ARES

The Autonomous Roving Exploration System for <u>active-source seismology</u> on the Moon and Mars

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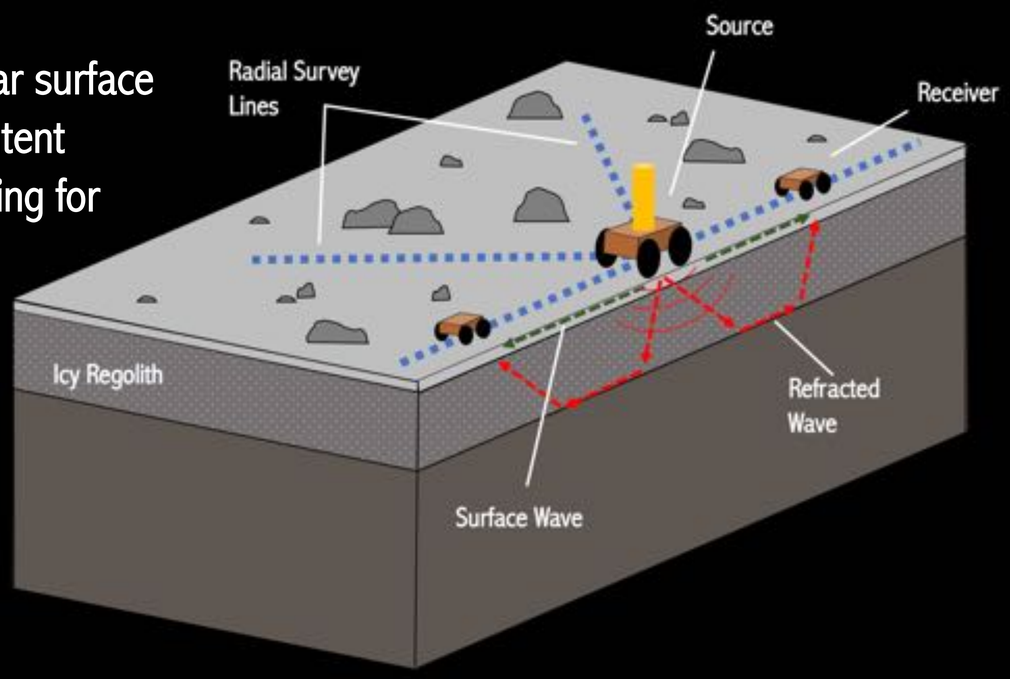
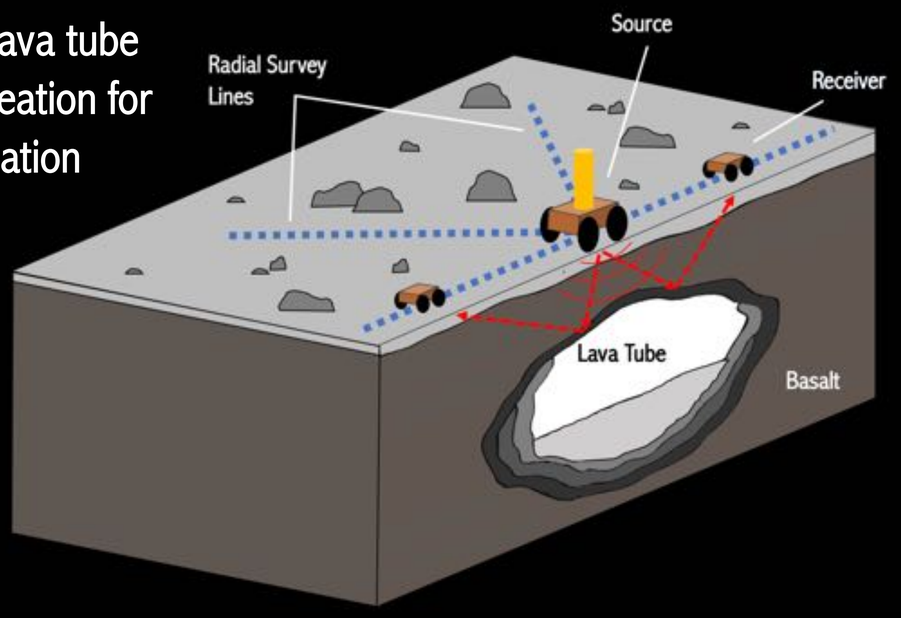
In preparation for human exploration:

1). Near surface ice content surveying for ISRU



2). Lava tube delineation for habitation



Why ARES?

- Need resource evaluation at landing sites before human arrival [1]
- Orbiters can't do the job: no validated lava tube detections on Mars [2], and ice content is questioned [3]
- Active source seismology is well developed [4] and has been done on the Moon before.
- Seismic data complements ground penetrating radar (GPR) data, and rovers could include GPR if desired [5,6]

The Apollo seismic "thumper" source. Image credit: NASA.gov

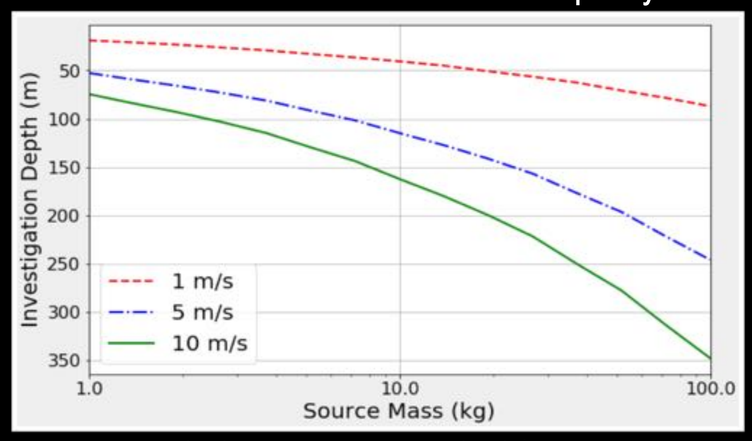
ARES components

- 1 Source rover with simple and repeatable accelerated weight drop source
- 2+ Receiver rovers with mounted wireless geophones

(a) Lunar Outpost's 10 kg autonomous resource prospector rover, ideal for acting as a receiver rover. (b) GTI's NuSeis wireless nodal geophone, ideal for attaching to a small rover.

Source Mass Tradeoff

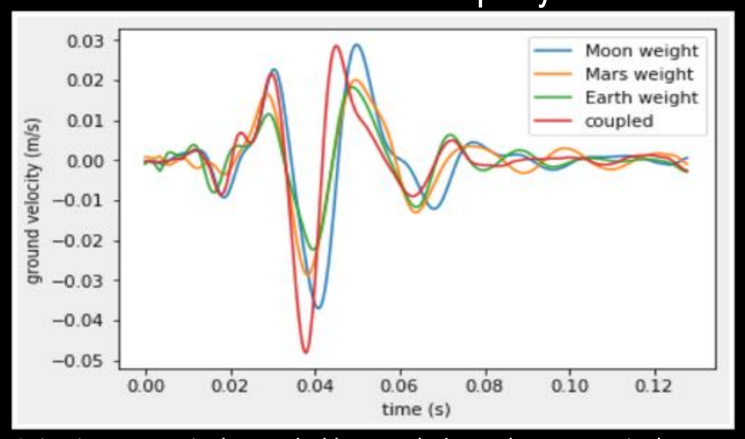
- Greater source energy (mass and velocity) means greater investigation depth/range [7,8]
- Greater mass means more cost and complexity



Source mass and velocity vs investigation depth/range

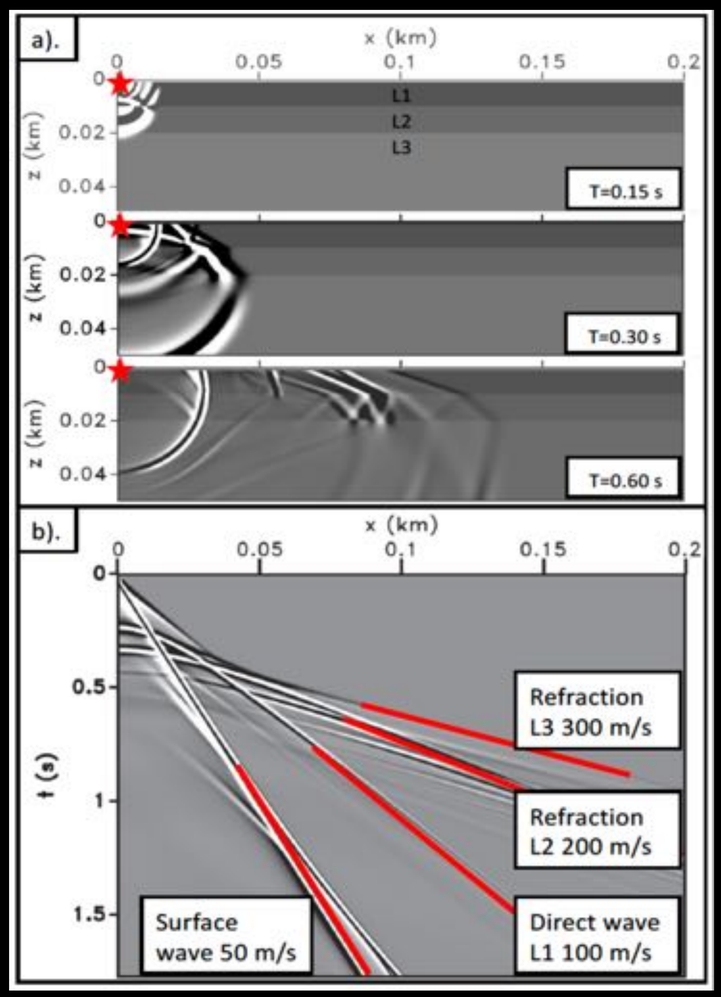
Receiver Coupling Tradeoff

- Inserting geophones in regolith (coupling) is complex but yields more accurate data
- Mounting geophones on rover is simple but yields reverberations that reduce data quality



Seismic wave arrival recorded by coupled geophone vs arrival recorded by geophone mounted on 10 kg rover as it would weigh on the Earth, the Moon, and Mars.

Acquisition Simulation



(a) Numerical wavefield simulation of weight drop source over layered regolith model depicted in scenario 1 above. (b) Synthetic data (with interpretation) as would be recorded by ARES along a radial survey line. See abstract for lava tube imaging example

References: [1]MEPAG, 2015. [2] M. R. Perry et al. AGU Fall Meeting, (P24D-07), 2018. [3] A. Abbud-Madrid et al. Report of the Mars Water In-Situ Resource Utilization (ISRU)Planning (M-WIP) Study, 90, 2016. [4] K. Aki and P. G. Richards. Quantitative seismology. 2002. [5] S. W. Courville et al. AGU Fall Meeting, (P54D-02), 2018.
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[7] M. A. Meschede et al. Geophys. J. Int., 187(1):529–537, 2011.
[8] R. D. Miller et al. Geophysics, 51(11):2067–2092, 1986.

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