Examining the Reserve Potential of Lunar Polar Volatiles

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"Resource" vs. "Reserve"

Resources is a broad term. Resources are materials *that may or may not be discovered* that might be feasible for economic extraction [1].

Reserves is a specific term that implies *assured recoverability of a commodity* through economic and legal extraction [1].

Defining these two terms when discussing space resources, and specifically lunar polar volatiles is necessary. It is impossible to establish demand and prices without knowing exactly how much of a resources is available in reserves. We still do not know what reserves, if any, will be accessible at the lunar south pole.

Lunar Ore Reserve Standards (LORS)

LORS Classification	Geological Knowledge Error (GKE)		
	Min (%)	Mid (%)	Max (%)
Measured Resources	0	15	19
Indicated Resources	20	25	29
Inferred Resources	30	50	69
Prospective Areas	70	75	79
Speculative Regions	80	85	90

Figure 1: shows the Geological Knowledge Error (GKE) ranges for each geological certainty level in the initial classification system (GR-CS1) of the LORS standards.

The Lunar Ore Reserves Standards (LORS) provide a framework through which lunar reserves may be classified and communicated to interested parties wishing to explore, extract, and engage in the commercial transaction and use of space resources [2].

The LORS establishes three main classification systems (CS) for extraterrestrial resources and reserves for commercial and non-commercial purposes [2].

CS-1: The first level is based on *geological resources*

CS-2: The second level is *extractable resources*

CS-3: The third level is *economically extractable reserves*

Terrain Type I

Figure 2*: TTI contains volatiles at the surface, thick ice layers deposited in macro cold traps. Infrared and microwave heating could potentially be used to prospect.

*Figures 2-4 Terrain Types (TT) modified from [3].

Terrain Type II

Figure 3*: TTII contains volatiles ≤1m below the surface, instruments specializing in subsurface measurements such as ground-penetrating radar and drilling are required.

Terrain Type III

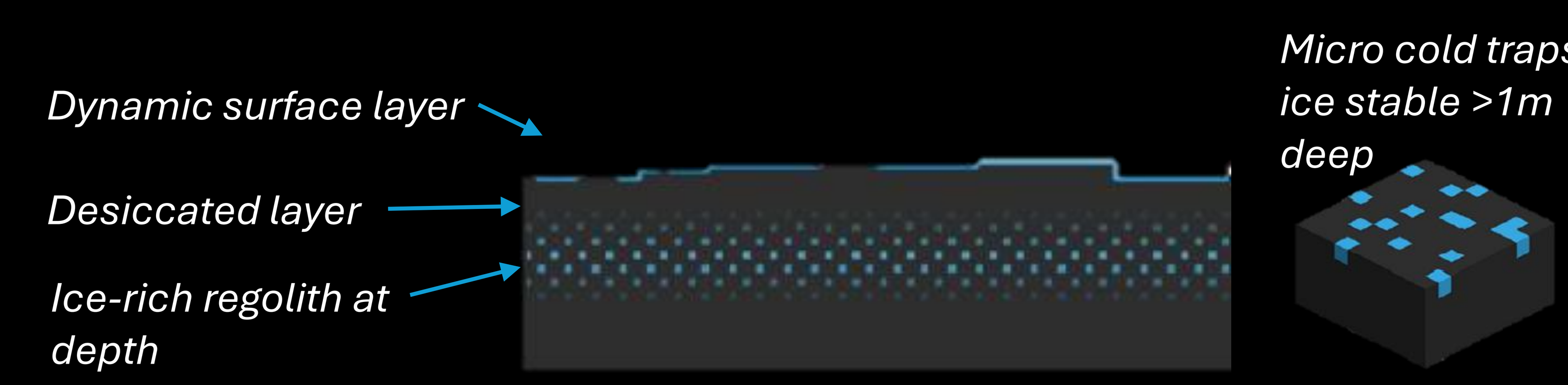

Figure 4*: TTIII contains volatiles >1m beneath the surface. The volatiles have been compacted into ice-rich layers below the surface through impact gardening. Some radar may be able to detect thick layers, but drilling is necessary to quantify deposits.

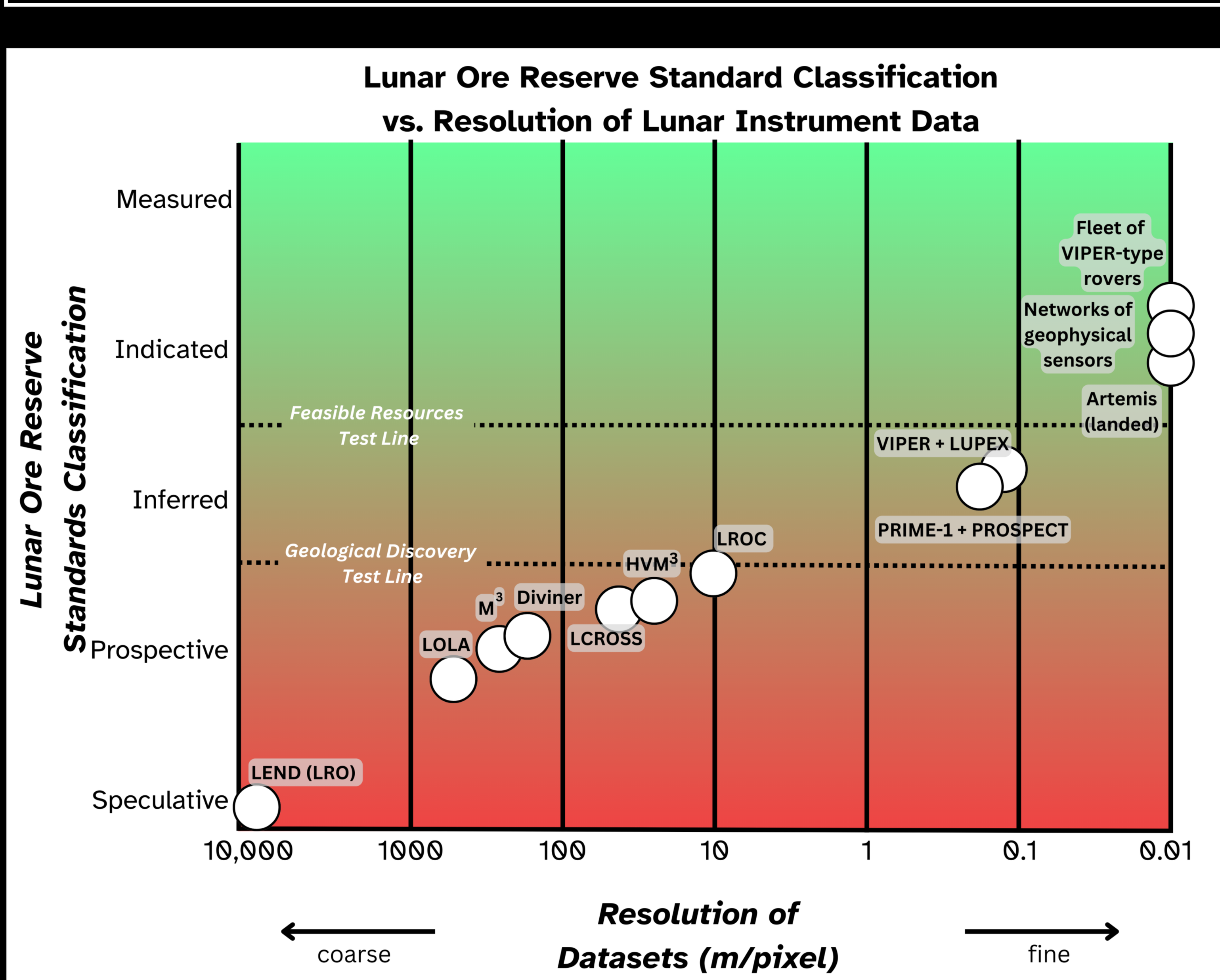

Figure 5: Historic lunar datasets plotted with planned and hypothetical lunar mission data sets along the LORS CS-1 Classification System.

Science Enables Exploration & Exploration Enables Science. Both Enable Commerce.

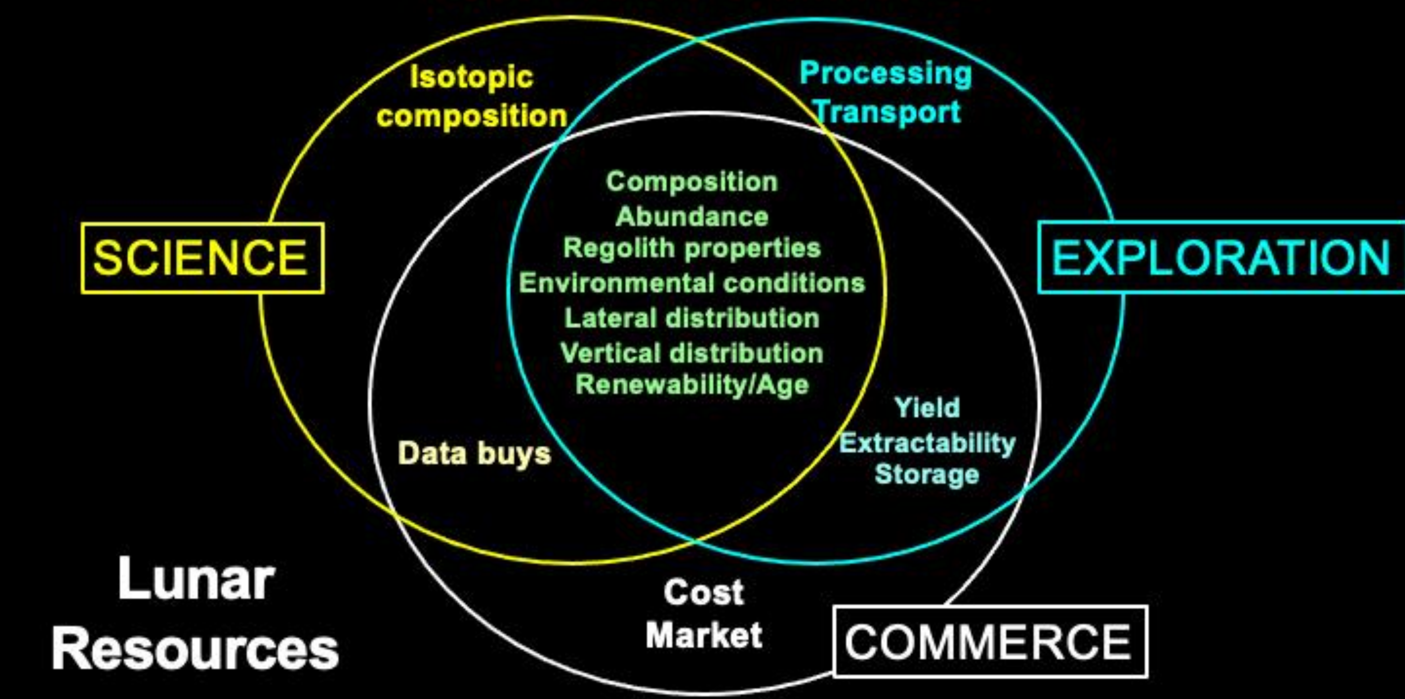

Figure 6: Venn diagram from [1] that demonstrates how science and exploration enable and validate each other, and how both enable commerce.

Conclusion

Consistent standards and language around 'resources' versus 'reserves' needs to be established. Current lunar datasets are not sufficiently robust to reliably prospect for lunar reserves. The LORS provides a dedicated framework for discussing lunar reserves. Instrumentation and data collection needs to vary based on the lunar terrain and location of ice deposits. To access potential reserves, we must have the highest fidelity data from multinational missions. A coordinated, global campaign is needed to adequately assess lunar polar reserves.

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References

[1] Neal C.R. et al. (2024) *Acta Astronautica*, *214*, 737–747. [2] Espejel C.D. et al. (2023) *Handbook of Space Resources*. pp. [3] Cannon K.M. & Britt D.T. (2020) *Icarus*, *347*, 113778.