

Irreversible Commitments in Lunar Subsurface Exploration

Ignorance, Disturbance, and Precedent Formation

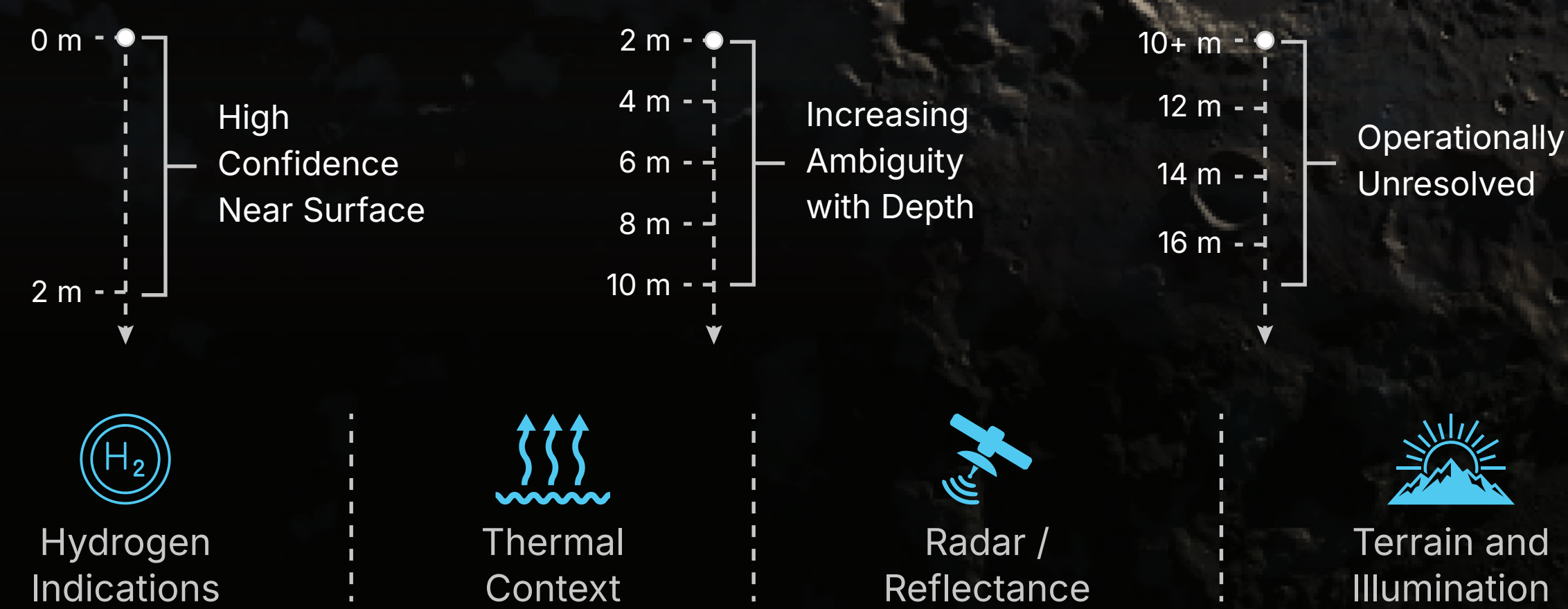
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Sustainable Exploration

1. DETECTABILITY LIMITS

What can indirect sensing resolve before disturbance?

Detectability decreases with depth and indirectness.

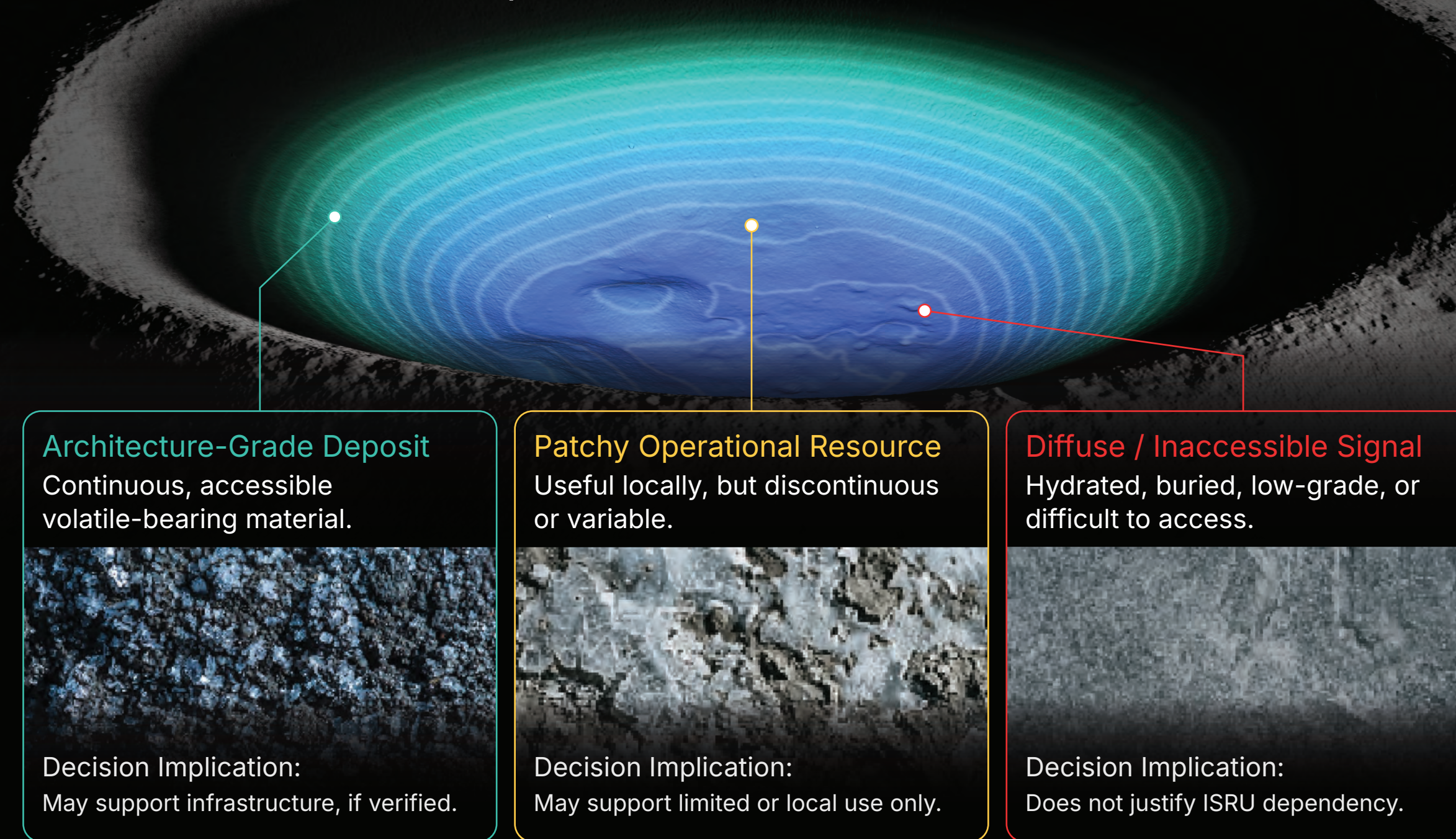


Indirect sensing constrains the search space, but operationally relevant subsurface conditions remain only partially observable.

2. AMBIGUITY PERSISTENCE

One signal can remain consistent with multiple operating realities.

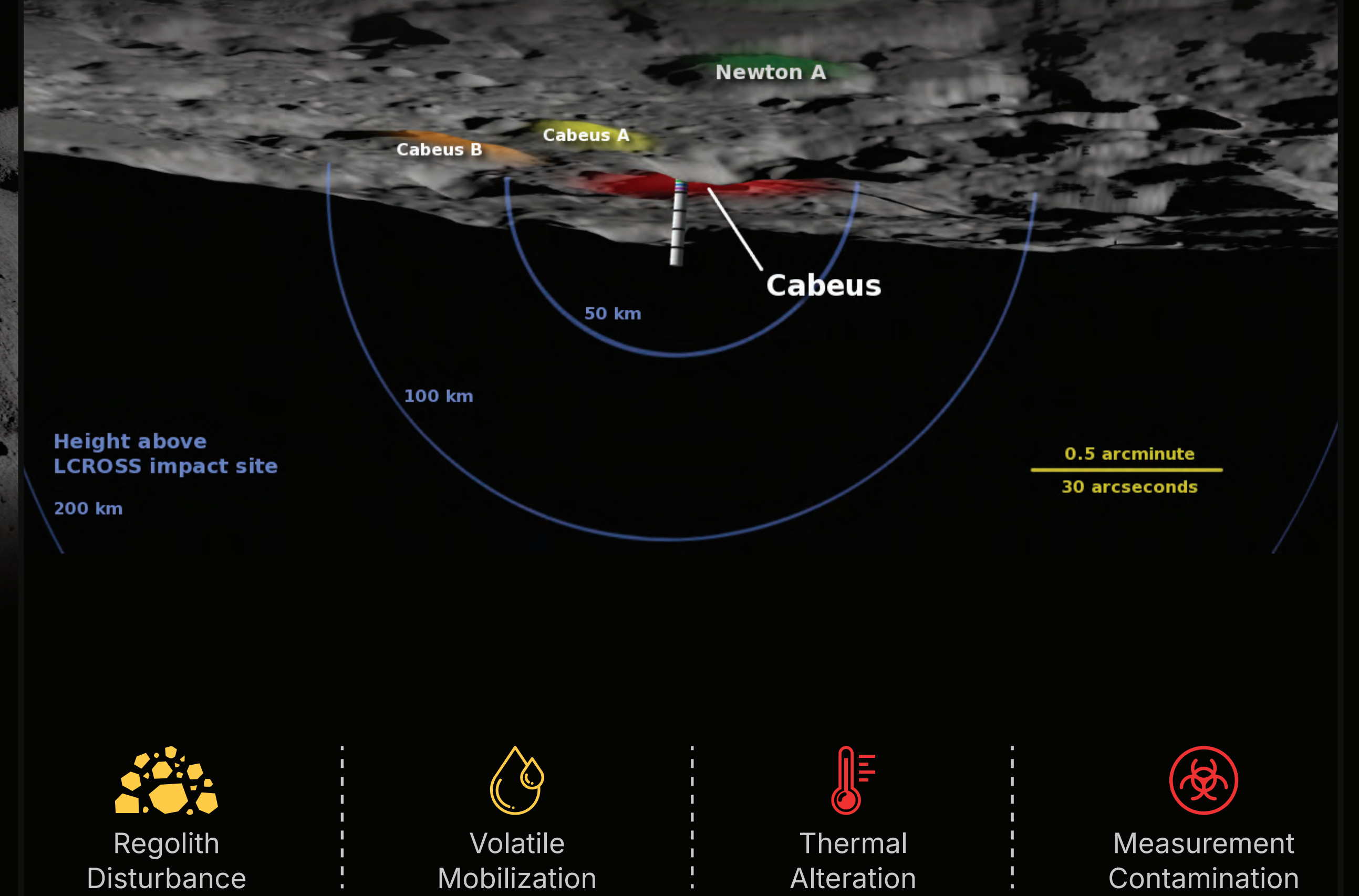
Same signal. Different realities.
Different commitment implications.



Indirect evidence narrows the search space. It does not determine volatile form, continuity, concentration, accessibility, or extractability.

3. ENVIRONMENTAL RESPONSE

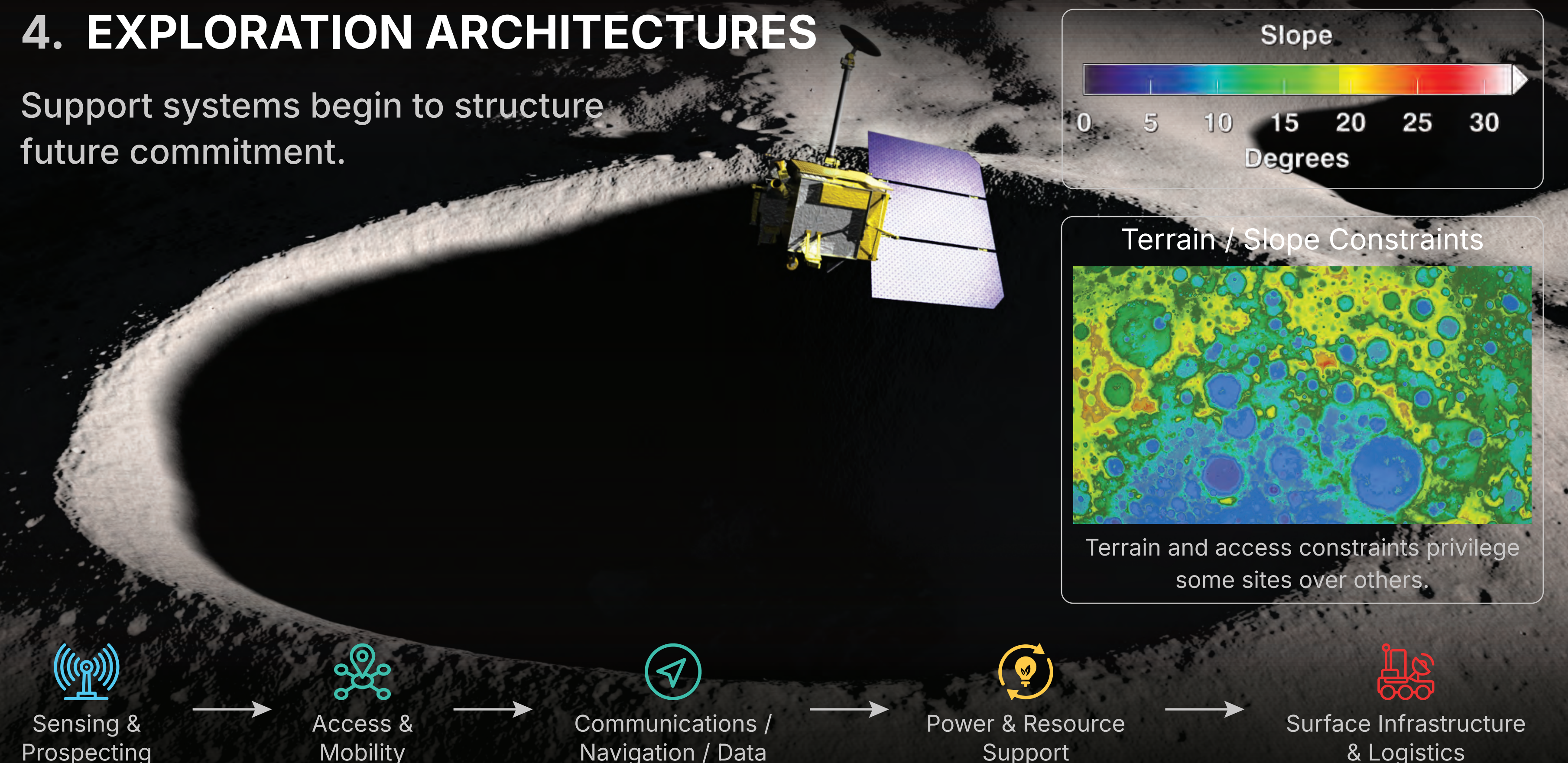
Verification changes the system under evaluation.



Disturbance can produce knowledge while altering the evidence baseline.

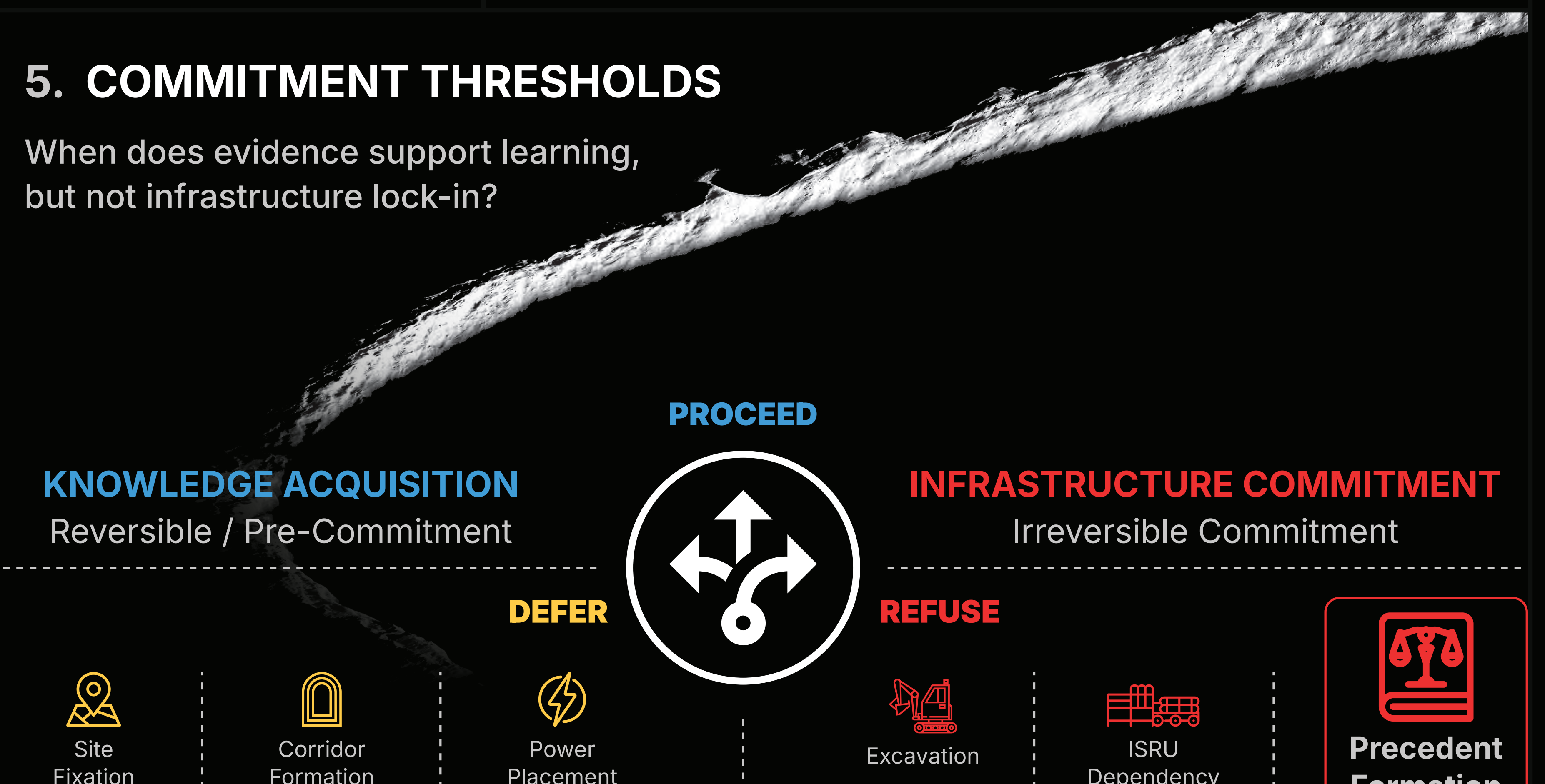
4. EXPLORATION ARCHITECTURES

Support systems begin to structure future commitment.



5. COMMITMENT THRESHOLDS

When does evidence support learning, but not infrastructure lock-in?



Commitment becomes admissible only when remaining uncertainty no longer has the power to change key decisions. These may include site, access, support, disturbance, resource dependency, or precedent formation.

Imagery and visualizations adapted from NASA Scientific Visualization Studio and NASA mission datasets, including LRO/LROC, LEND, LOLA, and LCROSS where applicable.



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COLOR LEGEND (By Commitment State)

Reversible Knowledge Operational Enablement Emerging Commitment Irreversible Commitment