Why We Expect More Lunar Ice Than We've Found

Confirmed Observations:

- *LCROSS (2009)*: Impact into Cabeus crater ejected a plume with ~5.6% water content by mass at just ~1 meter depth.
- *Orbital Spectrometry*: Hydrogen signatures are found across lunar poles, crater rims, and some mid-latitudes.
- *Surface Frost*: Detected in permanently shadowed regions (PSRs) and embedded in regolith grains.

The Implication: If water is detectable in shallow impacts and surface frost, then it is likely more widespread—potentially concentrated in stable subsurface zones.

Supporting Evidence & Reasoning:

1. Regolith is an Excellent Insulator

- Only 20–50 cm of lunar soil is needed to preserve ice for billions of years.
- Shallow ice doesn't require deep burial in polar regions.

2. Hydrogen is Widespread

- Orbital neutron data suggests broad hydrogen distribution.
- Indicates ice is not confined to isolated pockets.

3. No Atmosphere = No Erosion or Loss

- Ice delivered by comets or volcanic outgassing remains undisturbed.
- No hydrological cycle to redistribute or remove it.

4. Earth Analogues Suggest Deeper Ice is Likely

- Fossil aquifers, subglacial lakes, permafrost on Earth show how water can remain trapped underground.
- Luna had volcanism, impacts, and cooling—conditions favorable to sealed ice deposits.

What It Means for ISRU and Infrastructure:

- Even one deep, stable deposit could support massive extraction rates.

- Shielding water, propellant feedstock, and life support become practical at scale.
- Tools exist now: shallow drills, seismic sensors, ground-penetrating radar.

Conclusion: We've found water near the surface. But the best may still be hidden just below. To support lunar infrastructure, we must search deeper—intelligently, methodically, and soon.