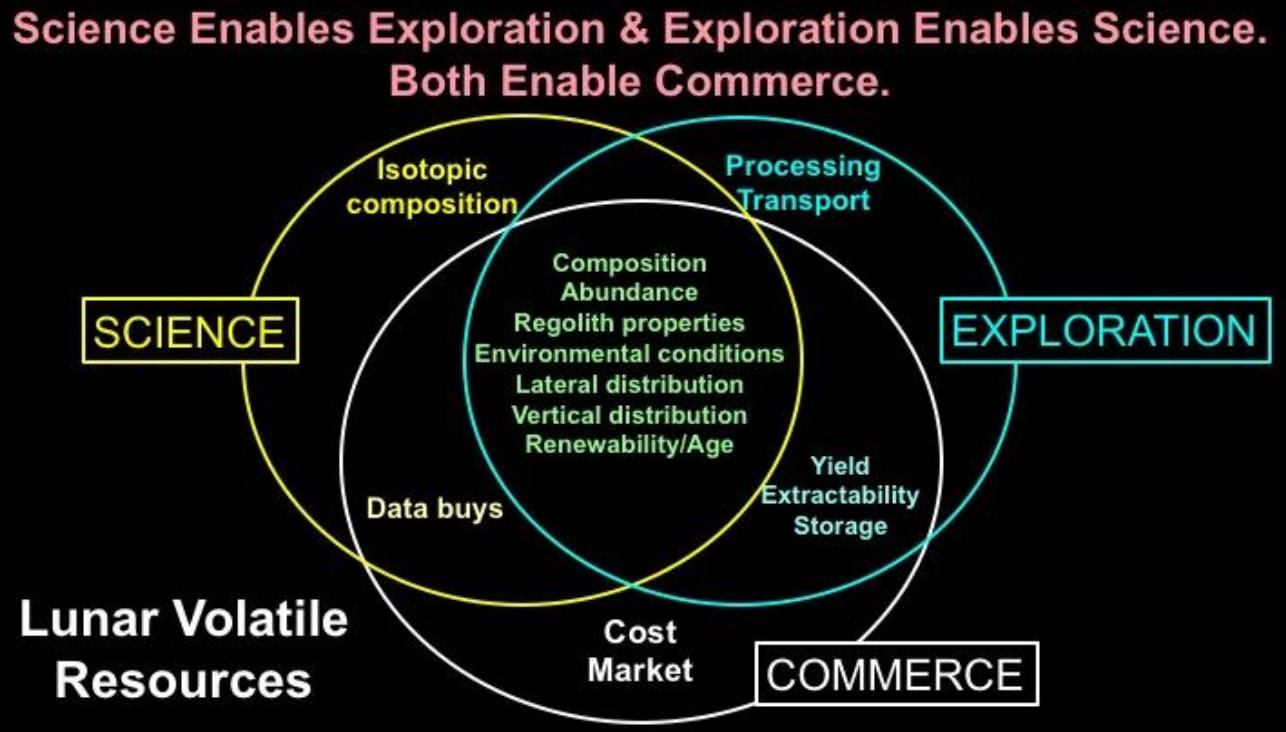
Dataset	Specific Data	Use	Measurement
Composition	Concentration of the resource; Concentration & composition of impurities	Evaluate potential investment needed for refining the product	100 µg/g
Form	Cement in pore space; Layers; Irregular blocks; Loose ice grains with regolith	Develop efficient extraction techniques	Image: 0.5 mm/pixel
Distribution	Horizontal; Vertical	Variability needs to be documented to understand the volume of the resource	10 cm
Geotechnical	Torque and power required for any machinery to penetrate the deposit; Energy required to move loose regolith; Hardness of the deposit	Understand the effort required to mine the deposit and investment needed in developing extraction capabilities.	TBD
Near-surface Regolith Stratigraphy	Buried and surface rock populations Ice block/layer distribution	Will impact the extractability of the regolith resource	10 cm
Accessibility	Safe traverse paths	Ease of accessibility has an impact on cost of developing robotic miners.	TBD

NOTE: 10 most promising sites for polar volatiles cover over 5,900 km^2

Brown et al., 2022, *Icarus* ***377***, 114874
https://doi.org/10.1016/j.icarus.2021.114874

No resource prospecting campaign has been conducted on the Moon

Prospecting campaigns will deliver data that informs multiple stakeholders



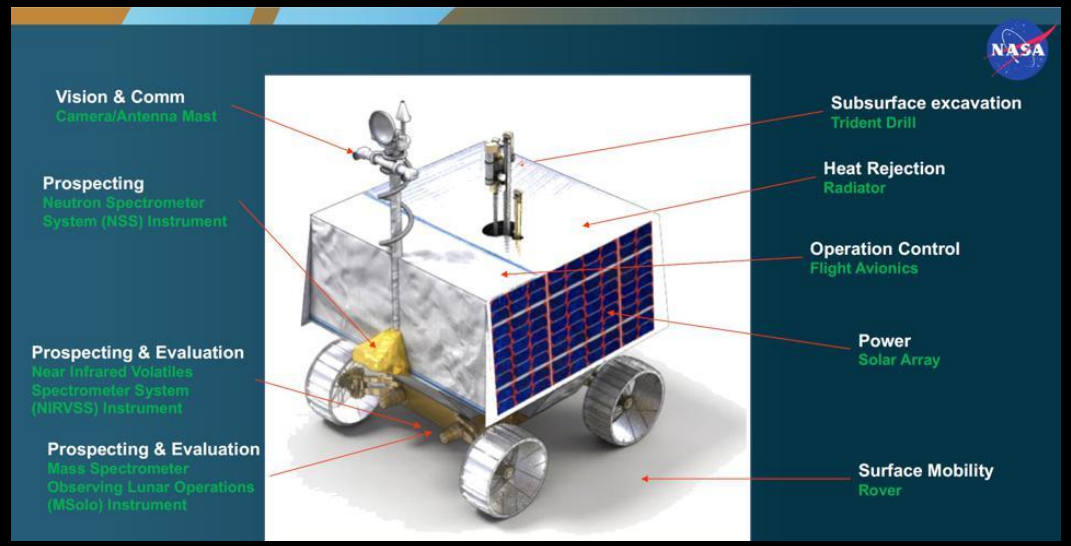
Protection of areas that contain resources for science is unnecessary; prospecting will deliver science data on these areas & environments that otherwise would likely not be visited.

OST Article 1, paragraph 2:

Outer space, including the Moon and other celestial bodies, *shall be free for exploration and use by all States* without discrimination of any kind, on a basis of equality and in accordance with international law, *and there shall be free access to all areas* of celestial bodies.

When we go to the Moon, Mars & beyond, we should go together

Campaigns require cooperation between science, exploration, commerce, and international agencies



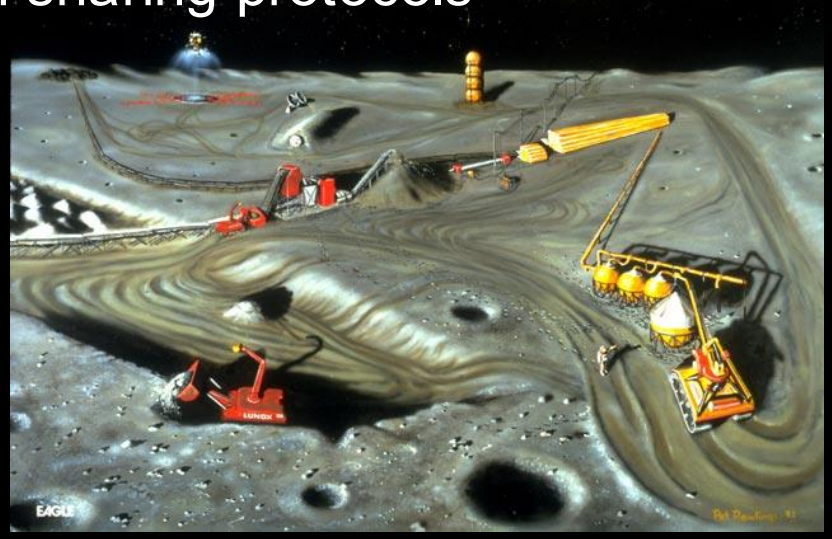
VIPER: Volatiles Investigating Polar Exploration Rover

Prospecting campaigns to characterize resources and their environments is the immediate next step for the Moon:

- Partnerships between lunar science, exploration, commerce
- Opportunities for international cooperation, development of interoperability standards, promotion of information sharing protocols

Resource utilization is in the future:

- Science must be involved
- Follow the “construction model” in Europe
- Science and exploration enable each other, and both enable commerce



Creating an International Lunar Resource Prospecting Campaign (ILRPC) has begun for polar volatiles

Coordinate existing & scheduled missions:

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The Moon needs an international lunar resource prospecting campaign

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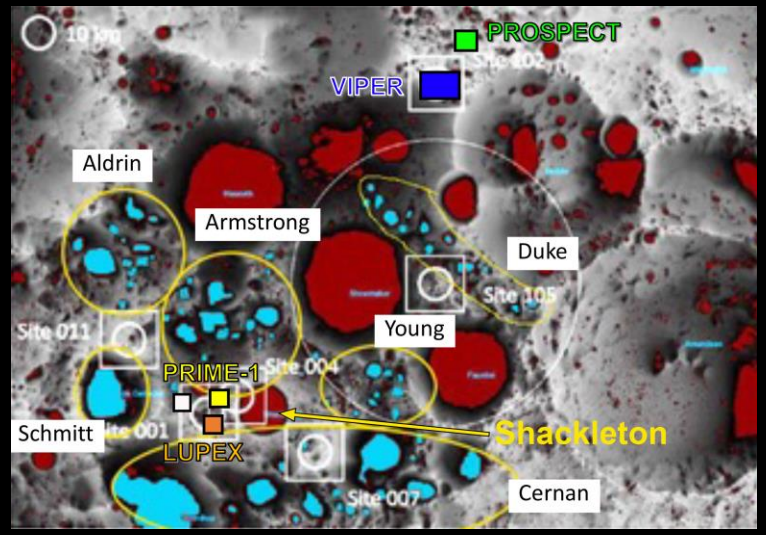
- Small permanently shadowed regions (PSRs) = shorter traverses & easier access
- Decrease risk
- Integrate data sets – prospectivity maps



Landed and Orbital missions

- USA: LRO
  - VIPER
  - (Artemis 3)

Canada: Lunar Rover Mission (south pole)

Korea: Korean Pathfinder Lunar Orbiter (KPLO)

India: Chandrayaan-2

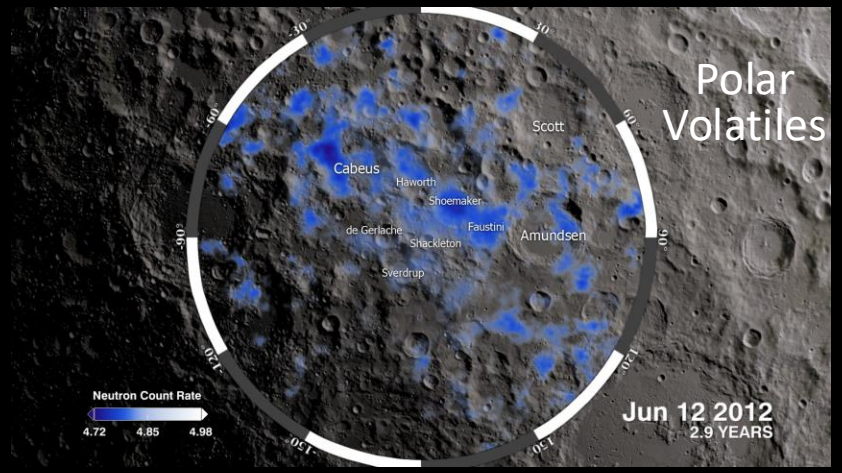
Japan & India: LUnar Polar EX mission (LUPEX)

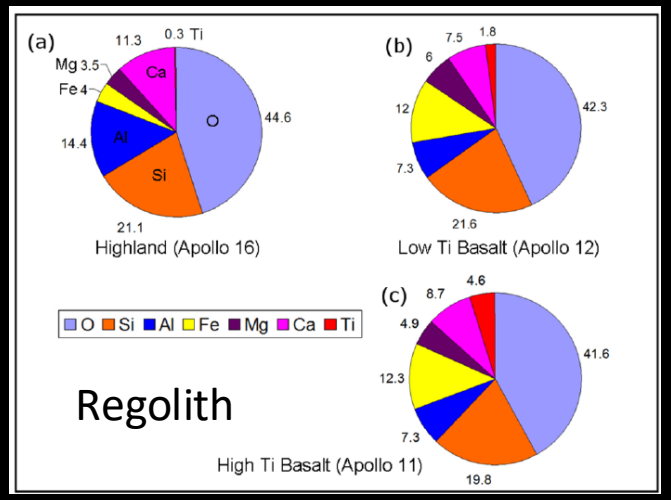
ESA: Package for Resource Observation and in-Situ Prospecting for Exploration, Commercial exploitation and Transportation (PROSPECT)

There are 26 scheduled missions to the Moon before 2030

There are other potential lunar resources that can be used in situ, for export, or both

1) **Polar volatile deposits**
2) **Regolith:**
   - Building materials (e.g., 3D printing)
   - Metals
   - Oxygen
   - Solar wind implanted volatiles (H, He C, N, etc.)
   - Platinum group metals
   - Rare earth elements
   - Th, U
3) **Pyroclastic Deposits:**
   - Volatiles
   - Metals
4) **Geologic Structures:**
   - Lava tubes
   - Impact craters





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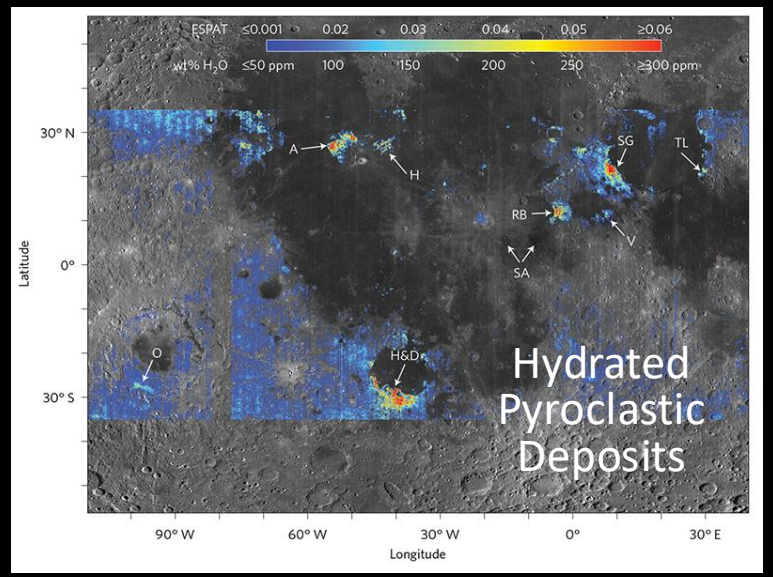

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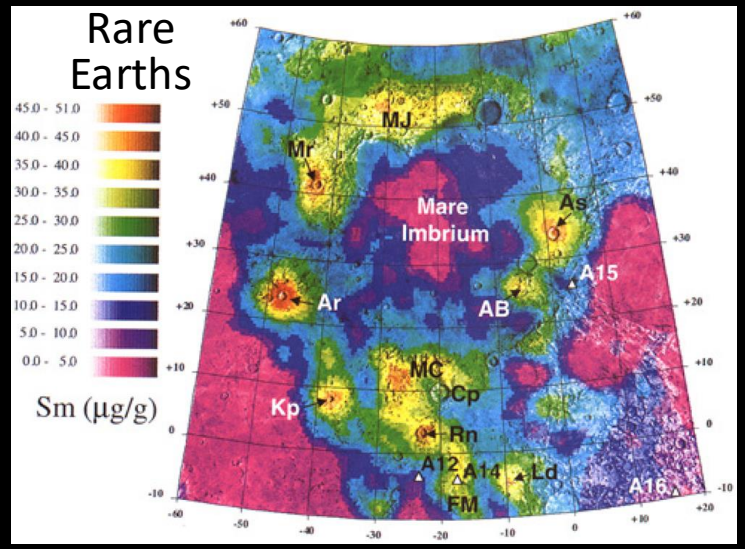

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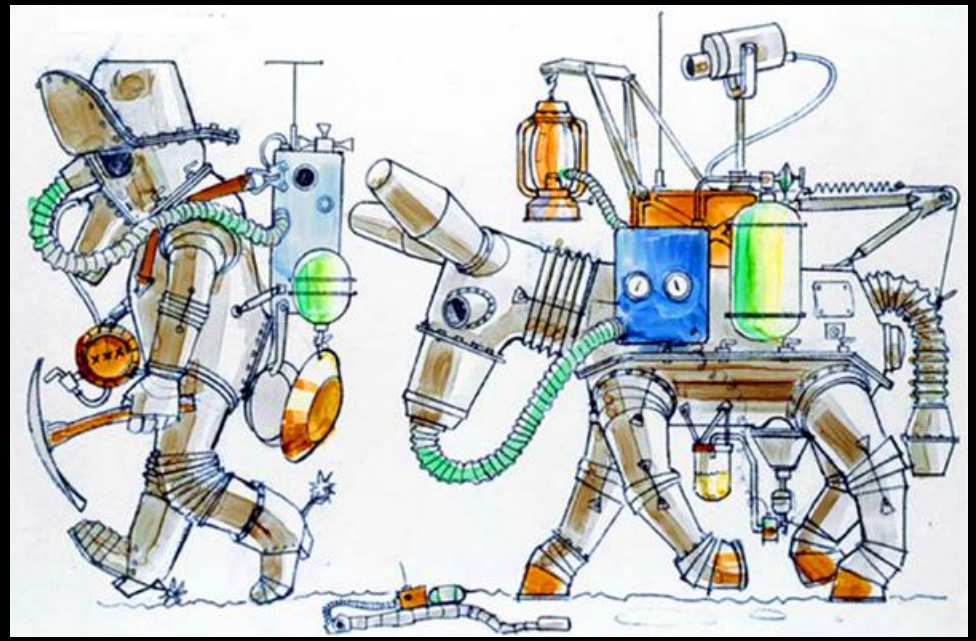
The integrated datasets produced by the ILRPC can help inform the Space Resources WG

These data could inform the WG on how to formulate an international framework for lunar/space resources.
Obtaining new prospecting data would:

- Nurture international cooperation
- Develop information sharing protocols
- Initiate interoperability requirements
- Conduct science, exploration, & commercial activities at the same time
- Understand the resources in order to responsibly utilize them



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